NAVAL POSTGRADUATE SCHOOL ACADEMIC CATALOG

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Quick Facts

The School

The Naval Postgraduate School provides defense-focused graduate education, including classified studies and interdisciplinary research, to advance the operational effectiveness, technological leadership and warfighting advantage of the Naval service.

The Campus

Located in Monterey, California on the Pacific Ocean, 120 miles south of San Francisco, the Naval Postgraduate School campus covers 627 acres of land. The site, home to NPS since 1951, houses state-of-the-art laboratories, numerous academic buildings, an award-winning library, government housing and impressive recreational facilities.

The Students

The student body consists of officers from all branches of the U.S. uniformed services, civilian employees of the federal, state and local governments, as well as officers and civilians from many foreign countries. A limited number of defense contractors and enlisted personnel are also enrolled. Selection for graduate education at NPS is based upon outstanding professional performance, promotion potential, and a strong academic background.

The Faculty

Drawn from a broad array of educational institutions, the faculty represent a prestigious collection of scholars, the majority of whom are civilians. Faculty interaction with students is high and every class is taught directly by a faculty member. All tenure and tenure-track faculty hold a doctoral degree. Other faculty are credentialed experts in their fields of study.

The Degrees

The Naval Postgraduate School confers the following advanced degrees: Masters Degree, Master of Arts Degree, Master of Science Degree, Engineer's Degree, Doctor of Philosophy, and Doctor of Engineering.

For more information on admission, contact:

Naval Postgraduate School
Admissions Office
1 University Circle, He-022
Monterey, CA 93943

Telephone: (831) 656-3093 / DSN 756-3093
E-mail: grad-ed@nps.edu

The Academic Catalog

The policies and regulations of the Naval Postgraduate School may be amended periodically by action of the responsible bodies. Therefore, the documents in this catalog are subject to change during the academic session.

Current and archival editions of the Academic Catalog may be found at:
https://nps.edu/web/registrar/academic-catalog

The Naval Postgraduate School

The Institution

To meet its advanced educational requirements, the Navy has a unique academic institution at the Naval Postgraduate School (NPS) with specially tailored academic programs and a distinctive organization tying academic disciplines to naval and joint war fighting applications.

The student body consists of officers from all branches of the U.S. uniformed services, officers and civilians from other countries and civilian employees of the federal government as well as state and local governments. A limited number of defense contractors and enlisted personnel are also enrolled. Selection for graduate education at NPS is based on outstanding professional performance, promotion potential, and a strong academic background. Students receive graduate degrees as a result of successful completion of programs designed primarily to prepare them for future career assignments. Degrees are awarded on the basis of the same high academic standards that prevail at other accredited institutions.

As an academic institution, NPS emphasizes study and research programs that are relevant to the Navy's interests, as well as the interests of other branches of the Department of Defense (DoD). The programs are designed to accommodate the unique requirements of the military, defense department and other federal agencies, including requirements for Defense Acquisition Certification.

Mission

The Naval Postgraduate School provides defense-focused graduate education, including classified studies and interdisciplinary research, to advance the operational effectiveness, technological leadership and warfighting advantage of the Naval service.

Accreditation

WSCUC

The Western Association of Schools and Colleges (WASC) Senior Colleges and Universities Commission has accredited the Naval Postgraduate School since 1955.

EAC of ABET

In addition to institutional accreditation, the former Graduate School of Engineering and Applied Science's Electrical, Mechanical, Systems and Astronautical Engineering degree programs are accredited by the Engineering Accreditation Commission (EAC) of ABET, http://www.abet.org.

Dept. of Electrical Engineering
    Master of Science in Electrical Engineering

Dept. of Mechanical and Aerospace Engineering
    Master of Science in Mechanical Engineering
    Master of Science in Astronautical Engineering

Dept. of Systems Engineering
    Master of Science in Systems Engineering
    Master of Science in Systems Engineering (Distributed Learning)

AACSB

The Department of Defense Management programs are accredited by the Association to Advance Collegiate Schools of Business (AACSB).

NASPAA

The Master of Science in Management programs are accredited by the Network of Schools of Public Policy, Affairs, and Administration (NASPAA).

Administration

The President of the Naval Postgraduate School is the academic coordinator for all graduate education programs in the Navy. The President administers fully-funded graduate educational programs at the Naval Postgraduate School, other service graduate schools and civilian universities.

Leadership

President
Ann E. Rondeau, Ed.D., VADM, USN (Ret.)

Provost and Academic Dean
Scott Gartner, Ph.D.

Chief of Staff
Brandon Bryan, CAPT, USN

Academic Administration

Vice Provost of Academic Leadership
Jomana Amara, Ph.D.

Vice Provost of Research
Kevin B. Smith, Ph.D.

Dean of Students
Thor Martinsen, CAPT, USN

Vice Provost of Academic Affairs, Acting
James B. Michael, Ph.D.

University Librarian
Thomas Rosko

Administrative Staff (Academic)

Associate Provost for Faculty Affairs
Dennis Lester, Ph.D.

Director of Academic Administration and Registrar
Jessica Bawdon

Director of Admissions, Acting
Cheryl Southern

Director, Faculty Development
Ali Rodgers

Director, Graduate Writing Center and Thesis Processing Office
Sandra Leavitt, Ph.D.

Director of International Graduate Programs Office
Danial Pick, COL, USA (Ret.)

Director of Programs
Sabina Pamaran, CDR, USN

Distinguished Professors

"Distinguished Professor" is an honorary title conferred upon certain faculty members in recognition of meritorious scholarly accomplishments and sustained, significant contributions to the educational mission of the Naval Postgraduate School. Their research or scholarly contributions while at the Naval Postgraduate School have had a significant impact on their fields of expertise.

Agrawal, Brij
Mechanical and Aerospace Engineering

Apte, Uday
Business and Public Policy

Arquilla, John (Emeritus)
Defense Analysis

Ball, Robert (Emeritus)
Mechanical and Aerospace Engineering

Brown, Gerald (Emeritus)
Operations Research

Bruneau, Thomas (Emeritus)
National Security Affairs

Butler, John T. (Emeritus)
Electrical and Computer Engineering

Chang, Chih Pei (Emeritus)
Meteorology

Chiu, Ching-Sang (Emeritus)
Oceanography

Chu, Peter C.
Oceanography

Colson, William (Emeritus)
Physics

Denning, Dorothy (Emerita)
Defense Analysis

Denning, Peter
Computer Science

Elsberry, Russell (Emeritus)
Meteorology

Euske, Kenneth (Emeritus)
Business and Public Policy

Fuhs, Allen (Emeritus)
Mechanical and Aerospace Engineering

Giet, George (Emeritus)

Electrical and Computer Engineering

Giraldo, Francis
Mathematics

Haderlie, Eugene (Emeritus)
Oceanography

Haegel, Nancy
Physics

Healey, Anthony (Emeritus)
Mechanical and Aerospace Engineering

Irvine, Cynthia E.
Computer Science

Jacobs, Patricia A.
Operations Research

Karunasiri, Gamani
Physics

Kinney, Gilbert
Physics

Kress, Moshe
Operations Research

Kwon, Young W.
Mechanical and Aerospace Engineering

Loomis, Jr., Herschel H. (Emeritus)
Electrical and Computer Engineering

Looney, Robert (Emeritus)
National Security Affairs

Marshall, Kneale (Emeritus)
Operations Research

Marto, Paul (Emeritus)
Mechanical and Aerospace Engineering

McEachen II, John
Electrical and Computer Engineering

McNelley, Terry (Emeritus)
Mechanical and Aerospace Engineering

Montgomery, Michael T.
Meteorology

Morgan, Michael (Emeritus)
Electrical and Computer Engineering

Netzer, David (Emeritus)
Mechanical and Aerospace Engineering

Owen, Guillermo (Emeritus)
Mathematics

Pace, Phillip (Emeritus)
Electrical and Computer Engineering

Platzer, Max (Emeritus)
Mechanical and Aerospace Engineering

Porch, Douglas (Emeritus)
National Security Affairs

Powers, John (Emeritus)
Electrical and Computer Engineering

Renard, Robert (Emeritus)
Meteorology

Ross, Michael
Mechanical and Aerospace Engineering

Sanchez, Susan
Operations Research

Sarpkaya, Turgut (Emeritus)
Mechanical and Aerospace Engineering

Schrady, Dave (Emeritus)
Operations Research

Shin, Young (Emeritus)
Mechanical and Aerospace Engineering

Thornton, Edward (Emeritus)
Oceanography

Washburn, Alan (Emeritus)
Operations Research

Whitcomb, Clifford
Systems Engineering

Wood, R. Kevin (Emeritus)
Operations Research

Yakimenko, Oleg
Systems Engineering

Yost, David S. (Emeritus)
National Security Affairs

Yun, Xiaoping
Electrical Engineering

Academic Organization

The Naval Postgraduate School has several academic departments as well as research and education institutes and centers. Institutes and centers provide groups of faculty an additional structure for collaborative and interdisciplinary teaching and research activities. The Naval Postgraduate School also has a number of interdisciplinary committees and groups that oversee and advise education programs.

Departments

Applied Mathematics
Computer Science
Defense Analysis
Defense Management
Electrical and Computer Engineering
Information Sciences
Meteorology
Mechanical and Aerospace Engineering
National Security Affairs
Oceanography
Operations Research
Physics
Systems Engineering

Groups and Committees

Cyber Academic Group
Data Science and Analytics Academic Group
Energy Academic Group
Engineering Acoustics Academic Committee
Space Systems Academic Group
Undersea Warfare Academic Group

Institutes and Centers

Center for Executive Education
Center for Homeland Defense and Security

Graduate Writing Center

The mission of the Graduate Writing Center (GWC) is to develop the writing and critical thinking skills of NPS students for success in graduate school and as military and civilian leaders. It does so by providing: one-on-one coaching with resident and distance learning students in 30- to 60-minute appointments using the students' coursework and thesis proposals and chapters; hands-on workshops offered in the first four weeks of each quarter and in regular classes; a *Foundations of Academic Writing* presentation for new students; weekly write-ins for time to make progress on a paper or thesis; online reference materials for self-paced learning; and confidential plagiarism checks on drafts to help students learn how to provide appropriate source attribution.

The GWC supports students wherever they are in their writing and academic programs. Writing-specific instruction covers the writing process, brainstorming, overcoming writer's block, organization, argumentation, drafting, revising, editing, attribution norms and rules, writing about figures and tables, technical writing, grammar and punctuation, style, clarity, concision, and accuracy. Writing coaches, workshop instructors, and online materials also cover reading actively and critically, note-taking, academic presentations, designing graphics and research posters, time management, the advisor-advisee relationship, and publishing.

The GWC's Learning Tools webpage provides a starting point for information that helps students optimize their learning environments and manage personal challenges that affect learning and mission completion. Topics include the importance of sleep and a healthy lifestyle, support networks, learning styles, English as a second language, and reasonable accommodation.

For more information, please visit https://nps.edu/web/gwc.

Information Technology and Communications Services

The ITACS (Information Technology and Communications Services) organization incorporates all communication services, telephone support, and network support into the core computing functions that have been provided by the Naval Postgraduate School since 1953. For more information, please visit https://www.nps.edu/Technology.

International Graduate Programs Office

The International Graduate Programs Office is responsible for the cultural, social and academic integration of the international community. The office is charged with interacting with outside agencies, military and civilian to accomplish the goals of the Joint Security Cooperation Education and Training (JSCET) Program and the Field Studies Program (FSP). Additionally, it is responsible for the International Sponsor Program and acts as the Command Sponsor to the International Executive Committee. It also serves as the Admissions Office for sponsored international applicants.

Since 1954, over 6697 International officers and government sponsored civilians from over 126 countries have graduated from NPS. Many have gone on to achieve positions of prominence within their military services, governments, and private industry. The International Program at NPS serves as an integral link in establishing the long-term military-to-military relationships between our U.S. and international officers. The International Graduate Programs Office sponsors the following courses:

IT1500 Informational Program Seminar for International Officers (4-0)
Provides international students with an awareness and functional understanding of internationally recognized human rights and the American democratic way of life. Areas of emphasis introduced during the seminar include civil-military relations, human rights, relationships in a democratic society, and a comparative look at the U.S. free enterprise system.

IT1600 Communication Skills for International Officers (3-0)
Provides the opportunity to enhance English speaking and listening skills for professional and academic environments through exercises, group discussions, and instructional briefings on a variety of subjects. The course addresses pronunciation, fluency, idiomatic usage, cultural conventions, and language functions by incorporating texts, videos, and realia to improve collaborative interaction. Building reading and writing skills is part of the course but not the main focus.

IT1700 Academic Writing for International Officers (3-0)
Prepares international students for the task of writing a research papers and/or thesis for an American institution of higher-education. A vigorous dedication to the writing process (pre-writing, writing, revision, and proofing) is required. The course covers the rhetorical considerations and styles of academic writing by examining appropriate organization, content, audience consideration, voice, and source citation in anticipation of degree coursework. Analysis and discussion of sample articles and essays from a variety of sources are important elements supporting skills development. Students should expect to devote up to six (6) non-instructional hours each week completing assignments.

The point of contact for requests to the International Graduate Programs office is:

Danial Pick, COL, USA (Ret)
Director, International Graduate Programs Office
Commercial: (831) 656-2186

DSN 756-2186
Fax: (831) 656-3064
Website: https://nps.edu/web/igpo

International Student Admission

Military officers and government civilian employees from other countries may be admitted to most curricula. The procedures for application are available from the Security Assistance Office or Defense Attaché Office of the U.S. Embassy, the MLO, MAAG, OMC, OSC, or ODC, as appropriate. Correspondence must be processed through official channels; requests from individual prospective students should not be sent directly to the School.

All candidates must satisfy the curriculum academic standards, as described in this catalog. International candidates from non-English speaking countries will also be required to validate their fluency in English through the Test of English as a Foreign Language (TOEFL). Minimum TOEFL score required for direct entry to NPS is 83 IBT (Internet Based Test) or 560 (Written Test). Candidates for PhD Programs or Accelerated Programs need to score at least 100 on the IBT. Waivers will be considered on a case by case basis for scores between 90 and 100 based on the overall application package. (For candidates applying for entry into the Department of National Security Affairs curricula 681-693, an IBT score of 90 is required.) If a candidate fails to achieve the 83 IBT or 560 Written score, but does achieve a score of 70 IBT or 523 Written or higher, he/she is eligible to attend the TOEFL Preparatory Academic Writing Course, ADVANCED LANGUAGE PROFICIENCY III, MASL P177022 (16 weeks) at the Defense Language Institute, DLIELC in San Antonio, Texas.

The only countries exempted from TOEFL testing are those countries who are exempted from all ECL testing requirements as determined by the Defense Security Cooperation Agency (DSCA) Policy memorandum dtd January 2022 (Antigua, Australia, Bahamas, Barbados, Belgium, Belize, Brunei, Canada, Denmark, Dominica, Finland, Grenada, Guyana, India, Ireland, Jamaica, Malta, Mauritius, Netherlands, New Zealand, Norway, Seychelles, Singapore, St. Kitts, St. Lucia, St. Vincent, Sweden, Trinidad and Tobago, and the United Kingdom). Note: Students from Austria, Germany, Kenya, Pakistan, and Switzerland scheduled for senior PME courses, including NPS, are also exempt from all in-country and CONUS ECL, TOEFL, and OPI testing.

When applying for a TOEFL exam, the NPS identification code is 4831. This code should be included on the registration application so a copy of the results can be

sent directly to NPS. TOEFL test results are valid for two years from the test date and must be valid when the student reports to NPS. Questions regarding available programs or admission procedures should be directed to Code 940, 1 University Circle, Rm B-047, Naval Postgraduate School, Monterey, CA 93943-5025. Telephone: (831) 656-2186 or e-mail: IMSO_NPS_IGPO@nps.edu.

Library

Dudley Knox Library (DKL) contributes to teaching, learning, and research—anytime and anywhere—through relevant and evolving collections, tools, services, and spaces. The Library provides the NPS community, locally and remotely, with access to purchased, licensed and open-access academic resources, restricted documents (to SECRET), and NPS-authored content. A tailored mix of library services are delivered by friendly, knowledgeable staff and supported by intuitive, seamless technology interfaces. We also provide individual and collaborative group study, research and learning spaces.

The Library website is the gateway to a variety of curated scholarly resources and information including print and electronic books and journals, academic databases, media and maps, NPS dissertations/theses/reports, faculty publications, NPS and Hotel Del Monte history, and much more. Off-campus remote access to licensed e-resources is available to authorized users 24 hours a day, 7 days a week. Through inter-library loan, the NPS community can also request materials from other libraries with many of these items delivered digitally to a website portal, accessible 24/7.

Librarians have created topical bibliographies, instructional tutorials, and research guides pertinent to the education, research and national defense needs of NPS faculty, students (resident and distance learners), and staff. They offer workshops on how to use the library and other resources for research and thesis work, attribution, and citation-management programs, as well as personalized individual and group research instruction.

The Library is a selective depository for government documents and information distributed through the Federal Depository Program. Also located in the Dudley Knox Library (Bldg. 339) are the Graduate Writing Center and Thesis Processing Office, along with other academic services, and a Starbucks Coffee shop.

For more information, please visit http://library.nps.edu.

Thesis Processing Office

The mission of the Thesis Processing Office (TPO) is to help students become published authors of NPS theses, capstone reports, final project reports, and dissertations. The TPO works with each student or student team to

meet NPS formatting, style, citation, distribution marking, copyright, and department-approval requirements before their documents are released to the Dudley Knox Library and the Defense Technical Information Center for publication. The thesis processors maintain and facilitate use of the Thesis Module in Python, which allows increased visibility on work in progress, deadlines, requirements, and electronic routing for approval of thesis proposals and final drafts. Approximately 85 percent of theses are publicly releasable, while 12 percent are controlled but unclassified and 3 percent are classified. For more information, please visit https://nps.edu/web/thesisprocessing.

General Academic Information

Institutional Learning Objectives

All NPS master's degree programs provide graduate-level education to achieve these objectives:

Subject Matter Competence: Student demonstrates graduate-level knowledge and competencies in their academic field.

Methods and Technical Merit: Student demonstrates the ability to apply technical expertise and appropriate methodological rigor in conducting research and analysis.

Critical Thinking: Student demonstrates the ability to apply critical thinking and logical reasoning to research questions and to implement creative or innovative approaches to answer them.

Communication Skills: Student demonstrates proficiency in communicating and presenting the results of their inquiry and learning in written documents and/or oral presentations.

Defense Relevance: Student demonstrates the ability to apply education and learning to problems of relevance in the defense or national security community.

These general educational objectives reflect the core benefit from a graduate education: Knowledge, Competence, Critical Thinking, Communications – all applied in a Defense setting. NPS believes these core skills prepare officers to better fulfill all future assignments.

Degrees Conferred

Meeting the highest academic standards, the curricula are tailored to address defense and national security requirements and are developed within the framework of classical academic degrees.

For details, see Degree-Specific Requirements (p. 11).

Master
- Applied Computing
- Cost Estimating and Analysis
- Engineering Acoustics
- Human Systems Integration
- Operational Analysis (Warfare)
- Operational Modeling and Analysis
- Systems Analysis

Master of Arts
- Identity Management and Cyber Security
- Security Studies (Civil-Military Relations)

- Security Studies (Combating Terrorism: Policy and Strategy)
- Security Studies (East Asia and the Indo-Pacific)
- Security Studies (Europe and Eurasia)
- Security Studies (Homeland Security and Defense)
- Security Studies (Middle East, South Asia, Sub-Saharan Africa)
- Security Studies (Strategic Studies)
- Security Studies (Western Hemisphere)

Master of Engineering
- Computer Engineering
- Electrical Engineering
- Mechanical Engineering
- Aerospace Engineering
- Astronautical Engineering

Master of Science
- Aerospace Engineering
- Applied Cyber Operations
- Applied Design for Innovation
- Applied Mathematics
- Applied Modeling and Simulation in Healthcare
- Applied Physics
- Applied Science
- Applied Science (Acoustics)
- Applied Science (Operations Research)
- Applied Science (Physical Oceanography)
- Applied Science (Signal Processing)
- Astronautical Engineering*
- Combat Systems Technology
- Computer Engineering
- Computer Science
- Contract Management
- Cyber Systems and Operations
- Defense Analysis
- Defense Contract Management
- Defense Financial Management
- Defense Logistics Management
- Defense Program Management
- Electrical Engineering*
- Engineering Acoustics
- Engineering Science
- Engineering Science (Aerospace Engineering)
- Engineering Science (Astronautical Engineering)
- Engineering Science (Computer Engineering)
- Engineering Science (Electrical Engineering)
- Engineering Science (Mechanical Engineering)

- Engineering Systems
- Financial Management
- Human Systems Integration
- Information Strategy and Political Warfare
- Information Technology Management
- Information Warfare Systems Engineering
- Leadership Education and Development
- Management
- Mechanical Engineering*
- Meteorology
- Meteorology and Physical Oceanography
- Modeling Virtual Environments and Simulation
- Network Operations and Technology
- Nuclear Operations
- Operations Research
- Physical Oceanography
- Physics
- Product Development
- Program Management
- Software Engineering
- Space Systems Operations
- Strategy (Nuclear Command, Control, and Communications)
- Strategy (Space Operations)
- Systems Engineering*
- Systems Engineering Analysis
- Systems Engineering Management

Master of Science in Engineering Science

- Electrical Engineering

Engineer

(Typically requires one year of study beyond the master's degree)

- Aerospace Engineer
- Astronautical Engineer
- Electrical Engineer
- Mechanical Engineer

Doctor of Philosophy

- Applied Mathematics
- Applied Physics
- Astronautical Engineering
- Computer Science
- Electrical Engineering
- Engineering Acoustics
- Information Sciences
- Mechanical Engineering
- Meteorology
- Modeling, Virtual Environments and Simulation
- Operations Research
- Physical Oceanography

- Security Studies
- Software Engineering
- Systems Engineering

*Apart from institutional accreditation, the former Graduate School of Engineering and Applied Science's Electrical, Mechanical, Systems and Astronautical Engineering degree programs are accredited by the Engineering Accreditation Committee (EAC) of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 – telephone: (410) 347-7700.

Institutional Requirements for Master of Arts and Master of Science Degrees

The master's degree may be awarded for successful completion of a curriculum, which has the approval of the Academic Council as meriting the degree. Such curricula shall conform to current practice in accredited institutions and shall contain a well-defined major.

General Naval Postgraduate School minimum requirements for the master's degree are as follows:

- 32 quarter-hours of graduate level credits of which at least 24 quarter-credits must be earned from NPS*.
- A thesis or its equivalent is required.

*NPS generally allows a maximum of 12 graduate-level, quarter-credits to be transferred for purposes of earning a graduate degree. However, an additional 12 quarter-credits may be transferred from the Air Force Institute of Technology (AFIT) in Dayton, Ohio. This is in addition to the normal transfer allowed (12), bringing the total to a maximum of 24 quarter-credits transferable from AFIT to NPS. Permission to transfer a specific course to serve as a substitute for a degree requirement will be determined by the Department Chairman or equivalent person responsible for nominating candidates for degrees at NPS and must be pre-approved in a coherent plan of study for the student. Regardless of transfer credits allowed, all NPS master's degrees still require at least 24 quarter-credits be earned directly from NPS.

To be eligible for the master's degree, the student must attain a minimum average quality point rating of 3.00 in all of the 3000 and 4000 level courses in his/her curriculum a 2.75 in all courses of the curriculum.

Degree-Specific Requirements

Master's Degrees

Master of Applied Computing

1. Completion within five years (per NPS APM) of three or four NPS certificates, all but one of which must be managed by the CS Department. New certificates will be eligible for inclusion, subject to approval by CS Department.

2. Minimum 44 graduate credit hours (per NPS APM), at least 20 hours of which are from CS, MV, or SW courses.

3. A minimum of 12 4000-level credit hours from CS, MV, or SW courses.

4. (Optional) At the preference of certain sponsors, a capstone project may be completed with three CS4920 "Advanced Topics in CS" or similar courses, as equivalent to the fourth required certificate.

Master of Arts in Identity Management and Cyber Security

1. At least 40 quarter-hours of graduate-level work, per NPS requirements.

2. Completion of the specific sequence of courses satisfying the breadth and subject matter requirements of Identity Management and Cyber Security.

3. Completion of an applications project.

Master of Arts in Security Studies

1. Total required credit hours will vary between 48-80 depending on students' length of program.

2. The completion of an approved sequence of graduate courses, including at least three courses at the 4000 level, in one of the following curricula: Strategic Studies, Civil-Military Relations, Homeland Security and Defense, Combating Terrorism, or Area Studies (Middle East, South Asia and Sub-Saharan Africa; East Asia and the Indo-Pacific; Europe and Eurasia; Western Hemisphere).

3. Successful completion of departmental comprehensive examination or completion of an acceptable thesis.

4. Depending on the curriculum, thesis research may be substituted by a combination of a comprehensive exam and the successful completion of a foreign language program at the Defense Language Institute.

Master of Cost Estimating and Analysis

1. Completion of a minimum of 40 quarter-hours of graduate-level courses with:

2. At least 15 quarter-hours of 4000-level courses.

3. Cost Estimating and Analysis core courses and a series of supporting courses in Probability, Statistics, Defense Acquisition, Financial Management, and Systems Engineering, all of which are set in a matrix approved by the Chairman, Department of Operations Research.

4. Students are required to demonstrate mastery of Cost Estimating and Analysis practice through satisfactory completion of a Capstone Project approved by the Chairman, Department of Operations Research. The quarter-hours earned in the Capstone project are applied towards satisfying the minimum graduate level quarter-hours for the degree.

Master of Computing Technology

1. At least 40 quarter-hours of graduate-level work, of which at least 12 quarter-hours must be at the 4000 level.

2. Completion of an approved sequence of courses constituting specialization in an area of computing technology.

3. Completion of a capstone paper.

Master of Engineering (Computer Engineering)

1. The Master of Engineering (Computer Engineering) is a course-based degree program for non-resident students enrolled in distance learning programs. Specific courses are required by the department.

2. Students must complete a minimum of 36 credit hours of graduate level course work which includes a minimum of four courses and 12 credit hours of 4000 level course work where at least three of the four 4000-level courses must be graded.

3. MEng (CE) degree programs must contain a minimum of eight courses in Electrical and Computer Engineering, Computer Science, or Software Engineering.

4. This degree program is quite flexible and can be designed with a focus tailored to meet distance learning customer requirements for work-force development.

Master of Engineering (Electrical Engineering)

1. The Master of Engineering (Electrical Engineering) is a course-based degree program for non-resident students enrolled in distance learning programs.

2. Students must complete a minimum of 32 credit hours of graduate level course work, which includes a minimum of 3 courses and 10 credit hours of 4000 level course work.

3. MEng (EE) degree programs must contain a minimum of 5 courses in electrical and computer engineering.

4. This degree program is quite flexible and can be designed with a focus tailored to meet distance learning customer requirements for work-force development.

Master of Engineering (Mechanical Engineering)

Master of Engineering (Astronautical Engineering)

Master of Engineering (Aerospace Engineering)

The MEng {ME, Astro or Aero} degree requires the following:

1. A minimum of 44 quarter-hours of graduate level engineering coursework.
   a. Technical Depth: A minimum of 16 quarter-hours of advanced-level technical depth coursework in a single focus area, with at least 8 quarter-hours at the 4000-level.

2. Before commencing the program, candidates must create their plan-of-study to satisfy the degree requirements and obtain approval from the relevant Academic Associate, Program Officer, and Department Chair. Any subsequent modifications to the plan-of-study must also receive approval from the Academic Associate.

3. Optional Capstone: The plan-of-study may contain a

culminating major engineering design experience. This option should be included in as appropriate capstone coursework and must satisfy the ABET EAC baccalaureate criteria for the experience that 1) incorporates appropriate engineering standards and multiple constraints, and 2) is based on the knowledge and skills acquired in earlier course work.

4. Due to the accelerated nature of the program, candidates are required to have completed post-secondary educational and professional experiences that align with the ABET Criteria for Accrediting Engineering Programs, General Criteria for Stand-Alone Master's Level Programs, Criterion MS1. If the student has graduated from an EAC of ABET accredited baccalaureate program, then the presumption is that these prerequisites/ corequisites have been satisfied.

Master of Engineering Acoustics

1. A minimum of 32 graduate credit quarter-hours of course work of which at least 20 must be taken in acoustics and its applications.
2. At least three 4000 level courses from any three of the following six areas: wave propagation; transducer theory and design; noise, shock, and vibration control; sonar systems; signal processing; and communications. These courses must include at least one from each of the sponsoring disciplines (physics and electrical engineering).
3. Completion of an acceptable one-quarter capstone project advised by a member of the Electrical and Computer Engineering or Physics Departments.

Master of Human Systems Integration

1. Completion of a minimum of 40 quarter-hours of graduate-level courses with:
2. At least 20 quarter-hours of 4000-level courses
3. Human Systems Integration core courses and a series of supporting courses, including coursework in HSI domains, Systems Engineering, Defense Acquisition, Cost Estimation, and Probability and Statistics, all of which are set in a matrix approved by the Chairman, Department of Operations Research.
4. Students are required to demonstrate mastery of Human Systems Integration practice through satisfactory completion of a two-quarter capstone project approved by the Chairman, Department of Operations Research. The quarter-hours earned in the Capstone project are applied towards satisfying the minimum graduate level quarter-hours for the degree.

Master of Operational Modeling and Analysis

1. Completion of a minimum of 40 quarter-hours of graduate-level courses with:
2. At least 20 quarter-hours of 4000-level courses, of which at least 16 are OA.
3. An operational modeling and analysis sequence approved by the Chairman, Department of Operations Research.

4. Completion of an acceptable capstone project on a subject previously approved by the Chairman, Department of Operations Research.

Master of Science in Aerospace Engineering

1. A minimum of 48 quarter-hours of graduate level work.
2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:
   a. There must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.
   b. Of the 32 quarter-hours, at least 24 quarter-hours must be in courses offered by the MAE Department.
3. A student must demonstrate knowledge of aerodynamics, aircraft stability and control, avionics, aircraft structures, aircraft and missile propulsion.
4. The student must also demonstrate competence at the advanced level in one of the above disciplines of Aeronautical Engineering. This may be accomplished by completing at least eight quarter-hours of the 4000 level credits by courses in this department and a thesis in the same discipline area. The typical specialization track is in Aircraft Structures, Aerodynamics, Stability and Control, Avionics or Propulsion.
5. An acceptable, individually-authored thesis for a minimum of 16 credits is also required. The student's thesis advisor, the Academic Associate, the Program Officer, and the Department Chairman must approve the study program and the Thesis Proposal.

Master of Science in Applied Cyber Operations

1. All required courses must be satisfied through the course of study or through validation prior to graduation.
2. Completion of a minimum of 40 quarter-hours of graduate-level courses.
3. At least 12 quarter-hours of courses must be at the 4000 level.
4. To ensure a sufficient breadth in operational understanding of the cyber domain, the following course topics must be satisfied as part of the course of study or through validation prior to graduation:
   a. Introduction to Cyber Systems and Operations (CY3000) or Command and Control (CC3000),
   b. Introduction to Computer Security (CS3600),
   c. One of Cyber Network & Physical Infrastructures (EC3730, Reverse Engineering (EC3740), or Information Operations Systems (EC3760),
   d. Applied Defensive Cyber Operations (CY4700) or Adversarial Cyber Operations (CY4710).
5. Completion of a specialization track.
6. Submission of an acceptable capstone project on a subject previously approved by the Information Sciences Department Chair.

Master of Science in Applied Design for Innovation

1. This degree requires 45 quarter-hours of graduate-level work, of which 15 hours must represent courses at the 4000 level.
2. In addition to the 45 hours of course credit, an acceptable thesis or capstone project must be completed.
3. Approval of the candidate's program by the Chair, Department of Defense Analysis.

Master of Science in Applied Mathematics

1. A minimum of 32 quarter-hours of graduate-level (3000-4000 numbered) courses with a minimum QPR of 3.0. The program specifications must be approved by the Chairman of the Department of Applied Mathematics and the Academic Associate.
2. A student must complete or validate the four 1000 level calculus sequence and the introductory courses in linear algebra and discrete mathematics.
3. The program must include at least 16 hours in 3000 level mathematics courses and 16 hours of approved 4000 level mathematics courses.
4. Courses in Ordinary Differential Equations, Real Analysis, and upper division Discrete Mathematics are specifically required, and those at the 3000 level or above may be applied toward requirement (2).
5. An acceptable thesis is required. The Department of Applied Mathematics permits any student pursuing a dual degree to write a single thesis meeting the requirements of both departments, subject to the approval of the Chairmen and Academic Associates of both departments.

Master of Science in Applied Physics

1. At least 32 quarter-hours of graduate level courses in physics, mathematics, and engineering including 20 at the 4000 level. Of these 32 hours, at least 20 will be physics courses including 12 at the 4000 level.
2. At least one graduate level course in each of the following areas: mechanics, electromagnetism, and quantum physics.
3. An area of concentration containing a four-course sequence of graduate-level courses in addition to the above requirements, at least two at the 4000 level, in an area related to applied physics.
4. An acceptable thesis advised or co-advised by a member of the Physics Department.

Master of Science in Applied Science (Acoustics), (Operations Research), (Physical Oceanography), or (Signal Processing)

1. A minimum of 32 quarter-hours of graduate level courses relevant to undersea warfare, including at least 20 hours to satisfy a major from either the Physics Department (Acoustics), Operations Research Department (Operations Research), Oceanography Department (Physical Oceanography), or Electrical and Computer Engineering Department (Signal Processing).
2. A sequence of at least 12 hours of graduate level courses representing a specialization in some area other than that of the major.
3. At least 12 hours of coursework at the 4000 level.
4. An acceptable thesis advised or co-advised by a member of the department.

Master of Science in Astronautical Engineering

1. A minimum of 48 quarter-hours of graduate level work.
2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:
   a. There must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.
   b. Of the 32 quarter-hours, at least 24 quarter-hours must be in courses offered by the MAE Department.
3. A student must demonstrate knowledge of orbital mechanics, attitude determination, guidance and control, telecommunications, space structures, spacecraft rocket propulsion, space power, spacecraft thermal control, and spacecraft design and testing.
4. The student must also demonstrate competence at the advanced level in one of the above disciplines of Astronautical Engineering. This may be accomplished by completing at least eight quarter-hours of the 4000 level credits by courses in this Department in a particular area and a thesis in the same discipline area. The typical specialization track is in Structures, Dynamics, and Control, and requires two (2) non-design AE48XX courses.
5. An acceptable, individually-authored thesis for a minimum of 16 credits is also required. The student's thesis advisor, the Academic Associate, the Program Officer, and the Department Chairman must approve the study program and the Thesis Proposal.

Master of Science in Combat Systems Technology

1. A minimum of 32 quarter-hours of graduate work in physics, mathematics, and engineering, with at least 18 quarter-hours at the 4000 level. Included in these hours must be at least 20 quarter-hours of graduate-level physics, including 12 quarter-hours at the 4000 level.
2. Two approved sequences of courses related to combat systems technology. Each sequence must consist of at least four graduate-level courses with at least two courses at the 4000 level. A list of approved sequences is available from the Chairman.
3. A thesis advised or coadvised by a member of the Physics Department.

The Master of Science in Computer Engineering

1. A minimum of 52 credits of graduate level work, of which at least 24 credits must be in Electrical and Computer Engineering, Computer Science, or Software Engineering.

2. Specific courses are required by the department, and at least four courses that total a minimum of 12 credits must be in the course sequence 4000-4999.

3. An acceptable thesis for a minimum of 16 credits must be presented to, and approved by, the department.

Master of Science in Computer Science

1. At least 40 quarter hours of graduate-level work, of which at least 12 quarter hours must be at the 4000 lev-el.

2. At least 28 of the 40 graduate-level credit hours listed above must be CS, MOVES, and SW courses.

3. To ensure a sufficient breadth across the field of Computer Science, the following course topics must be satisfied as part of the course of study or through validation prior to graduation: Artificial Intelligence (CS3310), Networks (CS3502), Automata (CS3101), and Introduction to Computer Security (CS3600).

4. Completion of an approved sequence of courses constituting specialization in an area of computer science.

5. Completion of an acceptable thesis or a capstone project.

Master of Science in Contract Management

1. Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 that are at the 4000 level. (Credit hour requirement does not include 4 hours assigned for the capstone applied project.)

2. Completion of an acceptable capstone applied project, with at least one advisor from the Department of Defense Management.

3. Approval of the candidate's program by the Chair, Department of Defense Management.

Master of Science in Cyber Systems and Operations

1. All courses must be satisfied through the course of study or through validation prior to graduation.

2. Completion of a minimum of 40 quarter-hours of graduate-level courses, of which at least 16 quarter hours are CY4000-level courses.

3. To ensure a sufficient breadth in operational under-standing of the cyber domain, the following course topics must be satisfied as part of the course of study or through validation prior to graduation: Cyber Policy and Strategy (CY4410), Network Operations in a Con-tested Environment (CY4600) or Information Operations Systems (EC3760), Cyber Wargame: Defensive Cyberspace Operations (CY4700), Cyber Wargame: Red Force Operations (4710).

4. Minimum degree requirements of the NPS must be met.

5. Completion of an acceptable thesis or capstone project on a subject previously approved by the Chair, Cyber Academic Group.

Master of Science in Defense Analysis

1. This degree requires 45 quarter-hours of graduate-level work, of which 15 hours must represent courses at the 4000 level in at least two disciplines. Within the course program there must be a specialization sequence consisting of at least six courses.

2. In addition to the 45 hours of course credit, an acceptable thesis or capstone project must be completed.

Master of Science in Defense Contract Management

1. Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 which are at the 4000 level.

2. Completion of an acceptable capstone applied project, with at least one advisor from the Department of Defense Management.

3. Approval of the candidate's program by the Chair, Department of Defense Management.

Master of Science in Defense Financial Management

1. Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 which are at the 4000 level.

2. Completion of an acceptable capstone applied project, with at least one advisor from the Department of Defense Management.

3. Approval of the candidate's program by the Chair, Department of Defense Management.

Master of Science in Defense Logistics Management

1. Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 which are at the 4000 level.

2. Completion of an acceptable capstone applied project, with at least one advisor from the Department of Defense Management.

3. Approval of the candidate's program by the Chair, Department of Defense Management.

Master of Science in Defense Program Management

1. Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 which are at the 4000 level.

2. Completion of an acceptable capstone applied project, with at least one advisor from the Department of Defense Management.

3. Approval of the candidate's program by the Chair, Department of Defense Management.

Master of Science in Electrical Engineering

1. A minimum of 52 credit hours of graduate level work.

2. There must be a minimum of 36 credits in the course sequence 3000-4999, of which at least 30 credits must be in Electrical and Computer Engineering. The remainder of these 36 credits must be in engineering, mathematics, physical science, and/or computer science.

3. Specific courses may be required by the department and at least four courses that total a minimum of 12

credits, must be in the course sequence 4000-4999.

4. An acceptable thesis for a minimum of 16 credits must be presented to, and approved by, the department.

Master of Science in Electronic Warfare Systems Engineering

1. Completion of a minimum of 45 quarter-hours of graduate-level work, of which at least 15 hours must represent courses at the 4000 level, and in two (or more) discrete disciplines.
2. Graduate courses in at least four discrete academic specialization sequences, minimum, and in two disciplines, a course at the 4000 level must be included.
3. One Systems Engineering class.
4. In addition to the 45 graduate hours of course work, an acceptable thesis must be completed.

Master of Science in Engineering Acoustics

1. A minimum of 32 graduate credit quarter-hours of course work of which at least 20 must be taken in acoustics and its applications.
2. At least three 4000 level courses from any three of the following six areas: wave propagation; transducer theory and design; noise, shock, and vibration control; sonar systems; signal processing; and communications. These courses must include at least one from each of the sponsoring disciplines (physics and electrical engineering).
3. Completion of an acceptable thesis on a topic approved by the Engineering Acoustics Academic Committee.

Master of Science in Engineering Science (Aerospace Engineering)

1. A minimum of 48 quarter-hours of graduate level work.
2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:
   a. There must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.
   b. Of the 32 quarter-hours, at least 24 quarter-hours must be in courses offered by the MAE Department.
3. A student must demonstrate knowledge of aerodynamics, aircraft stability and control, avionics, aircraft structures, aircraft and missile propulsion.
4. The student must also demonstrate competence at the advanced level in one of the above disciplines of Aeronautical Engineering. This may be accomplished by completing at least eight quarter-hours of the 4000 level credits by courses in this department and a thesis in the same discipline area. The typical specialization track is in Aircraft Structures, Aerodynamics, Stability and Control, Avionics or Propulsion.
5. An acceptable, individually-authored thesis for a minimum of 16 credits is also required. The student's thesis advisor, the Academic Associate, the Program Officer, and the Department Chairman must approve the study program and the Thesis Proposal.

Master of Science in Engineering Science (Astronautical Engineering)

1. A minimum of 48 quarter-hours of graduate level work.
2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:
   a. There must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.
   b. Of the 32 quarter-hours, at least 24 quarter-hours must be in courses offered by the MAE Department.
3. A student must demonstrate knowledge of orbital mechanics, attitude determination, guidance and control, telecommunications, space structures, spacecraft/rocket propulsion, space power, spacecraft thermal control, and spacecraft design and testing.
4. The student must also demonstrate competence at the advanced level in one of the above disciplines of Astronautical Engineering. This may be accomplished by completing at least eight quarter-hours of the 4000 level credits by courses in this department and a thesis in the same discipline area. The typical specialization track is in Structures, Dynamics, and Control, and requires two (2) non-design AE48XX courses.
5. An acceptable, individually-authored thesis for a minimum of 16 credits is also required. The student's thesis advisor, the Academic Associate, the Program Officer, and the Department Chairman must approve the study program and the Thesis Proposal.

Master of Science in Engineering Science (Computer Engineering)

1. A minimum of 52 credit hours of graduate level work.
2. There must be a minimum of 36 credits in the course sequence 3000-4999, of which at least 24 credits must be in Electrical and Computer Engineering, Computer Science, or Software Engineering.
3. Specific courses are required by the department, and at least four courses that total a minimum of 12 credits must be in the course sequence 4000-4999.
4. An acceptable thesis for a minimum of 16 credits must be presented to, and approved by, the department.

Master of Science Engineering Science (Electrical Engineering)

1. A student needs a minimum of 52 credit hours of graduate-level work.
2. There must be a minimum of 36 credits in the course sequence 3000-4999, of which at least 30 credits must be in Electrical and Computer Engineering. The remainder of these 36 credits must be in engineering, mathematics, physical science, and/or computer science.
3. Specific courses may be required by the department and at least four courses that total a minimum of 12

credits, must be in the course sequence 4000-4999.

4. An acceptable thesis for a minimum of 16 credits must be presented to, and approved by, the department.

Master of Science in Engineering Science (Mechanical Engineering)

1. A minimum of 48 quarter-hours of graduate level work.
2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:
   a. There must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.
   b. Of the 32 quarter-hours, at least 24 quarter-hours must be in courses offered by the MAE Department.
3. The candidate must demonstrate competence at the advanced level in at least one of the available disciplines of Mechanical Engineering. These disciplines are the thermal-fluid sciences; solid mechanics, shock and vibration; dynamic systems and control; system design; and materials science. This is accomplished by completing at least eight quarter-hours of the 4000 level credits by courses within one discipline, and a thesis in this same discipline.
4. An acceptable, individually-authored thesis for a minimum of 16 credits is also required for the Master of Science in Engineering Science (Mechanical Engineering) degree.
5. The student's thesis advisor, the Academic Associate, the Program Officer, and the Department Chairman must approve the study program and the thesis topic.

Master of Science in Engineering Systems

1. A minimum of 48 quarter-hours of graduate level work.
2. The candidate must take all courses in an approved study program, which must satisfy the following requirements: There must be a minimum of 36 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 16 quarter-hours at the 4000 level. The course work must include the four core SE courses.
3. The candidate must complete either a 12-hour equivalent team systems engineering project or an individual thesis.

Master of Science in Financial Management

1. Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 which are at the 4000 level.
2. Completion of an acceptable capstone applied project, with at least one advisor from the Department of Defense Management.
3. Approval of the candidate's program by the Chair, Department of Defense Management.

Master of Science in Human Systems Integration

1. Completion of a minimum of 40 quarter-hours of graduate-level courses with:

2. At least 20 quarter-hours of 4000 level courses.
3. An elective sequence approved by the Chairman, Department of Operations Research.
4. Submission of an acceptable thesis on a subject previously approved by the Chairman, Department of Operations Research.

Master of Science in Information Strategy and Political Warfare

1. This degree requires 45 quarter-hours of graduate-level work, of which 15 hours must represent courses at the 4000 level.
2. Completion of an acceptable thesis or capstone project.

Master of Science in Information Technology Management

1. Completion or validation of core courses in each of the following disciplines: Information Systems, Computer Science, Electrical and Computer Engineering, and Systems Management.
2. Completion of a minimum of 52 hours of graduate-level courses, at least 20 hours of which are at the 4000 level.
3. Completion of an acceptable thesis.

Master of Science in Information Warfare Systems Engineering

1. Completion of a minimum of 45 quarter-hours of graduate-level work, of which at least 15 hours must represent courses at the 4000 level, and in two (or more) discrete disciplines.
2. Graduate courses in at least four discrete academic specialization sequences, minimum, and in two disciplines, a course at the 4000 level must be included.
3. One Systems Engineering class.
4. In addition to the 45 graduate hours of course work, an acceptable thesis must be completed.

Master of Science in Management

1. Completion of a minimum of 48 hours of graduate-level courses, at least 12 hours of which are at the 4000 level.
2. Completion or validation of the Management Fundamentals program, which consists of a total of 32 quarter-hours of 2000 and 3000 level courses, including a minimum of the following hours by discipline:
3. Accounting and Financial Management (6)
4. Economics (6)
5. Organization and Management (6)
6. Quantitative Methods (8)
7. Completion of an approved sequence of courses in the student's area of concentration.
8. Completion of an acceptable thesis.
9. Approval of the candidate's program by the Chair, DDM.

Master of Science in Mechanical Engineering

1. A minimum of 48 quarter-hours of graduate level work.
2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:
   a. There must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a mini-mum of 12 quarter-hours at the 4000 level.
   b. Of the 32 quarter-hours at least 24 quarter-hours must be in courses offered by the MAE Department.
3. The candidate must demonstrate competence at the advanced level in at least one of the available disciplines of Mechanical Engineering. These disciplines are the thermal-fluid sciences; solid mechanics, shock and vibration; dynamic systems and control; system design; and materials science. This is accomplished by completing at least eight quarter-hours of the 4000 level credits by courses within one discipline, and a thesis in the same discipline.
4. An acceptable, individually-authored thesis for a minimum of 16 credits is also required for the Master of Science degree in Mechanical Engineering. An acceptable thesis for the degree of Mechanical Engineer may also meet the thesis requirement of the Master of Science in Mechanical Engineering degree.
5. The student's thesis advisor, the Academic Associate, the Program Officer and the Department Chairman must approve the study program and the thesis topic.

Master of Science in Meteorology

1. Necessary prerequisite courses in mathematics (through partial differential equations) and meteorology,
2. The sequence of core courses in the fields of dynamical, numerical, physical and synoptic meteorology,
3. An approved selection of graduate elective courses,
4. An acceptable thesis.
5. The total number of quarter-hours in (2) and (3) above must be at least 36. These 36 hours must include 18 quarter-hours at the 4000 level in courses other than directed study.

Master of Science in Meteorology and Physical Oceanography

1. Necessary prerequisite courses in mathematics (through partial differential equations), meteorology, and physical oceanography,
2. The sequence of core courses in the fields of dynamical, numerical, physical and synoptic meteorology and oceanography,
3. An approved selection of graduate elective courses in meteorology and oceanography,
4. A significant educational experience in the field using instruments.
5. An acceptable thesis on a topic approved by the department.

6. The total number of quarter-hours in (2) and (3) above must be at least 48. These 48 hours must include 20 hours at the 4000 level in courses other than directed study, and they should show an approximate balance between the disciplines of meteorology and oceanography.

Master of Science in Modeling, Virtual Environments, and Simulation

1. At least 40 quarter-hours of graduate-level work, of which at least 12 quarter-hours must be at the 4000 level.
2. Completion of an approved sequence of courses constituting specialization in an area of Modeling, Virtual Environments, and Simulation.
3. Completion of an acceptable thesis in addition to the required course work.

Master of Science in Network Operations and Technology

1. Completion of a minimum of 36 quarter-hours of core graduate course work, of which 12 quarter hours must be at the 4000 level.
2. In addition to these 36 hours of core work, students must complete an approved specialization sequence of courses in one of the following areas:
3. Decision Superiority
4. Network Operations
5. Information Systems Management
6. Complete an acceptable thesis or research project approved by the Chairman, Information Sciences Department.

Master of Science in Operations Research

1. Completion of a minimum of 40 quarter-hours of graduate-level courses with:
2. At least 20 quarter-hours of 4000-level courses, of which at least 16 are OA.
3. An elective sequence approved by the Chairman, Department of Operations Research.
4. Submission of an acceptable thesis on a subject previously approved by the Chairman, Department of Operations Research.

Master of Science in Physical Oceanography

1. Completion of at least eight physical oceanography graduate courses with at least four courses in the OC4000 series. The sequence of core courses in physical oceanography encompasses the fields of dynamic, acoustical, and coastal/littoral oceanography. The entire sequence of courses selected must be approved by the Department of Oceanography. Significant experience in the field using instruments is required for the degree. (OC3570 satisfies this requirement).
2. At least 32 credit hours of approved graduate study, of which must include at least eight physical oceanography courses totaling 28 credit hours, and of the 28 credit hours at least 13.5 credit hours must be at

the 4000 level in courses other than directed study. Four credit hours of directed study or additional OC elective courses would count for the remainder of the degree requirements.

3. Completion of an acceptable thesis on a topic approved by the Department of Oceanography.

Master of Science in Physics

1. A minimum of 32 quarter-hours of courses at the graduate level.

2. A minimum of 30 quarter-hours of graduate level physics courses (not including thesis); of these 30 hours at least 15 must be at the 4000 level. Upon approval of the Chairman of the Physics Department, a maximum of 4 hours of courses taken in another department may be applied toward satisfying the total physics requirement. Students who are qualified to pursue graduate courses in physics when they arrive at the Naval Postgraduate School may complete a minimum of 20 hours entirely of 4000 level physics courses in place of the 30 quarter-hour physics requirement.

3. Successful completion of the following specific courses (or their equivalents): PH3152 Analytical Mechanics, PH3360 Electromagnetic Waves, PH3991 Theoretical Physics, PH3782 Thermodynamics and Statistical Physics, PH4353 Topics in Advanced Electricity and Magnetism, PH4656 Quantum Mechanics, plus a sequence of two graduate level physics courses, at least one of which must be at the 4000 level.

4. An acceptable thesis advised by a member of the Physics Department.

Master of Science in Product Development

1. A minimum of 48 quarter-hours of graduate level work.

2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:

3. There must be a minimum of 36 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 16 quarter-hours at the 4000 level.

4. The course work must include a four-course core in systems engineering methods.

5. Additional courses must be selected from an approved list.

6. The candidate must complete an approved thesis.

Master of Science in Program Management

1. Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 which are at the 4000 level.

2. Completion of an acceptable capstone applied project, with at least one advisor from the Department of Defense Management.

3. Approval of the candidate's program by the Chair, Department of Defense Management.

Master of Science in Software Engineering

1. At least 40 quarter-hours of graduate-level work, per NPS requirements, and within that 40 hours at least 12 graduate-level Software Engineering courses.

2. Completion of an acceptable thesis in addition to the required course work.

Master of Science in Space Systems Operations

1. A minimum of 32 quarter-hours of graduate level work is required, of which at least 15 hours must be at the 4000 level.

2. Graduate courses in at least four different subject areas must be included and in two areas, a course at the 4000 level must be included. There is also a requirement of three courses constituting advanced study in an area of specialization.

3. Each student is required to write a thesis that is space oriented.

4. The Chairman of the Space Systems Academic Group must approve all study programs.

Master of Science in Strategy (Nuclear Command, Control, and Communications)

1. A minimum of 60 combined graduate hours.

2. A minimum of 40 credit hours from the National Security Affairs Department.

3. A minimum of 12 credit hours from the Space Systems Academic Group, with specific requirements for a series of courses on either Nuclear Command, Control and Communications (curriculum 695) or Space Systems Operations (curriculum 696).

4. Completion of a minimum of three 4000-level courses.

5. Successful completion of an acceptable thesis combining strategy and technology.

Master of Science in Strategy (Space Operations)

1. A minimum of 60 combined graduate hours.

2. A minimum of 40 credit hours from the National Security Affairs Department.

3. A minimum of 12 credit hours from the Space Systems Academic Group, with specific requirements for a series of courses on either Nuclear Command, Control and Communications (curriculum 695) or Space Systems Operations (curriculum 696).

4. Completion of a minimum of three 4000-level courses.

5. Successful completion of an acceptable thesis combining strategy and technology.

Master of Science in Systems Engineering

1. An ABET EAC accredited Bachelor of Science degree in an engineering discipline or established equivalency.

2. Completion of an approved curriculum that includes:

3. A minimum of 36 quarter credit hours of 3000 and 4000 level courses, 16 of which must be at the 4000 level.

4. A series of courses in systems engineering defined by each curriculum.

5. Completion of a 12 quarter credit hour thesis course sequence and a thesis or a capstone project course

sequence and capstone project report, depending on curriculum requirements.

Master of Science in Systems Engineering Analysis

1. A minimum of 48 quarter-hours of graduate-level work.
2. The candidate must take all courses in an approved study program, which must also satisfy the following requirements:
3. A minimum of 36 quarter-hours of credit in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.
4. Participation in a capstone project with a minimum of 12 credits is required for the degree. An acceptable thesis, for a minimum of 12 credits, may be substituted in lieu of a team project. The Academic Associate and the Program Officer must endorse such a request, which will be subject to final approval by the Chair Professor.

Master of Science in Systems Engineering Management

An accredited Bachelor of Science or Bachelor of Arts degree.

1. Completion of an approved curriculum that includes:
   a. A minimum of 36 quarter credit hours of 3000 and 4000 level courses, 16 of which must be at the 4000 level.
   b. A series of courses in systems engineering defined by each curriculum.
2. Completion of a thesis course sequence and a thesis, or a capstone project course sequence and capstone project report, depending on curriculum requirements.

Master of Systems Analysis

1. Completion of a minimum of 32 quarter-hours of graduate-level courses with:
2. At least 16 quarter-hours of 4000-level courses.
3. Systems analysis core courses and a Systems Analysis context sequence approved by the Chairman, Department of Operations Research.
4. Students are required to demonstrate mastery of Systems Analysis practice through satisfactory completion of the thesis-equivalent three-course sequence in Systems Analysis Cases culminating in a final project approved by the Chairman, Department of Operations Research. The quarter-hours earned in the Systems Analysis Cases courses are applied towards satisfying the minimum graduate-level quarter-hours for the degree.

Engineer Degrees

Aerospace Engineer

1. A candidate must take all courses in a curriculum approved by the Chairman of the MAE Department.
2. The Aerospace Engineer degree requires at least 64 quarter-hours of graduate level credits in Aerospace Engineering or Mechanical Engineering, at least 32 of which must be at the 4000 level.

3. At least 12 quarter-hours of graduate level credits must be earned outside of the MAE Department (chair may waive, as needed). At least one advanced 4xxx Mathematics course should normally be included in these 12 quarter-hours.
4. An acceptable thesis of 28 credit hours is required for the Aerospace Engineer degree. Approval of the thesis advisor and program must be obtained from the Chairman of the MAE Department.

Astronautical Engineer

1. At least 64 quarter-hours of graduate level credits in Astronautical Engineering or Mechanical Engineering and Materials Science, at least 32 of which must be at the 4000 level.
2. At least 12 quarter-hours of graduate level credits must be earned outside of the MAE Department.
3. At least one advanced mathematics course should normally be included in these 12 quarter-hours.
4. An acceptable thesis of 28 credit hours is required for the Astronautical Engineer Degree. Approval of the thesis advisor and program must be obtained from the Chairman of the MAE Department.

Electrical Engineer

1. The EE degree program requires more course work and a more comprehensive thesis than a master's degree program but does not require the seminal research demanded in a Ph.D. program.
2. A minimum of 96 total graduate credits is required for the award of the engineer's degree, of which at least 24 must be in accepted thesis research, and at least 54 credits must be in Electrical and Computer Engineering courses.
3. At least 36 of the total hours are to be in courses in the sequence 4000-4999.
4. Approval of all programs must be obtained from the Chairman, Department of Electrical and Computer Engineering.

Mechanical Engineer

1. At least 64 quarter-hours of graduate level credits in Mechanical Engineering and Materials Science, at least 32 of which must be at the 4000 level.
2. At least 12 quarter-hours of graduate level credits must be earned outside of the MAE Department.
3. At least one advanced mathematics course should be included in these 12 quarter-hours.
4. An acceptable thesis of 28 credit hours is required for the Mechanical Engineer Degree. Approval of the thesis advisor and program must be obtained from the Chairman of the MAE Department.

Doctoral Degrees

Doctor of Philosophy in Aeronautical Engineering

Same as Doctor of Philosophy in Mechanical Engineering above.

Doctor of Philosophy in Applied Mathematics

The Department of Applied Mathematics offers the Doctor of Philosophy in Applied Mathematics degree. Areas of specialization will be determined by the department on a case by case basis. Requirements for the degree include course work followed by an examination in both major and minor fields of study, and research culminating in an approved dissertation. It may be possible for the dissertation research to be conducted off-campus in the candidate's sponsoring organization.

Doctor of Philosophy in Applied Physics

Same as above, but major in Applied Physics.

Doctor of Philosophy in Astronautical Engineering

Same as Doctor of Philosophy in Mechanical Engineering above.

Doctor of Philosophy in Computer Science

Specifics on the Ph.D. in Computer Science program are found in the linked CS Department Ph.D. Handbook.

Doctor of Philosophy in Electrical Engineering

The Department of Electrical and Computer Engineering has an active program leading to the Doctor of Philosophy degree. Joint programs with other departments are possible. A noteworthy feature of these programs is that the student's research may be conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the federal government. The degree requirements are as outlined under the general school requirements for the doctor's degree.

Doctor of Philosophy in Engineering Acoustics

The Department of Electrical and Computer Engineering and the Department of Physics jointly sponsor an interdisciplinary program in Engineering Acoustics leading to the Doctor of Philosophy degree. Areas of special strength in the departments are physical acoustics, underwater acoustics, acoustic signal processing, and acoustic communications. A noteworthy feature of this program is that a portion of the student's research may be conducted away from the Naval Postgraduate School at a cooperating laboratory or other federal government installation. The degree requirements and examinations are as outlined under the general school requirements for the doctorate degree. In addition to the school requirements, the departments require a preliminary examination to show evidence of acceptability as a doctoral student.

Doctor of Philosophy in Information Sciences

The Department offers the Ph.D. degree in Information Sciences. The program begins with advanced course work guided by the Departmental Ph.D. Committee, which leads to qualifying examinations. The primary emphasis then shifts to the student's research program, culminating in the Ph.D. dissertation. Three areas of primary concentration within the field of information sciences are available: information systems, command and control, and information operations/warfare.

Doctor of Philosophy in Mechanical Engineering

The Department offers Doctor of Philosophy (Ph.D.) degrees in Mechanical Engineering, Astronautical Engineering, and Aeronautical Engineering.

Every applicant who is accepted for the doctoral program will initially be enrolled in one of the following programs: Mechanical Engineer, Astronautical Engineer, or Aeronautical Engineer Program; under a special option which satisfies the broad departmental requirements for the Engineer's degree, which includes research work. As soon as feasible, the student must identify a faculty advisor to supervise research and to help formulate a plan for advanced study. As early as practicable thereafter, a doctoral commit-tee shall be appointed to oversee that student's individual doctoral program as provided in the school-wide requirements for the doctor's degree. Joint programs with other departments are possible.

Doctor of Philosophy in Meteorology

The Ph.D. program is offered in the Department of Meteorology in the following areas of study: numerical weather prediction, geophysical fluid dynamics, boundary-layer meteorology, analysis of atmospheric systems and tropical meteorology.

The requirements for the degree are grouped into three categories: course work, research in conjunction with an approved dissertation and examination in both the major and, if elected, a minor field. The minor field is usually in physical oceanography, mathematics or physics.

The Department of Meteorology also may require a preliminary examination to show evidence of acceptability as a doctoral student.

Doctorate in Modeling, Virtual Environments, and Simulation

The Ph.D. degree requires the equivalent of at least three academic years of study beyond the baccalaureate level (some of which may be for another post-baccalaureate degree), with at least one academic year (or its equivalent) being spent in residence at NPS. The student must complete, in order, the following steps, which are detailed at www.movesinstitute.org.

Doctor of Philosophy in Operations Research

The program begins with advanced course work guided by the student's doctoral committee and leading to qualifying examinations in optimization, statistics, and stochastic processes as well as completion of a minor field of study outside of operations research. The primary emphasis then shifts to the student's research pro-gram, culminating in the Ph.D. dissertation.

Doctor of Philosophy in Physical Oceanography

The Ph.D. program is in Physical Oceanography, including areas of study in ocean circulation theory, air-sea inter-action, ocean acoustics, nearshore, and coastal/littoral oceanography among others.

Doctor of Philosophy in Security Studies

The Ph.D. in Security Studies awarded by the Department of National Security Affairs requires one year of in-residence course work beyond the Master's plus at least two years to develop and execute a satisfactory dissertation. While the entirety of the dissertation need not be written in-residence, candidates for the Ph.D. should plan on a three-year tour, which is the norm for doctoral work at NPS.

Doctor of Philosophy in Software Engineering

The Ph.D. program in Software Engineering is designed for DoD software practitioners who want to acquire the skill and knowledge to perform state-of-the-art research on issues related to the development and evolution of large, complex, software systems, and to intelligently manage the research of other software practitioners. It offers the software professionals a unique program of study and advances software engineering principles and technology vital to DoD researchers and program managers.

The Ph.D. degree is awarded after successful defense of a dissertation that advances the state of the art in Software Engineering. Ph.D. seminars are available to assist students in reaching that goal. See the online handbook for details on admission, requirements, and procedures:

Software Engineering Ph.D. Handbook

Doctor of Philosophy in Systems Engineering

The Department of Systems Engineering offers a Doctor of Philosophy (Ph.D.) degree in Systems Engineering. Students take graduate level course in systems engineering (as needed to pass the oral and written qualifying examinations), advanced graduate courses in systems engineering and an application domain, and perform research that leads to a dissertation involving some aspect of systems engineering. Research topics may be selected from a broad variety of studies of the systems engineering process, applications of systems engineering to solving complex problems, systems level modeling and simulation, and systems suitability assessment. Subject to approval of the student's dissertation committee chairman, dissertation research may be conducted away from NPS at cooperating facilities. Students must satisfy a one-year residency requirement.

Course Codes

Courses are designated by an alphanumeric symbol consisting of two letters and four numbers. The first two letters designate the academic department, committee or group that offers the course and are defined as follows:

Course Prefix	Academic Group Name	Dept or Academic Group Prefix
AE	Mechanical and Aerospace Engineering	MAE
CC	Information Sciences	IS
CS	Computer Science	CS
CY	Information Sciences	IS
DA	Defense Analysis	DA
EC	Electrical and Computer Engineering	EC
EN	Energy Academic Group	EAG
EO	Electrical and Computer Engineering	EC
FL	National Security Affairs	NS
GB	Department of Defense Management	DDM
GE	Department of Defense Management	DDM
IO	Information Sciences	IS
IS	Information Sciences	IS
IT	International Programs Office (IPO)	INT
IW	Information Sciences	IS
MA	Mathematics	MA
ME	Mechanical and Aerospace Engineering	MAE
MN	Department of Defense Management	DDM
MO	Mathematics	MA
MR	Meteorology	MR
MS	Mechanical and Aerospace Engineering	MAE
MV	Modeling, Virtual Environments and Simulation	MOVES
MX	Mechanical and Aerospace Engineering	MAE
NS	National Security Affairs	NS
NW	Naval War College (NW)	NW
OA	Operations Research	OR
OC	Oceanography	OC
OS	Operations Research	OR
PC	Physics	PH
PH	Physics	PH

SE	Systems Engineering	SE
SI	Systems Engineering	SE
SO	Defense Analysis	DA
SS	Space Systems	SP
SW	Computer Science	CS
TS	Mechanical and Aerospace Engineering	MAE
UW	Undersea Warfare	USWAG

Course Credit Value

Following the course designator are two numbers in parentheses separated by a hyphen, which indicate the hours of instruction per week in the classroom and in the laboratory, respectively. When calculating quarter-hours for the credit value of the course, laboratory hours are assigned half the value shown. Thus a (3-2) course, having three hours lecture and two hours of laboratory, will be assigned a credit value of four-quarter-hours.

Courses are assigned numbers in accordance with their level of academic credit:

0001-0999	No credit
1000-1999	Lower division college credit (Freshman - Sophomore Level)
2000-2999	Upper division college credit (Junior - Senior level)
3000-3999	Graduate credit
4000-4999	Graduate credit
5000-5999	Doctoral (dissertation-related)

Time Limits for Completing the Master's Degree

Students pursuing a master's degree in either a resident or DL program must complete all requirements for the degree, including any thesis work, within **five years** of starting the first quarter of enrollment in a master's degree program at NPS. Students may request an extension beyond the five-year limit, but such extensions will only be granted in exceptional circumstances. Requests for an extension of candidacy beyond five years may be submitted concurrently with the request for thesis extension, including the same approvals and explanations detailed in paragraph 5.2.5 of the Academic Policy Manual. Approved extensions of candidacy will be for a maximum of one year per request.

Thesis Format Requirements

The Thesis/Dissertation/Project Report and Joint Applied Project Preparation Manual provides formatting and procedural guidance for preparing and processing electronic thesis/dissertation/reports at the Naval Postgraduate School. It covers both unclassified and classified theses/reports. All references to "theses" also refer to Dissertations, Professional Reports and Joint Applied Projects. The document is on the web at http://www.nps.edu/research/research1.html

Dual Degree Programs

An internal dual degree program at NPS is one in which a student begins coursework for a second master's degree before completion of his/her first degree. The dual degree program leads to the award of two distinct master's degrees and it must be approved by the Academic Council via the Special Programs Committee. A program in which the coursework for the second master's degree begins after completion of the first NPS master's degree is not considered a dual degree program.

Qualified students may pursue an internal dual degree program by requesting approval from the Academic Council to be admitted to the second degree. Any student not fully approved and not officially enrolled in a second degree program prior to the 12-month approval deadline is ineligible to receive the second degree.

The Program Officer and Academic Associate must certify that the applicant possesses a CQPR of at least 3.75.

The program which leads to two NPS graduate degrees must satisfy the requirements of both degrees.

A single thesis may be used to satisfy the requirements of both academic units provided it shows relevance to and mastery of both fields, is permitted by the policy of both academic units, and is coadvised by a member of each academic unit.

The dual NPS degree program must satisfy the enrollment limitations cited in this Manual. If a student requires waivers for enrollment limitations, the request for waiver must be included in the application for the special program.

A student desiring admission in an internal dual NPS degree program must apply at least one year prior to their projected graduation date, but not before having completed a minimum of 12 hours of graduate course work in their assigned program. Students within one year of graduation are not eligible to apply for enrollment in internal dual degree programs.

The application endorsements must represent approval from all involved academic units:

1. Chairs;
2. Academic Associates;
3. Service Representative or International Programs Office as applicable;
4. Program Officers.

Endorsement by the academic unit Chairs will signify that

the applicant meets any and all additional requirements for dual master's degrees that have been established by the respective academic units. The application must also include:

1. The approved degree requirements for each program.
2. A listing of courses and course hours for each program.
3. A single course matrix, graphically depicting all courses necessary for each degree program and showing that the program will not exceed quarterly credit hour limits per §6.5 *Course Enrollment Limitations.* Quarters where enrollment limitation waivers are requested must be highlighted.
4. Requests for enrollment waivers (if necessary).

Satisfactory progress in course and thesis work must be maintained by the student in the NPS dual degree program. Deficiencies in course and/or thesis performance have to be promptly reported to the Special Programs Committee by the thesis advisor(s) or the Academic Associate.

If satisfactory progress is not maintained, the Academic Council will require that the student revert to his/her original single degree program.

Educational Skill Requirements

The majority of NPS curricular programs are developed based on Education Skill Requirements (ESRs). Education Skill Requirements define the fundamental concepts required in the graduate education curriculum as directed by each curriculum sponsor and Subject Matter Expert (SME). These ESRs represent the criteria essential for successful performance in billets requiring each subspecialty.

The Program Officers and academic staff at the Naval Postgraduate School coordinate biennial curriculum reviews with the curriculum sponsors for each curriculum. These reviews are conducted to ensure that the ESRs are current and relevant to the needs of the military, that programs meet the knowledge, skill and competencies of the ESRs, and that the changing needs of the sponsors are reflected in each curriculum. The ESRs for each curriculum offered at Naval Postgraduate School are included in this catalog at the end of each curriculum listing as applicable.

Curriculum content is continually updated to maintain pace with changes in each field of study. The Naval Postgraduate School Program Officers and faculty maintain a continuous dialogue with curriculum sponsors and Subject Matter Experts. These dialogues culminate in the biennial curriculum reviews. Curriculum sponsors and SMEs are active in each curriculum in areas such as providing current and relevant material and speakers for classes, forwarding potential thesis topics that are of interest to the military, and providing opportunities and financial support for student experience tours and travel.

These partnerships between the Naval Postgraduate

School and the curriculum sponsors ensure that the educational needs of each subspecialty community are continually met through relevant education in each curriculum at NPS.

Half-Quarter Math Refresher

This is a sequence of courses developed specifically to provide a refresher of subject material pertinent to the curriculum to be studied. The number and types of courses, which comprise the technical refresher, are developed by the Program Officer and Academic Associate for the students primary curriculum. The purpose of the technical refresher is to reacquaint students with technical material and at the same time help them build good study habits.

The Six-Week Math Refreshers begin during the first half or second half of the quarter and typically consist of:

Math Refresher I (first half of quarter)

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0
MA1115	Multi Variable Calculus	4	0

Math Refresher II (last half of quarter)

| MA1114 | Single Variable Calculus II with Matrix Algebra | 4 | 0 |
| MA1116 | Vector Calculus | 3 | 0 |

Prospective students are encouraged to contact the Program Officer regarding the specifics of their particular Six-Week Technical Refresher course sequence.

Technical Refresher Quarter

This is a sequence of courses developed by the Program Officer and the Academic Associate to better prepare incoming students for entering a technical curriculum.

This course sequence is designed for prospective students who:

1. have an Academic Profile Code (APC) that indicates a deficiency in mathematics and/or scientific and technical subject matter (i.e., their APC does not qualify them for direct entry to a technical curriculum),

    Or

2. in completing their review of the prospective student's academic record, the Program Officer and Academic Associate have concluded that sufficient time has expired since the student's most recent college experience and as such, the student would benefit from the Technical Refresher Quarter.

For some students, this may also include courses from the Six-Week Math Refresher.

The refresher sequence is normally twelve weeks in length; however, there are occasions when a student may be assigned two quarters of refresher prior to entering a

technical curriculum.

Typical course sequences for refresher quarters are shown in these examples:

Space Systems Operations

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
PH1121	Mechanics	4	2
PH1322	Electromagnetism	4	2

Operations Analysis

MA1113	Single Variable Calculus I	4	0
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
MA1025	Introduction to Mathematical Reasoning	4	0
OA1600	Introduction of Operations Analysis I	2	2

Mechanical Engineering

EC1010	Introduction to MATLAB	1	1
MA1113	Single Variable Calculus I	4	0
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
PH1121	Mechanics	4	2

Computer Science

MA2025	Bridge to Advanced Mathematics	4	1
MV1000	Becoming a Master Learner	2	2
NW3230	Strategy & War	4	2

Prospective students are encouraged to contact the Program Officer regarding the specifics of their particular refresher course sequence.

Grading

A graduate student's performance will be evaluated by giving a letter grade as described below:

The A grade states that the student has shown excellent insight, competence, and great depth of understanding in attaining course outcomes in the aspect of the discipline under study. For graduate students in graduate level courses, this implies mastery of course content at the highest level.

The B grade states that the student has shown competence and an acceptable level of understanding in attaining course outcomes in the aspect of the discipline under study. For graduate students in graduate level courses, this implies an adequate level of achievement, although a B- grade indicates a marginally acceptable performance.

The C grade states that the student has shown marginal to unsatisfactory performance and understanding in attaining course outcomes in the aspect of the discipline

under study.

The D grade indicates unsatisfactory performance and an inadequate level of understanding in attaining course outcomes. The D grade states that the student has given little to no evidence of understanding or ability in the discipline.

The X grade indicates unacceptable performance.

Student academic performance is evaluated in terms of quality points assigned to the letter grade achieved in a course. Based on the level of achievement associated with each letter grade, the corresponding quality point values range from a maximum of 4 to a minimum of 0 as follows:

Grade	Point Value
A	4
A-	3.7
B+	3.3
B	3
B-	2.7
C+	2.3
C	2
C-	1.7
D+	1.3
D	1
X	0

Letter designations for which no quality points are assigned are given as follows:

I	Incomplete
W	Withdrew
N	Un-graded
P	Pass
F	Fail
T	Thesis Research

Incomplete Grade: A grade of I is given when an identifiable portion of the course remains unaccomplished at the end of the quarter. One additional quarter is granted to submit the delinquent work. If the "I" is not removed within the twelve weeks following the end of the term in which it was assigned, it becomes an X.

Pass/Fail Grade: Courses may be designated for P and F grading when approved by the Academic Department and the Academic Council. A student in a degree program who wishes to take courses not in his or her normal program may also elect to take them in the Pass/Fail mode. Approval must be granted by the student's cognizant Program Officer and Department Chairman. It is the

responsibility of the student to exercise the P/F option by informing the instructor in writing at the time of enrollment that a P/F grade is desired. A copy of the approval request shall be forwarded to the Registrar. Students electing to receive the P/F grade in letter graded courses may not apply the hours toward the degree and curriculum requirements of any program.

Thesis Research Grade: A grade of T indicates that satisfactory progress is being made on thesis work (XX 0810), dissertation work (XX 5810), or on a project (XX 4090), but evaluation depends on completion of the research, thesis, dissertation or project, at which time the instructor, Academic Department, or Academic Council shall change the T grade to one reflecting the Pass/Fail evaluation.

Quality Point Rating (QPR)

When the quarter-hour value (credit) of a course is multiplied by the point value of the student's grade, a quality point value for the student's work in the course is obtained.

Quarter-hour value for a course is defined as the scheduled number of weekly lecture hours plus one-half of the scheduled number of laboratory hours as listed in the NPS Course Catalog.

Example: A student receives a grade of B in a course with three hours lecture and two hours lab. The course credit value of four quarter-hours is multiplied by the point value assigned to the grade of B, resulting in 12.0 quality points for the course.

The sum of the quality points for all courses divided by the sum of the quarter-hour credit of these courses gives a weighted numerical evaluation of the student's performance, termed the Quality Point Rating (QPR). A student achieving a QPR of 3.0 has maintained a "B" average in all courses undertaken with a proper weight assigned for course hours.

Withdrawing from a Course

A student may withdraw from a course up to the end of the second week of the quarter without any record of it showing on the transcript. Subsequent withdrawals may be made up to the end of the eighth week of the quarter, but a grade of "W" is entered for the course on the transcript. No withdrawals can be made after the eighth week.

Course Registration and Credit

Each student must be registered in each course in which he/she is a candidate for credit not later than the tenth school day the quarter (holidays excluded). No student will receive credit for a course unless registration in that course has been approved by one of the following: the student's Program Officer or Academic Associate, the Chairman of his/her doctoral committee or the Vice

Provost for Academic Affairs.

Repetition of Courses

A student may repeat a course for the purpose of improving a grade provided such course repetition is offered by the Naval Postgraduate School. Approval must be granted by both the Program Officer and the Department or Group Chairman concerned and the Registrar is to be notified.

For record purposes, both the original and the repeated courses are to be shown on the transcript. For Quality Point Rating computation, the credit hours of the course shall be counted once, using the grade received from the most recent time that the student enrolled in the course.

Overload

Without special permission, a student may enroll for no more than 17 total credit hours or more than four 3000 level and/or 4000 level courses per quarter.

A student may enroll in more than 17 and less than 21 total credit hours with explicit permission of the Vice Provost for Academic Affairs and for more than 21 hours only with explicit permission of the Provost.

If an established degree program's course matrix includes a quarter with more than 17 hours, the students in the program need not apply for a course enrollment limitation waiver. This limit is automatically waived in these cases.

Auditing

Eligible persons will be allowed to audit courses on a space-available basis with the approval of the professor teaching the course. When approval is obtained to audit, students may attend classes, but they have no entitlement to submit papers, questions, or tests for grading nor consume the instructor's time outside of class. Auditors will receive no grade for the course, no credit toward graduation, and no formal recognition of accomplishment for courses they have audited.

Credit by Examination

The award of credit solely on the basis of examination for any 1000 or 2000 level course is permissible. Grades for such courses shall be awarded on a Pass/Fail basis.

Validation

A student with the appropriate background may validate a course that is required for his/her curriculum. Validation will allow the student to omit that course from the program of study; however, no credit will be granted for a course that has been validated. The basic purpose of course validation is to make optimal use of the student's time at the Naval Postgraduate School. Every validation must be justified by documented evidence of prior work in the area of the course to be validated.

The validation of a course must be approved in writing by the Chairman of the department offering the course or a designated representative. Specific criteria for validation (e.g., review of the student's transcripts or examination on the material of the course) are left to the discretion of the cognizant Department Chairman.

After validating one or more courses, it may be possible for a student to complete the program in less than the maximum time allowed.

Veteran's Benefits

For the purpose of determining eligibility for veteran's benefits, full-time enrollment is a minimum of ten credit hours per academic quarter. Both lecture and lab credit hours are applicable to the minimum full load.

Transfer of Credits

Upon admission to the Naval Postgraduate School, each student's academic record will be evaluated for possible transfer of credit or for exemption from portions of the curricular program by validation of course work previously completed. Students may utilize knowledge gained through self-study or experience of service-related education to seek validation. They may also take a departmental examination to gain credit for curricular courses.

Twelve hours of graduate-level courses previously completed may be accepted for transfer credit. These include graduate-level courses taken after completion of the baccalaureate degree and those taken in the last term before award of the baccalaureate if certified to be in excess of degree requirements.

Initial permission to transfer a specific course to serve as a substitute for a degree requirement will be determined by the Department Chairman or equivalent person responsible for nominating candidates for degrees at NPS and must be pre-approved in a coherent plan of study for the student. Final approval of transfer credits shall be given by the Academic Council upon the recommendation of the Department Chair. Regardless of transfer credits allowed, all NPS master's degrees still require at least 20 quarter-credits be earned directly from NPS.

Questions on transfer credit should be directed by letter to the appropriate curricular Academic Associate as listed in this catalog.

Academic Counseling

The Naval Postgraduate School provides academic counseling services to assist officers in developing individual educational plans. Officers who have chosen specific curricula or who have been selected or detailed for graduate education in programs at Naval Postgraduate School, are advised to contact the appropriate Program Office listed in the Program Offices and Programs section of this catalog. Other prospective students seeking

general information about the curricula offered at the school or the fully-funded graduate education selection process are advised to contact the Director of Admissions (Code 01C3), Naval Postgraduate School, or telephone (831) 656-3093, DSN 756-3093, e-mail: grad-ed@nps.edu.

Medical and Operational Military Absences

The academic record of a student may be deleted completely for a given term when the student is absent for a portion of the term for medical or operational reasons. The transcript will show, "Excused for the term for medical reasons" or "for operational military reasons." The student shall not be permitted to delete only a portion of the courses for this reason. The grade "W" shall be used when it is necessary to withdraw from only a part of the student's program. Such excusals shall be requested by the Program Officer and approved by the Vice Provost for Academic Affairs.

Honor Code

Despite the varied backgrounds of our student body, all NPS students are expected to uphold the highest standard of honesty and integrity and must follow the academic honor code at all times. Plagiarism, fraud, cheating, and verbal or written misrepresentation constitute violations of the Academic Honor Code. Instructor-authorized group activities/projects should rightly acknowledge the efforts of all respective participants. Unless faculty clearly state that consultation/cooperation in an assignment or course is permissible, all work must be exclusively from the student(s) listed on the document for all graded work. Any restrictions placed by the instructor on the materials that may be used by a student in preparation for and performance of all graded work, must be followed.

While no single list can identify and define all types of academic honor code standards, the following are cited as examples of unacceptable behavior:

1. **Cheating -** Using unauthorized notes, study aids, or information on an examination; looking at another student's paper during an examination; altering a graded work after it has been returned, then resubmitting it for re-grading; allowing another person to do one's work and submitting it under one's own name.
2. **Plagiarism -** Submitting material that in part or whole is not entirely one's own work without attributing those same portions to their correct source. Student shall ensure all references are properly cited.
3. **Fabrication -** Falsifying or inventing any information, data, or citation.
4. **Obtaining an Unfair Advantage -** Gaining access to examination materials prior to the time authorized by the instructor; unauthorized collaboration on an academic assignment; possessing, using or circulating

previously given examination materials where those materials clearly indicate that they are to be returned to the instructor at the conclusion of the examination.

Appropriate disciplinary action may include disenrollment, fitness report comments, and/or a letter to appropriate government agencies or official service branches, and degree revocation if a violation was discovered after a student graduated. Individuals suspecting Academic Honor Code violations are required to inform the appropriate academic/curricular officials.

Equal Opportunity Environment

Institutional and individual discrimination based on race, color, ethnicity, national origin, sex, religious stereotypes, or age not only directly contradict the Navy core values, but also severely inhibit the ability of our student body to pursue their academic goals.   Because of this, these behaviors by students, staff, and faculty will not be tolerated at NPS.

All complaints will be handled in accordance with the applicable military instructions, NPS regulations, or international agreements and can be adjudicated in either a formal, informal, or alternative manner depending on the situation and parties involved. Disciplinary or administrative actions include, but are not limited to, NJP by the respective service, UCMJ charges, or disenrollment from NPS.

Should students observe or feel they have been the victim of an equal opportunity issue they are encouraged to initially inform their Program Officer. Due to the diversity of our student body, staff, and faculty, complaints of discrimination and sexual harassment will be given considerable attention and will be closely monitored by the President to ensure they are properly handled by the chain of command.

Transcript Requests

To request a copy of your transcript please visit the Registrar's website at http://www.nps.edu/Academics/Admissions/Registrar/Transcripts/Transcripts.html.

If you have any questions or concerns, please call or e-mail the Registrar's Office at (831) 656-2591 or registrar@nps.edu.

Recent graduates: Please note that it takes approximately 90 days after graduation for your diploma and final transcripts to be generated.

Admissions

An applicant is eligible to be considered for admission to a degree or a non-degree program if they possess an accredited baccalaureate degree, preferably from an institution that holds institutional accreditation from one of the six regional agencies or shall have completed equivalent academic preparation as determined by appropriate campus authorities.

For more information and to submit an application, visit http://nps.edu/web/admissions.

Academic Profile Codes (APC)

The Academic Profile Code (APC) is an internal academic index used in the initial evaluation of applicants. This is a three-digit code that is calculated by NPS Admissions. The APC summarizes pertinent portions of a student's prior academic performance. The three independent digits reflect an individual's cumulative grade-point average, exposure to and performance in mathematics courses and exposure to and performance in selected science and engineering areas. Some departments have additional application requirements, which are outlined within this catalog under the specified program.

For more information and to submit an application, visit http://nps.edu/web/admissions.

Transcripts

After submitting your application, official transcripts must be ordered from all undergraduate and graduate institutions attended and delivered from the institution(s) directly to NPS Admissions. Transcripts must come directly from the institution or their designated transcript exchange service, **we do not accept transcripts submitted by the applicant.**

Transcripts must be delivered electronically to admissions@nps.edu or physically to our mailing address:

Admissions Office (Official Transcripts)
Naval Postgraduate School
1 University Circle, He-061A
Monterey, CA 93943-5006

It is recommended that applicants apply and submit all required materials **at least six months prior** to the estimated arrival date, or corresponding graduate education selection board. Any delay in the arrival of necessary documentation, including official transcripts, will impede the evaluation for admission.

For more information and to submit an application, visit http://nps.edu/web/admissions.

Departments

Department of Applied Mathematics

Chairman

Frank Giraldo
Spanagel Room 250

(831) 656-2293, DSN 756-2293
fxgirald@nps.edu

Associate Chairman for Student Programs

Ralucca Gera, Ph.D.
Code MA, Spanagel Hall, Room 260

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rgera@nps.edu

Associate Chairman for Research

Lucas Wilcox
Spanagel Room 238B

(831)656-3249, DSN 756-3249
lwilcox@nps.edu

* The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

Anthony Austin, Assistant Professor (2019); Ph.D., University of Oxford, UK, 2016.

Carlos F. Borges, Professor (1991); Ph.D., University of California, Davis, 1990.

Jong Chung, Lecturer (2018); Ph.D., Naval Postgraduate School, 2013.

Christopher Frenzen, Professor (1989); Ph.D., University of Washington, 1982.

Ralucca Gera, Professor (2005); Ph.D., Western Michigan University, 2005.

Frank Giraldo, Distinguished Professor (2006); Ph.D., University of Virginia, 1995.

Hongde Hu, Lecturer (2018); Ph.D., McGill University, 1992.

Wei Kang, Professor and Chair (1994); Ph.D., University of California, Davis, 1991.

Arthur Krener, Research Professor (2006); Ph.D., University of California, Berkeley, 1971.

Thor Martinsen, CDR, USN, Assistant Professor and Associate Chair for Student Programs (2012); Ph.D., Naval Postgraduate School, 2017.

Guillermo Owen, Distinguished Professor (1983); Ph.D., Princeton University, 1962.

Clyde Scandrett, Professor (1987); Ph.D., Northwestern University, 1985.

Gabriela Stanica, Lecturer (2012); MA SUNY Buffalo, 1999.

Pantelimon Stanica, Professor (2006); Ph.D., State University of New York at Buffalo, 1998.

Lucas Wilcox, Associate Professor (2012); Ph.D., Brown University, 2006.

Hong Zhou, Professor (2004); Ph.D., University of California, Berkeley, 1996.

Professors Emeriti:

Donald A. Danielson, Professor Emeritus (1985); Ph.D., Harvard University, 1968.

Fariba Fahroo, Professor Emeritus (1992); Ph.D., Brown University, 1991.

Richard Franke, Professor Emeritus (1970); Ph.D., University of Utah, 1970.

Harold M. Fredricksen, Professor Emeritus (1980); Ph.D., University of Southern California, 1968.

Toke Jayachandran, Professor Emeritus (1967); Ph.D., Case Institute of Technology, 1967.

Beny Neta, Professor Emeritus, (1985); Ph.D., Carnegie-Mellon University, 1977.

Craig Rasmussen, Professor Emeritus (1991); Ph.D., University of Colorado at Denver, 1990.

Arthur L. Schoenstadt, Professor Emeritus (1970); Ph.D., Rensselaer Polytechnic Institute, 1968.

* The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

Brief Overview

As well as the Master of Science and Ph.D. programs in Applied Mathematics, the Applied Mathematics Department offers individually tailored minor programs for many of the school's doctoral students. The majority of the department instructional—effort is devoted to the service courses offered.

Degrees

Master of Science in Applied Mathematics

In order to enter a program leading to the degree Master of Science in Applied Mathematics, the prospective student is strongly advised to possess either a Bachelor degree with a major in mathematics or a strong mathematical orientation in a Bachelor degree in another discipline.

Any program that leads to the degree Master of Science in Applied Mathematics for a student who has met the entrance criteria must contain:

1. A minimum of 32 quarter-hours of graduate-level (3000-4000 numbered) courses with a minimum QPR of 3.0. The program specifications must be approved by the Chairman of the Department of Applied Mathematics and the Academic Associate. The program is subject to the general conditions specified in the

Academic Council Policy Manual as well as the following:

2. A student must complete or validate the four 1000 level calculus sequence and the introductory courses in linear algebra and discrete mathematics.

3. The program must include at least 16 hours in 3000 level mathematics courses and 16 hours of approved 4000 level mathematics courses.

4. Courses in Ordinary Differential Equations, Real Analysis, and upper division Discrete Mathematics are specifically required, and those at the 3000 level or above may be applied toward requirement (2).

5. An acceptable thesis is required. The Department of Applied Mathematics permits any student pursuing a dual degree to write a single thesis meeting the requirements of both departments, subject to the approval of the Chairmen and Academic Associates of both departments.

In addition to the core courses required in item (3), the program allows the student to select an applied subspecialty option from the following list: applied mathematics, numerical analysis and computation, discrete mathematics, operations research, theoretical mathematics, and intelligence.

Doctor of Philosophy

The Department of Applied Mathematics offers the Doctor of Philosophy in Applied Mathematics degree. Areas of specialization will be determined by the department on a case by case basis. Requirements for the degree include course work followed by an examination in both major and minor fields of study, and research culminating in an approved dissertation. It may be possible for the dissertation research to be conducted off-campus in the candidate's sponsoring organization.

Entrance into the program will ordinarily require a master's degree, although exceptionally well-prepared students with a bachelor's degree in mathematics may be admitted. A preliminary examination may be required to show evidence of acceptability as a doctoral student. Prospective students should contact the Chairman of the Applied Mathematics Department or the Academic Associate for further guidance.

Minor in Applied Mathematics

Ph.D. students from another department can qualify for a minor in mathematics by taking at least four mathematics courses at the 3000 or 4000 level; at least three of these must be at the 4000 level. The QPR for courses taken toward the minor requirement must be at least 3.5. The courses taken should constitute a coherent minor program, and must be approved by the Academic Associate for the Department of Applied Mathematics. The use of reading courses to satisfy the requirement is strongly discouraged.

Prerequisites

Prerequisites are as described in the course descriptions.

If a student has not taken the prescribed prerequisites at NPS, then a validation examination by the Applied Mathematics Department may be substituted.

Applied Mathematics Course Descriptions

MA Courses (p. 395)

MO Courses (p. 433)

Network Science Certificate - Curriculum 200

Program Manager

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Brief Overview

The Academic Certificate in Network Science provides education in the use of mathematical methods for the analysis, understanding, and exploitation of complex networks. Network Science has emerged as an area critical to the success of the mission of the Navy and the Department of Defense because of the central role it plays in cybersecurity, network-centric warfare, and other related areas of critical interest. A thorough understanding of the underlying mathematics is essential for the correct interpretation and further development of practical methods, models, and approaches to problems involving complex networks. The certificate program is designed to provide that very background. Upon successful completion of the coursework, students will be awarded an academic certificate in keeping with standard practices of the Naval Postgraduate School.

Requirements for Entry

Prospective students must have taken or validated one of MA3025 (suggested), MA2025, MA1025, or equivalent (a working knowledge of mathematical logic, proof techniques and elementary discrete mathematics).

Convenes

Program entry dates are flexible and students who wish to pursue this certificate should coordinate with the program manager.

Program Length

Variable, usually 1 year.

MA Academic Certificate Requirements

To earn the academic certificate students must pass all three courses with a C+ (2.3 Quality Point Rating (QPR)) or better in each course and an overall GQPR of 3.0 or better. Students earning grades below these standards will need to retake the courses to bring their grades within standards or they will be withdrawn from the program.

Prerequisite Courses

One of MA3025 (suggested), MA2025, MA1025, or

equivalent (a working knowledge of mathematical logic, proof techniques and elementary discrete mathematics).

Required Courses

MA4027	Graph Theory and Applications	4	0
MA4404	Structure and Analysis of Complex Networks	4	0

and one of the following:

MA4400	Cooperation and Competition	4	0
MA4494	Topics in Network Science	4	0
CS4558	Network Traffic Analysis	3	2
OA4202	Network Flows and Graphs	4	0
EC4770	Wireless Communications Network Security	3	2
DA4410	Models of Conflict	4	0
DA4600	Dark Networks	4	0

Mathematics of Secure Communication Certificate - Curriculum 280

Program Officer

LCDR Brannon Chapman
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Program Manager

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Brief Overview

The Mathematics of Secure Communication certificate program comprises three courses. Upon successful completion of the coursework, students will be awarded a certificate of accomplishment in keeping with standard practices of the Naval Postgraduate School. The purpose for its development is to provide Mathematics education to Naval officers and DoD civilians in the broad area of Cryptography and secure communications. As such it satisfies a "Knowledge, Skills, Abilities" (KSA) requirement in the Applied Technology field of "Fundamentals of cryptology and cryptanalysis" for Professional Military Education.

Requirements for Entry

Prerequisite Courses: One of MA3025 (suggested), MA2025, MA1025, or equivalent (a working knowledge of mathematical logic, proof techniques and elementary discrete mathematics). Also required is a baccalaureate degree with an academic profile code (APC) of 324.

Convenes

At the beginning of the spring and fall quarters, with start dates in late March/ early April and late September/ early October, respectively.

Program Length

Four quarters.

Graduate Certificate Requirements

To earn the academic certificate students must pass all four courses with a C+ (2.3 Quality Point Rating (QPR)) or better in each course and an overall QPR of 3.0 or better. Students earning grades below these standards will need to retake the courses to bring their grades within standards or they will be withdrawn from the program.

Required Courses

Quarter 1

Course	Title	Lecture	Lab
MA3560	Applied Modern Algebra and Number Theory	4	0

Quarter 2

MA4560	Coding and Information Theory	4	0

Quarter 3

MA4570	Cryptography - Foundations and Practice	4	1

Certificate in Scientific Computation - Curriculum 283

Program Officer

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Academic Associate

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Brief Overview

The Scientific Computation academic certificate provides education in the use of mathematical analysis and numerical solution techniques to model science and engineering problems on computers. Scientific Computation has become the third pillar of scientific research, a peer with traditional methods of physical experimentation and theoretical investigation, and as such has emerged as an area critical to the success of the mission of the Navy and the Department of Defense. High performance computers are already widely used in weather prediction, modeling ocean dynamics, design and

testing of advanced weapons systems, development of new smart materials, etc. And it has become very clear that even more broad application of scientific computation will be essential to accelerate scientific discovery for national competitiveness and global security.

A thorough understanding of the mathematics underlying the algorithms is essential for the correct interpretation and further development of computational approaches in science. The Scientific Computation certificate program is designed to provide that very background. It is comprised of four courses – the first two of these are fundamental and the other two are selected from a group of nine courses that allows the certificate to be tailored to a specific area of interest. Upon successful completion of the coursework, students will be awarded a certificate of accomplishment in keeping with standard practices of the Naval Postgraduate School.

Requirements for Entry

Prospective students must meet the necessary prerequisites for the courses in the program.

Convenes

Program entry dates are flexible and students who wish to pursue this certificate should coordinate with the program manager.

Program Length

Variable.

Graduate Certificate Requirements

To earn the academic certificate students must pass all four courses with a C+ (2.3 Quality Point Rating (QPR)) or better in each course and an overall QPR of 3.0 or better. Students earning grades below these standards will need to retake the courses to bring their grades within standards or they will be withdrawn from the program.

Required Courses

Course	Title	Lecture	Lab
MA3046	Matrix Analysis	4	1
MA3232	Numerical Analysis	4	0

And any two from

Course	Title	Lecture	Lab
MA4237	Advanced Topics in Numerical Analysis	V	0
MA4242	Numerical Solution of Ordinary Differential Equations	4	0
MA4243	Numerical Solution of Partial Differential Equations	3	1
MA4245	Mathematical Foundations of Galerkin Methods	4	0
MA4248	Computational Linear Algebra	4	1
MA4261	Distributed Scientific Computing	4	0
MA4311	Calculus of Variations	4	0
MA4377	Asymptotic and Perturbation Methods I	4	0
MA4620	Theory of Dynamical Systems	4	0

Applied Mathematics - Curriculum 380

Program Officer

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Brief Overview

This program is designed to meet the needs of the Department of Defense for graduates who are skilled in applying concepts of higher mathematics. The objective of the program is to equip an officer with the skill to analyze a military problem, formulate it in mathematical terms, solve or approximate a solution, and interpret and present the results.

Completion of this curriculum also qualifies an officer as an Applied Mathematics Subspecialty with a code of 4100P. A typical job in this subspecialty is an instructor in mathematics at the U.S. Naval Academy or the U.S. Military Academy at West Point.

Requirements for Entry

Preparatory to graduate work in applied mathematics, the officer shall have completed a strong program of study at the undergraduate level or the first three quarters of the mathematics core sequence, which includes linear algebra, advanced calculus in one and several variables, ordinary differential equations, probability and statistics. Officers not having the required qualifications for direct input enter the program indirectly through the Engineering Science (460) curriculum. An APC of 324 is required.

Convenes

Advanced Science (Applied Mathematics) is an eight-quarter course of study with preferred entry date in June. If further information is needed, contact the Academic Associate or Program Officer for this curriculum.

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0

Course	Title	Lecture	Lab
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
MA2025	Bridge to Advanced Mathematics	4	1
NW3230	Strategy & War	4	2
Quarter 2			
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
MA3025	Logic and Discrete Mathematics II	4	1
MA3042	Linear Algebra	4	0
Quarter 3			
MA3046	Matrix Analysis	4	1
MA3110	Intermediate Analysis	4	0
MA2121	Differential Equations	4	0
MA3560	Applied Modern Algebra and Number Theory	4	0
Quarter 4			
NW3275	Joint Maritime Operations - part 1	4	0
MA3301	Linear Programming	4	0
MA3132	Partial Differential Equations and Integral Transforms	4	0
OA3101	Probability	4	1
Quarter 5			
NW3276	Joint Maritime Operations - part 2	2	2
MA3607	Introduction to Real Analysis	4	0
MA3232	Numerical Analysis	4	0
OA3102	Statistics	4	2
Quarter 6			
MA4322	Principles and Techniques of Applied Mathematics I	4	0
MA3677	Theory of Functions of a Complex Variable	4	0
ELECT	Elective 3XXX		
OA3103	Data Analysis	4	1
Quarter 7			
MA4323	Principles and Techniques of Applied Mathematics II	4	0
MA0810	Thesis Research	0	8
ELECT	Elective 4XXX		
ELECT	Elective 4XXX		
Quarter 8			
MA0810	Thesis Research	0	8
MA0810	Thesis Research	0	8
ELECT	Elective 4XXX		
NW3285	Theater Security Decision Making	4	0

Educational Skill Requirements (ESR)
Applied Mathematics - Curriculum 380

The value of graduate education in mathematics lies in the vast breadth of its applicability. The officer with advanced education in mathematics possesses skills in problem solving, modeling, abstraction, optimization, and analysis that are sufficiently general that they apply in many arenas and never lose their currency in the face of changing technology and yet-to-be-identified needs. Graduate education in mathematics is a career-long enabler. Students in the Applied Mathematics curriculum will receive a solid mathematical foundation as they transition into graduate curricula emphasizing relevant and modern advanced mathematical techniques. Students will be encouraged to develop and utilize skills in analysis, reasoning, creativity, and exposition as they acquire knowledge of mathematics and its applications.

1. **Fundamental Areas:** The officer will complete courses in the following fundamental areas of Mathematics, developing sufficient mastery to qualify for teaching Mathematics at the undergraduate level.
   a. Single, Multivariate, and Vector Calculus
   b. Linear Algebra and Algebraic Structures
   c. Logic and Discrete Mathematics
   d. Real and Complex Analysis
   e. Modern Applied Algebra and Number Theory
   f. Numerical Analysis
   g. Mathematical Modeling in Applied Mathematics
   h. Ordinary and Partial Differential Equations
2. **Applications:** The officer will become well-versed in the applications of mathematics to real world problems of interest to the military, enhancing performance in post-graduate operational billets and policy making positions.
3. **Computer Skills:** The officer will acquire the ability to use higher-level structured computer languages on current workstations
4. **Communication and Research Skills:** The officer will perform independent research in an area of Mathematics, develop written and oral presentation skills, and gain instructional experience.
5. **Joint Professional Military Education:** Graduates will complete the Navy Joint Professional Military Education Phase I requirements.

Applied Mathematics PhD - Curriculum 381

Program Officer

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Brief Overview

The Department of Applied Mathematics offers the Doctor of Philosophy in Applied Mathematics degree. Areas of specialization will be determined by the department on a case by case basis. Requirements for the degree include course work followed by an examination in both major and minor fields of study, and research culminating in an approved dissertation. It may be possible for the dissertation research to be conducted off-campus in the candidate's sponsoring organization.

Entrance into the program will ordinarily require a master's degree, although exceptionally well-prepared students with a bachelor's degree in mathematics may be admitted. A preliminary examination may be required to show evidence of acceptability as a doctoral student. Prospective students should contact the Chairman of the Applied Mathematics Department or the Academic Associate for further guidance.

Subspecialty

Completion of this curriculum also qualifies an officer as an Applied Mathematics Subspecialty with a code of 4100D.

Minor in Applied Mathematics

Ph.D. students from another department can qualify for a minor in mathematics by taking at least four mathematics courses at the 3000 or 4000 level; at least three of these must be at the 4000 level. The QPR for courses taken toward the minor requirement must be at least 3.5. The courses taken should constitute a coherent minor program, and must be approved by the Academic Associate for the Department of Applied Mathematics. The use of reading courses to satisfy the requirement is strongly discouraged.

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* The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

Bruce Allen, Research Associate (2008); B.S., California State University at Sacramento, 1989.

Andrea Austin, Senior Lecturer (2021); Carver College of Medicine, University of Iowa, 2011.

Imre Balogh, Research Associate Professor, Director, MOVES Institute (2009); Ph.D., New Mexico State University, 1993.

Armon Barton, Assistant Professor (2020); Ph.D., University of Texas at Arlington, 2018.

Valdis Berzins, Professor (1986); Ph.D., Massachusetts

Institute of Technology, 1979.

Curtis Blais, Research Associate (1999); Ph.D., Naval Postgraduate School, 2018.

Arnie Buss, Research Associate Professor (1994); Ph.D., Cornell University, 1987.

Chris Darken, Associate Professor (2001); Ph.D., Yale University, 1993.

Rudy Darken, Professor (1996); D.Sc., George Washington University, 1995.

Arijit Das, Research Associate (2003); M.S., University of Nevada, 1989.

Cecelia Davis, Faculty Associate (2002); M.A., Trident University International, 2016.

Duane Davis, Senior Lecturer (2008); Ph.D., Naval Postgraduate School, 2006.

Peter J. Denning, Director of the Consortium for Intelligent Systems Education and Research, and Distinguished Professor (2002); Ph.D., Massachusetts Institute of Technology, 1968.

Doron Drusinsky, Professor (2002); Ph.D., Weizmann Institute of Science, 1988.

Chris Eagle, Senior Lecturer (1997); M.S., Naval Postgraduate School, 1995.

Christian Fitzpatrick, Research Associate (2018); M.S., Naval Postgraduate School, 2009.

John D. (JD) Fulp, Senior Lecturer (2001); M.S., Naval Postgraduate School, 1996.

Michael Guerrero, Research Associate (2006); M.S., Southern Methodist University, 2009.

Britta Hale, Assistant Professor (2018); Ph.D., University of London, Royal Holloway (NTNU), 2017.

Eric Heine, Research Associate (2008); B.S., UC Santa Cruz, 2004.

Ted Huffmire, Associate Professor (2007); Ph.D., University of California at Santa Barbara, 2007.

Cynthia Irvine, Professor and Director, Center for Information Systems Security Studies and Research (1994); Ph.D., Case Western University, 1975.

Erik Johnson, Research Associate (2002); B.S., Embry-Riddle Aeronautical University, 1995.

Mathias Kölsch, Associate Professor (2005); Ph.D., University of California at Santa Barbara, 2004.

Michael Krause, Research Associate (2020); Ph.D., University of Duesseldorf, 1999.

Joshua A. Kroll, Assistant Professor (2019); Ph.D., Princeton University, 2015.

Ryan Lee, Research Associate (2011); M.S., Southern Methodist University, 2010.

Luqi, Professor (1986); Ph.D., University of Minnesota, 1986.

Michael McCarrin, Research Associate (2014); M.S., Naval

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Patrick McClure, Assistant Professor (2022); Ph.D., University of Cambridge, 2018

Perry McDowell, Research Associate (2000); M.S., Naval Postgraduate School, 1995.

Bret Michael, Professor (1998); Ph.D., George Mason University, 1993.

Thuy Nguyen, Research Associate (2002); B.A., University of California at San Diego, 1982.

Terry Norbaten, Research Associate (2005); M.S., Naval Postgraduate School, 2004.

Marko Orescanin, Assistant Professor (2019); Ph.D., University of Illinois at Urbana-Champaign, 2010.

Loren Peitso, Senior Lecturer (2004); M.S., Naval Postgraduate School, 2002.

Charles Prince, Research Associate (2006); B.S., Oregon State University, 1993.

Brittany Ramsey, Research Associate (2010); B.A., University of Colorado, 2007.

David Reeves, Research Associate (2012); B.S., New Mexico State University, 2004.

Ed Rockower, Research Professor (1984, 2009); Ph.D., Brandeis University, 1999.

Neil Rowe, Professor (1983); Ph.D., Stanford University, 1983.

Amela Sadagic, Research Associate Professor and Co-director of NPS Center for Additive Manufacturing (2004); Ph.D., University College London, 1999.

Alan Shaffer, Senior Lecturer (2008); Ph.D., Naval Postgraduate School, 2008.

Gurminder Singh, Chairman, Department of Computer Sciences, Director of the Center for the Study of Mobile Devices and Communications, and Professor (2002); Ph.D., University of Alberta, 1989.

Kirk Stork, Research Associate (2008); M.S., Naval Postgraduate School, 1996.

Michael Thompson, Research Associate (2012); B.S., Marquette University, 1981.

Geoffrey Xie, Professor (1996); Ph.D., University of Texas at Austin, 1996.

Emeritus Professors

Mikhail Auguston, Associate Professor Emeritus (2003); Ph.D., Glushkov Cybernetics Institute, 1983.

Robert B. McGhee, Professor Emeritus (1986); Ph.D., University of Southern California, 1963.

Degrees

The Department of Computer Science provides graduate training and education in major areas of computer science; thus, both basic and advanced graduate courses are offered. Course work and research lead to either the Master of Science or Doctor of Philosophy degree. The

requirements to complete either program are rigorous and are comparable to those of other major universities.

Master of Science in Computer Science

Master of Applied Computing

Master of Science in Modeling, Virtual Environments, and Simulation

Master of Arts in Identity Management and Cyber Security

Doctor of Philosophy in Computer Science

Doctor of Philosophy in Modeling, Virtual Environments, and Simulation

Laboratories

There are currently 11 laboratories:

Introductory Computer Security Laboratory

This lab is primarily used by the Center for Information Security Studies and Research (CISR). The lab consists of a virtual infrastructure of clients and servers serving the needs of multiple CS department classes such as:

The studies of information assurance, computer security, high assurance system architecture and authentication where it is used to introduce students to studies in high assurance systems, public key infrastructure, mandatory access control, viruses, covert channels and the reference monitor concept.

The security manager's view of diverse management concerns associated with administering and operating an automated information system facility with minimized risk. Also used in certifying that students have met the requirements for educational standards published by the Committee on National Security Systems (CNSS).

The fundamentals of computer forensics in the context of DoN/DoD information operations. Students examine how information is stored and how it may be deliberately hidden and/or subverted.

The basis for understanding the potential vulnerabilities in networked systems by applying a problem-solving approach to obtain information about a remote network and exploit or subvert those systems using various techniques and tools along with discussing vulnerability discovery and mitigation.

Students taking the course this lab primarily serves are from multiple departments across campus. For more information, please contact Professors Cote or Clark.

Computer Information Security Research (CISR) Laboratory

This lab is primarily used by the Center for Information Security Studies and Research (CISR). The lab consists of a virtual infrastructure of clients and servers to allow the student to study network vulnerabilities, intrusion detection, secure system management and computer forensics; where tools used by administrators and hackers can be freely researched and studied. Students are given full administrator privileges on virtual machines so that

multiple operating systems and tools can provide a basis for understanding the potential vulnerabilities and their mitigation in networked systems by studying methods to: (1) obtain information about a remote network, (2) to possibly exploit or subvert systems residing on that network and (3) techniques to mitigate risks to networked systems. For more information, please contact Professors Cote or Clark.

Network Research and Experimentation Laboratories

Introductory PC Network Laboratory

Intermediate Local Area Network Laboratory

These two labs support the Networks Specialty and provide students the opportunity to apply network theory in concrete applications. The Introductory PC Network Laboratory enables students to install network hardware and software, learning firsthand the advantages, limitations, and intricacies of various components and operating systems. The Intermediate Local Area Network Laboratory allows students to participate in ongoing Next Generation INTERNET research, advanced protocol development, future high-speed digital switching systems experimentation, network management, and control design and analysis. These labs also directly support DoD-funded research for the Defense Advanced Research Projects Agency and the National Science Foundation (NSF).

Wireless and Mobile Computing Laboratory

The Wireless and Mobile Computing Lab provides the majority of academic computing needs to support the wireless and mobile computing specialty within the Department of Computer Science. This lab provides students with the opportunity to program and examine security aspects of mobile computing devices ranging from personal digital assistants (PDAs) through cellular phones.

Autonomous Robotics Coordination Laboratory

This teaching and research computer lab supports graduate students and faculty work on sponsored classes/research projects regarding the coordination between multiple autonomous robots to achieve a coordinated result. The lab is equipped with several types of programmable robots and a wide range of intelligent software tools, including programming languages, planners, language processors, image processors, and neural-computing.

Software Engineering Laboratory

This laboratory provides a state-of-the-art engineering systems environment to support graduate students and faculty work on sponsored classes and projects in software automation. The laboratory provides a test bed for DoD software-intensive systems and software for embedded safety-critical systems can be precisely tested in the lab. Evaluation and assessment on network-based system integration and interoperability, and the risk

assessment on systems of systems can be conducted effectively in the lab. The lab also provides support for requirements analysis, prototyping, specification, and computer-aided system architecture design.

Forensics Exploitation Lab

This laboratory provides a state-of-the-art forensics exploitation environment to support graduate students and faculty work on sponsored classes and projects in basic and applied forensics exploitation research projects. Primary work is done with new techniques for automatically processing data recovered from disk drives and other types of storage devices. Using forensic techniques, the data on a hard drive can reveal who used or broke into a computer system, what it was used for or what was done during a break-in, and the identities of those in question.

SCIF Security Lab

This laboratory provides a state-of-the-art engineering systems environment to support graduate students and faculty work on sponsored classes and projects in security areas that are required to be conducted in high-security, compartmented classifications and dedicated air-gapped hardware/networks.

Virtual Environments Lab

The Virtual Environments Lab provides the equipment necessary to experience and study virtual and augmented environments. Head-worn displays and associated tracking hardware display the visual content of artificially created environments. The immersive nature of these environments cannot be studied on other hardware such as computer monitors. Virtual and augmented environments are integral to the MOVES Institute's mission goals. They are of instrumental importance to many DoD training applications as well as military operations. Cross disciplinary classes and even student research projects can be performed with this equipment as well, for departments including Computer Science, Mechanical and Electrical Engineering, and Operations Research.

LVC Simulation Interoperability Lab

The MOVES Live Virtual Constructive (LVC) Simulation Interoperability Lab offers students and researchers the tools and network infrastructure needed to experiment with the connectivity of various simulations and command and control (C2) systems that support tactical training, system test & evaluation, and wargaming. The lab consists of twelve virtual and constructive simulations and three software interoperability architectures. In addition, the lab is connected to virtual private network (VPN) allowing faculty to interact with students while not physically in the lab. This VPN also enables MOVES to collaborate with other NPS Departments, National Labs and Universities on emerging simulation interoperability topics.

Computer Science Course Descriptions
CS Courses (p. 334)
MV Courses (p. 441)
SW Courses (p. 512)

Innovation and Design Certificate - Curriculum 109

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Brief Overview

This certificate supports students who are working to bring an innovation into adoption. The three courses teach how to design for a military environment, how processes of adoption work in organizations and communities, and how to learn the leadership skills to mobilize a community to adopt the innovation. The certificate includes a capstone project that applies the learning from the three courses to design a significant innovation and bring it into adoption in a military community. It includes coaching for the capstone project. Program prerequisites: none. Entry: 2.5 GPA and supervisor endorsement.

Convenes
Summer

Program Length
Four quarters

- Students will learn the strategic skill of interpreting military history through the lens of technological change. In doing so, they will explore the common dynamics of success and failure in confronting emerging technologies.
- Students will develop knowledge of commonly applied innovation adoption ideas, concepts, theories, frameworks and practices that are relevant for their military careers.
- Students will learn the eight practices of innovation leadership and demonstrate them through a successful capstone project.
- Students will define an innovation project that addresses a concern in a military community, design a

new technology or process to deal with it, and bring it into early adoption.

Certificate Requirements

Required Courses

Course	Title	Lecture	Lab
DA4104	Militaries and Technological Change	4	0
MN3811	Innovation Adoption & Implementation	3	0
CS4925	Innovation Leadership	3	2

Capstone due in fourth quarter. Capstone should be started by student in home department in Quarter 1 and be carried out in parallel with the courses.

The particular capstone course use will be in the student's home department. For the three departments involved in this certificate, they are:

CS0809 (0-4) – CS department

GB4090 (0-6) – GSDM

DA4500 (0-4) – DA department

Artificial Intelligence for Military Use Certificate - Curriculum 128 (DL)

Program Manager

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Brief Overview

This is a four-course sequence offered by distance learning (videoconferencing) in four successive quarters. Courses earn graduate-school credit. The goal is to provide military professionals and civilians with basic understanding of artificial-intelligence capabilities to enable good decisions on procurement, implementation, and application of artificial-intelligence technology. The focus is on the software concepts and technical details that can best support military operations and why. A bachelor's degree is required. No technical background is required beyond high-school algebra. However, students must be prepared to encounter some new mathematics. Some laboratory exercises will use artificial-intelligence tools but will not require programming. This curriculum supports the Federal Training and Development of Artificial Intelligence program.

Lectures will be given by Zoom or Teams videoconferencing software. They can be viewed while they are given (and questions will be fielded), but lectures will also be recorded for later viewing by those who cannot attend them. No travel is required for this program. The certificate program will generally be offered in four successive quarters starting in the Spring quarter. It may be possible to start in the Summer quarter with the second course since it is independent of the first course. However, an organization sending a cohort of 20 or more students can choose another quarter for all of them to start.

Completion of the four courses yields an Academic Certificate in Artificial Intelligence for Military Use. The certificate requires about 360 hours of total work over the four courses, including lectures, readings, homework, and test preparation. The courses total 14 graduate credit hours, 8 at the 3000 (introductory graduate) level, and 6 at the 4000 (advanced graduate) level. Four credit hours means four lecture hours per week plus around six hours outside class per week. Students must be U.S. Federal government employees (including active-duty military) or Federal contractors.

NPS distance learning programs are described at http://www.nps.edu/web/dl.

Program Length

Four quarters

- Students can define the key concepts of artificial intelligence and correctly assess which apply to a given real-world problem.
- Students can simulate, with paper and pencil, simple methods of artificial intelligence for logical reasoning, knowledge representation, probabilistic reasoning, and heuristic search.
- Students can identify the key military applications of artificial intelligence including those involving sensors, signals, imagery, natural language, planning, and adversarial situations.
- Students can identify key challenges and vulnerabilities of artificially intelligent systems including limitations on the abilities of particular underlying technologies, adversarial manipulation of examples presented to machine learning, and trust in artificially intelligent systems.

Course of Study

Quarter 1

Course	Title	Lecture	Lab
CS4000	Harnessing Artificial Intelligence	0	2

Quarter 2

Course	Title	Lecture	Lab
CS3331	Basics of Applied Artificial Intelligence	4	0

Quarter 3

Course	Title	Lecture	Lab
CS3332	Applied Machine Learning	4	0

Quarter 4

Course	Title	Lecture	Lab
CS4333	Current Directions in Artificial Intelligence	4	0

Innovation and Design Certificate - Curriculum 209 (DL)

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Brief Overview

This certificate supports students who are working to bring an innovation into adoption. The three courses teach how to design for a military environment, how processes of adoption work in organizations and communities, and how to learn the leadership skills to mobilize a community to adopt the innovation. The certificate includes a capstone project that applies the learning from the three courses to design a significant innovation and bring it into adoption in a military community. This certificate is delivered online with a mix of synchronous and asynchronous elements. It includes coaching for the capstone project. An optional in-person workshop will be offered for students who want to engage the courses practices with hands-on exercises. Program prerequisites: none. Entry: 2.5 GPA and supervisor endorsement.

Courses composing the certificate:

DA4104 -- Military Organizations and Technological Change (4-0)

MN3811 -- Innovation Adoption and Implementation (3-0)

CS4925 -- Innovation Leadership

Capstone -- In student's home department

Program Length

Four quarters

- Students will learn the strategic skill of interpreting military history through the lens of technological change. In doing so, they will explore the common dynamics of success and failure in confronting emerging technologies.
- Students will develop knowledge of commonly applied innovation adoption ideas, concepts, theories, frameworks and practices that are relevant for their military careers.
- Students will learn the eight practices of innovation leadership and demonstrate them through a successful capstone project.
- Students will define an innovation project that addresses a concern in a military community, design a new technology or process to deal with it, and bring it into early adoption.

Innovation and Design

Quarter 1

First of four courses in the certificate.

Course	Title	Lecture	Lab
MN3811	Innovation Adoption & Implementation	3	0

Quarter 2

Second of four courses in the certificate.

Course	Title	Lecture	Lab
CS4925	Innovation Leadership	3	2

Quarter 3

Third of four courses in the certificate.

Course	Title	Lecture	Lab
DA4104	Militaries and Technological Change	4	0

Quarter 4

Capstone due in fourth quarter. Capstone should be started by student in home department in Quarter 1 and be carried out in parallel with the courses.

The particular capstone course use will be in the student's home department. For the three departments involved in this certificate, they are:

CS0809 (0-4) – CS department

GB4090 (0-6) – DDM

DA4500 (0-4) – DA department

Implementing Technological Change Certificate - Curriculum 221

Program Officer

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Brief Overview

Rapid technological advances, emerging capabilities, and innovations by adversaries have engaged the U.S. in an aggressive technological and cyberspace response that demands of its technological solution leaders the ability to shepherd initiatives from conception to realization. This certificate offers cyberspace and other technology professionals the opportunity to cultivate essential skillsets to spearhead policy development and drive organizational change. It will empower technological leaders with the cognitive ability to synchronize intellectual, communication, and policy skills with complex technological change.

Program Length

12 months

- Understand policy for technology and cyberspace management.
- Translate complex technological concepts and challenges for non-technical stakeholders.
- Effectively advocate technological developments.
- Manage organizational change to enable technological innovations.
- Use high-impact writing and speaking strategies to effectively communicate and advocate technological change.

Certificate Requirements

To meet the certificate requirements, a student must complete two (2) required core courses (CS4926 and GB3012) and two (2) additional courses from among the selection below.

Required Core Courses

Course	Title	Lecture	Lab
CS4926	Advocating Emerging Technologies	4	1
GB3012	Communication for Managers	3	0

Additional Course Selections

The student will select two of the following courses (CY4410, CS4925, DA4104, and MN4125).

MN4015 may be taken in place of MN4125 (certificate credit for only one of MN4015 or MN4125 will be given).

CY4410	Cyber Policy and Strategy	3	0
CS4925	Innovation Leadership	3	2
DA4104	Militaries and Technological Change	4	0
MN4125	Managing Planned Change in Complex Organizations	4	0
	-or-		
MN4015	Management of Change	4	0

This certificate is intended for in-resident students who are already admitted to another curriculum.

Implementing Technological Change Certificate - Curriculum 231 (DL)

Program Manager

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Brief Overview

Rapid technological advances, emerging capabilities, and innovations by adversaries have engaged the U.S. in an aggressive technological and cyberspace response that demands of its technological solution leaders the ability to shepherd initiatives from conception to realization. This certificate offers cyberspace and other technology professionals the opportunity to cultivate essential skillsets to spearhead policy development and drive organizational change. It will empower technological leaders with the cognitive ability to synchronize intellectual, communication, and policy skills with complex technological change.

Program Length

Four quarters

- Understand policy for technology and cyberspace management
- Translate complex technological concepts and challenges for non-technical stakeholders
- Effectively advocate technological developments
- Manage organizational change to enable technological innovations
- Use high-impact writing and speaking strategies to effectively communicate and advocate technological change

Certificate Requirements

To meet the certificate requirements, a student must complete two (2) required core courses (CS4926 and MN3012/GB3012) and two (2) additional courses from among the selection below.

Required Core Courses

Course	Title	Lecture	Lab
CS4926	Advocating Emerging Technologies	4	1
MN3012	Communications Strategies for Effective Leadership	3	0

Additional Course Selections

The student will select two of the following courses (CY4410, CS4925, DA4104, and MN4125).

MN4015 may be taken in place of MN4125 (certificate credit for only one of MN4015 or MN4125 will be given).

CY4410	Cyber Policy and Strategy	3	0
CS4925	Innovation Leadership	3	2
DA4104	Militaries and Technological Change	4	0
MN4125	Managing Planned Change in Complex Organizations	4	0
	-or-		
MN4015	Management of Change	4	0

Healthcare Modeling and Simulation Certificate -- Curriculum 240 (DL)

Program Officer

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Brief Overview

The Naval Postgraduate School, in partnership with the Uniformed Services University of the Health Sciences, have collaborated to design and deliver a distance learning educational program for healthcare simulation professionals. This program focuses on the effective use of modeling and simulation in the healthcare domain. The materials developed have been reviewed and incorporated into an efficient, interactive, fast-paced certificate program for working professionals.

The certificate requires the completion of four courses, comprising 16 credit hours of work at the graduate level.

These courses form a coherent sequence to equip the certificate student with the core skills necessary to manage a modeling and simulation education and research program which can be completed in 12 months.

Program Length

Four quarters

Certificate Requirements

Required Courses

Course	Title	Lecture	Lab
MV4002	Simulation and Training	4	1
MV3403	Research Methods and Statistics for Healthcare Simulation	4	1
MV4003	Technology and Simulation in Healthcare Education	3	1
MV4460	Management of Modeling & Simulation Development	4	0

Cyber Security Fundamentals Certificate -- Curriculum 256 (DL), Curriculum 257 (RES)

Program Manager

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Brief Overview

The Cyber Security Fundamentals graduate certificate is intended to provide a technically rigorous foundation upon which to build knowledge and skills in computer network defense, attack and exploitation. Each course is comprised of both instruction and laboratory exercises involving cyber security aspects of computers and networks. These synergistic activities allow students to internalize key concepts in cyber security. The courses and material covered in the Cyber Security Fundamentals certificate satisfy prerequisite requirements for advanced courses in cyber security offered in the Computer Science Department of the Naval Postgraduate School.

Students entering this program must meet the prerequisites of the individual courses that make up the program. To this end, students are expected to have prior academic experience at the undergraduate or graduate level in computing systems and computer networking.

All of the courses in the sequence are extracted from the current set of graduate courses in the Computer and Network Security specialization offered by the CS Department. Of these, one is a core course. The total number of NPS graduate credits obtained for the certificate is up to 13.5, where laboratory credits are counted as half. This certificate program can also be applied toward a master's degree program, e.g., Curriculum 368.

Program Length

Six months.

Certificate Requirements

Required Courses

Course	Title	Lecture	Lab
CS3600	Introduction to Cybersecurity	4	1
	-or-		
CS4600	Secure System Principles	3	2
CS3670	Secure Management of Systems	3	2
CS3690	Network Security	4	1

Cyber Security Defense Certificate - Curriculum 258 (DL), Curriculum 259 (RES)

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Brief Overview

Using the foundation established through the Cyber Security Fundamentals certificate, students enrolled in Cyber Security Defense graduate certificate, will obtain a detailed understanding of and ability to function in real operational situations involving cyber security. They will gain the technical depth required to actively prepare for and respond to attacks. Students will learn to analyze network traffic to extract the observable characteristics of networks and network devices, thus providing a basis for defensive strategies. They will learn to build tools and how to configure systems and networks to permit systems to foster resiliency and continuity of operations, perhaps with reduced capacity, through attacks. Students will learn how to construct systems and tools to mitigate the impact of malicious software. Students will learn forensic techniques to retrieve and analyze stored information that may be corrupted or hidden. Considerable programming and hands-on work with systems and networks will be required. Entire courses, or units within them, may be taught at the classified level, thus facilitating classroom discussions on emerging challenges and capabilities.

Students entering this program are expected to have a strong foundation in cyber security and networking. In addition, entering students will be expected to understand and use the languages and techniques of operating system and network component development: the C programming language, assembly, shell scripting, use of linkers, loaders, and debuggers.

The total number of NPS graduate credits obtained for the certificate is 12, where laboratory credits are counted as half. This certificate program can also be applied toward a master's degree program, e.g. Curriculum 368.

Program Length

Four quarters

Certificate Requirements

Required courses are any three of the following:

Course	Title	Lecture	Lab
CS4558	Network Traffic Analysis	3	2
CS4677	Computer Forensics	3	2
CS4684	Cyber Security Incident Response and Recovery	3	2
CS4600	Secure System Principles	3	2

Cyber Security Adversarial Techniques Certificate - Curriculum 260 (DL)

Program Manager

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Brief Overview

Using the foundation established through the Cyber Security Fundamentals certificate, students enrolled in Cyber Security Adversarial Techniques graduate certificate, will obtain a detailed understanding of and ability to function in real operational situations in which adversarial techniques are being used. An understanding of overarching principles, computer and network architectural concepts, and exemplar cases will allow students to analyze current and future malware. Students will learn how to use network traffic analysis to extract the characteristics of ongoing attacks and to identify exploitable vulnerabilities. They will learn how to decipher subtle, clandestine host-based attack mechanisms and how these mechanisms are inserted into target systems. They will learn, in detail, how attack and exploitation software mechanisms are built and deployed, including the distributed command and control techniques used to manage large-scale malware networks. Considerable programming and hands-on work with systems and networks will be required. Entire courses, or units within them, may be taught at the classified level, thus facilitating classroom discussions on emerging challenges and capabilities.

Students entering this program are expected to have a strong foundation in cyber security and networking. In addition, entering students will be expected to understand and use the languages and techniques of operating system and network component development: the C programming language, assembly, shell scripting, use of linkers, loaders, and debuggers.

The total number of NPS graduate credits obtained for the certificate is 13.5, where laboratory credits are counted as half. This certificate program can also be applied toward a master's degree program, e.g. Curriculum 368.

Program Length

Four quarters

Understand an apply techniques for software analysis and reverse engineering.

Analyze malicious software for key characteristics including, but not limited to: behaviors, triggers, and indicators of provenance.

Use tools appropriate for massive data sets to identify and characterize software and digital communications, both benign and malicious.

Use rudimentary system exploitation techniques to gain privilege, persistence, command and control, obfuscation, and management of adversarial software.

Understand policies, eco-systems, and constraints as context for cyber operations.

Certificate Requirements

The student will select three of the following courses (CS4558, CS4648, CS4679, and CS4679).

Course	Title	Lecture	Lab
CS4558	Network Traffic Analysis	3	2
CS4648	Software Reverse Engineering and Malware Analysis	3	2
CS4678	Advanced Cyber Vulnerability Assessment	4	1
CS4679	Advances in Cyber Security Operations	4	1

Data Science Certificate -- Curriculum 268 (DL) (CS/OR)

Program Officer

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(Joint DL certificate program of the Department of Computer Science and Department of Operations Research.) This curriculum is described in the Department of Computer Science section of this Catalog. The Department of Operations Research supports this curriculum with courses and faculty.

Brief Overview

The Academic Certificate in Data Science provides education in distributed computing infrastructure and the application of statistical and machine learning techniques to appropriately manage and gain insights from data of all sizes and types. Data Science has emerged as an area critical to the mission of the Navy and the Department of Defense because of the central role it plays in intelligence, surveillance, and reconnaissance, talent management, cyber-security, and logistics functional areas. Upon successful completion of the course work, students will be awarded an Academic Certificate in keeping with standard practices of the Naval Postgraduate School.

Background in statistics and some experience with higher level programming language as evidenced by transcripts or work history is required for enrollment.

Program Length

Four quarters

- Possess the mathematical and computer programming skills required to conduct data science projects and be able to use computers to aid in data analytics.
- The graduate will be well-versed in the fundamentals of statistics and data analysis for applications to machine learning and data mining problems.
- The graduate will be able to identify, evaluate, and apply the concepts associated with managing large data sets, including cloud computing and split-merge distributed processing.
- The graduate will be able to clean, process, and summarize structured and unstructured (text) data.
- The graduate will know when and how to apply common machine learning tools, both supervised and unsupervised, and understand their strengths and weaknesses.
- The graduate will be able to evaluate the results of machine learning algorithms, and propose ways to improve their performance and utility in specific applications.
- The graduate will understand the use of the supervised methods of regression and classification, know when to implement them, and be able to apply basic and advanced techniques in appropriate settings including for large data sets.
- The graduate will be aware of common unsupervised methods and be able to use them particularly for large data sets of high dimension.
- The graduate will gain practical experience working on all aspects of a data science study, including interacting with a variety of different open-source databases, applying real-world applications with the cloud and high-performance computing environments, and demonstrating the ability to conduct independent analytical studies.

Course Requirements

Students are to complete the following four courses to earn the Data Science Certificate:

Course	Title	Lecture	Lab
CS4315	Introduction to Machine Learning and Data Mining	3	1
OS4106	Advanced Data Analysis	3	0
OA3802	Computational Methods for Data Analytics	4	0
OS4118	Statistical and Machine Learning	3	0

CY3650: Students who have enrolled in the Data Science Certificate and completed CY3650 by 31 December 2022 can substitute CY3650 for OA3802.

Information Systems Security Engineering (ISSE) Certificate – Curriculum 270 (RES & DL)

Program Manager

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Brief Overview

The role of Information Systems Security Engineering (ISSE) is to help ensure that the security requirements of systems are met. Lacking proper security engineering, systems fail to be certified and accredited, causing costly delays or failures. Ideally, the Information Systems Security Engineer (also known as an ISSE) will be a member of the system development team throughout its lifecycle; however, for preexisting systems, the ISSE may be required to assess existing system vulnerabilities and determine mitigating strategies.

As systems have grown more complex and adversaries continue to successfully exploit numerous vulnerabilities, the need for improved secure system engineering and the formation of a larger cadre of skilled ISSEs has become more acute. The ISSE course sequence provides the knowledge and analytical skills required to contribute productively in system developments and assist in building a larger cadre of skilled ISSEs to combat adversaries.

Requirements for Entry

- Acceptance by the Department of Computer Science: Entrance to this Computer Science-managed curriculum at the Naval Postgraduate School is through a three-part requirement consisting of a minimum grade point average of 2.2 at the undergraduate level, a sufficient mathematics background, and a sufficient background in technical undergraduate studies. Undergraduate degrees in computer science, applied science or engineering are highly desirable.
- Command/Company endorsement.

Convenes

Fall, Winter, Spring, Summer

Program Length

12 months

Subspecialty

6203L

Academic Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Required Courses

Course	Title	Lecture	Lab
CS3690	Network Security	4	1
CS4600	Secure System Principles	3	2
CS4650	Fundamentals of Information Systems Security Engineering	3	1
CS4652	Applied Information Systems Security Engineering	3	2

Identity Management Certificate -- Curriculum 278

Program Manager

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Brief Overview

Identity Management (IDM) is a growing concern throughout defense, government, and private sector organizations. It includes an infrastructure that supports the identification of humans in physical space, and the logical identification of human and non-human subjects, hardware, and software in cyber space.

The IDM Certificate is offered each academic quarter and is conducted in a hybrid mode that involves a one-week program of intense IDM education at NPS followed by 9 weeks of remote learning, and culminates with an on-site (NPS campus) course work at the end of the academic quarter. The hybrid approach reduces student attrition and has resulted in considerable esprit de corps and camaraderie among the students who represent a mixture of military and government civilians.

Upon completion of the courses with adequate grades, students may apply IDM course credits toward Identity Management specializations in either the Computer Science or Information Sciences degree programs. For more information, please visit the IDM website at: imep.nps.edu.

Convenes

Fall, Winter, Spring, Summer

Program Length

The IDM Certificate takes 2 quarters, or 6 months, to complete.

Certificate Sponsor

Biometrics Task Force

Certificate Requirements

Required Courses

Course	Title	Lecture	Lab
CS3686	Identity Management Infrastructure	3	0
CS3699	Biometrics	3	0
IS3710	Identity Management Operations	3	0
IS3720	Identity Management Policy	3	0

Applied Modeling and Simulation in Healthcare - Curriculum 340 (DL)

Program Officer

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Brief Overview

This master's degree program is a joint program with the Uniformed Services University of the Health Sciences and consists of 10 courses (three courses are taught through USUHS; of the seven courses taught through NPS, four are part of the existing Modeling & Simulation in Healthcare Certificate program). The program focuses on both the fundamentals of modeling and simulation (M&S) and the broad applications of M&S to healthcare training. The intended students for this program are military and U.S. government civilian personnel who work in the DoD Military Healthcare System (MHS), specifically physicians, nurses, administrators, educators and simulation operations specialists. Admission to this program requires the approval of the program sponsor.

Program Length

36 months

Required courses

This new Master's degree program will consist of 10 courses (four of which will be completed as part of the

existing Modeling & Simulation in Healthcare Certificate program). The program will focus on both the fundamentals of modeling and simulation (M&S) and the broad applications of M&S to healthcare training.

The intended student population is healthcare professionals.

Students will complete 1 course per quarter.

Course	Title	Lecture	Lab
MV4002	Simulation and Training	4	1
MV3403	Research Methods and Statistics for Healthcare Simulation	4	1
MV4003	Technology and Simulation in Healthcare Education	3	1
MV4460	Management of Modeling & Simulation Development	4	0
MV3101	Introduction to Department of Defense Modeling and Simulation	4	0
OA3411	Introduction to Human Systems Integration	3	0
MV0810	Thesis Research	0	8
MV0810	Thesis Research	0	8
MV0810	Thesis Research	0	8

One new course will be developed, entitled "Frontiers in M&S" Three courses will be taught through USUHS: MED 555 Theory to Practice II: Instructional Methods OR MED 560: Measurement, Assessment, & Evaluation. MED 565: Theory to Practice IV: Curriculum Development\ MED 1003: Survey Design OR MED 500 Leadership Roles in HPE

Applied Computing - Curriculum 367 (DL)

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Brief Overview

The Master of Applied Computing (MAC) is a distance learning (DL) degree program that equips graduates with the essential skills and knowledge to specify, evaluate, and manage computing systems, as well as the ability to provide technical guidance in the analysis, design, and application of computing systems used in the Navy. The MAC degree is designed to be completed by combining a sequence of NPS graduate-level certificates in areas related to computing, such as computer science, cyber systems and operations, robotics, and data science. The program's flexible design provides sponsoring agencies and students the ability to achieve specific professional education goals by selecting a tailored combination of certificates. There is no thesis or capstone requirement for this degree.

The MAC degree program is open to any U.S. military officers and U.S. Government civilians, as well as international students and defense contractors, who are eligible for entry to NPS certificate programs. The Master of Applied Computing program must be completed within 5 years.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of at least two semesters of college-level algebra or trigonometry is considered to be the minimum mathematical preparation. The minimum APC requirement for entry to this program 325; in addition, APC requirements for individual certificate programs that a student undertakes for the MAC degree will apply. International students should refer to the International Graduate Programs Office for current TOEFL and NPS Admissions for other entrance requirements.

Convenes

Fall, Spring

As a fully-online stackable certificate curriculum, entry date for this program will be predicated on specific entry dates for NPS DL certificate programs being undertaken for this degree. Students may be admitted into this curriculum after beginning work on NPS certificate programs, however, all NPS certificate programs require formal admission. If further information is needed, contact the Program Officer or the Academic Associate for this curriculum or the NPS Admissions Office.

Program Length

The length of the MAC curriculum will depend upon the length of time a student must take to complete the set of certificate programs used to meet the degree requirements. The typical length of time to complete the degree is 24 months. In all cases, the NPS Academic Policy Manual (APM) states that all requirements for any master's degree must be completed within a period of five (5) years after being accepted into the degree program.

Degree Requirements

1. Completion within five years (per NPS APM) of three or four NPS DL certificates, all but one of which must be managed by the CS Department. New certificates will

be eligible for inclusion, subject to approval by CS Department.

2. Minimum 44 graduate credit hours, at least 20 hours of which are from CS, MV, or SW courses.

3. A minimum of 12 4000-level credit hours from CS, MV, or SW courses.

4. (Optional) At the preference of certain sponsors, a capstone project may be completed with three CS4920 "Advanced Topics in CS" or similar courses, as equivalent to the fourth required certificate.

Graduates of the MAC program will be able to:

- Apply current best practices to solve computing problems (analyze, design, implement and evaluate).
- Apply the knowledge of computing and data systems theory to analyze problems, assess trade-offs, and develop creative solutions.
- Analyze the current and evolving state of computing tools and technologies.
- Assess and recommend computing technology innovations in military contexts
- Demonstrate flexible communication to work with diverse teams and audiences.

Typical Course of Study

The following certificate programs show a typical course of study a student may take to complete the MAC degree in cyber security or artificial intelligence focus-areas:

Cyber Security Fundamentals

(Curriculum 256, 12.5-13 hours)

Course	Title	Lecture	Lab
CS4600	Secure System Principles -or-	3	2
CS3600	Introduction to Cybersecurity -and-	4	1
CS3670	Secure Management of Systems	3	2
CS3690	Network Security	4	1

Cyber Security Defense

(Curriculum 258, 12 hours) – choose any 3 of the following courses:

CS4558	Network Traffic Analysis	3	2
CS4600	Secure System Principles	3	2
CS4677	Computer Forensics	3	2
CS4684	Cyber Security Incident Response and Recovery	3	2

Cyber Security Adversarial Techniques

(Curriculum 260, 13.5 hours)

CS4648	Software Reverse Engineering and Malware Analysis -or-	3	2
CS4558	Network Traffic Analysis -and-	3	2

CS4678	Advanced Cyber Vulnerability Assessment	4	1
CS4679	Advances in Cyber Security Operations	4	1

Artificial Intelligence for Military Use

(Curriculum 128, 13 hours)

CS4000	Harnessing Artificial Intelligence	0	2
CS3331	Basics of Applied Artificial Intelligence	4	0
CS3332	Applied Machine Learning	4	0
CS4333	Current Directions in Artificial Intelligence	4	0

Data Science

(Curriculum 268, 14 hours)

CS4315	Introduction to Machine Learning and Data Mining	3	1
CY3650	Foundations in Data Science	3	1
OS4106	Advanced Data Analysis	3	0
OS4118	Statistical and Machine Learning	3	0

Robotics

(Curriculum 223, 17 hours)

ME3420	Computational Foundations for Robotics	3	2
EC4310	Fundamentals of Robotics	3	2
PC3014	Intermediate Applied Physics Laboratory	3	4
AE4820	Robotic Multibody Systems	3	2

Computer Science - Curriculum 368

Program Officer

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Brief Overview

The Computer Science curriculum is designed to provide the officer with the technical knowledge and skills necessary to specify, evaluate, and manage computer system design; to provide technical guidance in applications ranging from data processing to tactical embedded systems; to educate the officer in the analysis and design methodologies appropriate for hardware,

software, and firmware; and provide practical experience in applying modern computer equipment and research techniques to solve military problems.

The principles presented in the curriculum have two layers: computing mechanics deals with the workings of computations, communications, computers, and memories; and computing design deals with the ways of organizing software systems for simplicity, reliability, performance, security, and value.

Our curriculum also provides for concrete experience in computing practices—the skills and ways of thinking that mark a computing professional. These include programming, engineering of systems, modeling, and innovating. We offer a unique course called Technology, Innovation, and Leadership that teaches the practices and discipline of innovation.

The two dimensions—computing principles and practices—define the space in which the core technologies of computing exist and serve application domains: algorithms, architecture, artificial intelligence, database, networking, operating systems, security, and more.

Requirements for Entry

A baccalaureate degree, or the equivalent, with above average grades in mathematics, (including discrete math, and differential and integral calculus) resulting in an APC of at least 322 is required for direct entry. Undergraduate degrees in applied science or engineering are highly desirable. Students lacking these prerequisites may be acceptable for the program, through a "foundations" 12-week refresher quarter, provided that their undergraduate records and/or other indicators of success, such as the Graduate Record Examination (GRE), indicate an ability to work in quantitative subjects. While previous academic or practical experience in computer science is certainly helpful and can enhance the applicant's potential for admission, such experience is not a prerequisite.

Convenes

Computer Science is an eight-quarter course of study with entry dates in March and September. Prospective students requiring a 12-week "foundations" refresher will begin study one quarter prior to those entry dates. If further information is needed, contact the Academic Associate or Program Officer for this curriculum.

Degree

Master of Science in Computer Science

The degree of Master of Science in Computer Science is awarded after the satisfactory completion of a program which satisfies, as a minimum, the following degree requirements:

1. At least 40 quarter hours of graduate-level work, of which at least 12 quarter hours must be at the 4000 level.
2. At least 28 of the 40 graduate-level credit hours listed

above must be CS, MOVES, SW courses.

3. To ensure a sufficient breadth across the field of Computer Science, the following course topics must be satisfied as part of the course of study or through validation prior to graduation: Artificial Intelligence (CS3310), Networks (CS3502), Automata (CS3101), and Introduction to Computer Security (CS3600).
4. Completion of an approved sequence of courses constituting specialization in an area of computer science.
5. Completion of an acceptable thesis or a capstone project.

Requirements for the Master of Science in Computer Science degree are met as a milestone en-route to satisfying the Educational Skill Requirements established by the sponsor for the curricular program.

Subspecialty

Completion of curriculum 368 qualifies a USN officer as a Computer Science Subspecialist with a subspecialty code of 6203P.

U.S. Marine Corps officers completing this curriculum fulfill the requirements for MOS 8846.

Typical Subspecialty Jobs

Computer Science Instructor, U.S. Naval Academy
Preoperational Test and Evaluation, SPAWAR, Washington, D.C.
Computer Systems Analyst, COMNAVSECGRU, Washington, D.C.
ADP Systems Director, Naval Security Group, Pensacola, FL
Chief SEID, Joint Staff, Washington, D.C.
Operational Test and Evaluation, COMOPTEVFOR
ADP System Security, NSA/CSS, Ft. Meade, MD
National Mission Team, NSA/CSS, Ft. Meade, MD

Typical Course of Study (24-Month Track)

Refresher Quarter 0 (If Required)

Course	Title	Lecture	Lab
CS2020	Introduction to Programming	3	2
CS2001	Fundamentals of Computing Systems	3	Current: 3; New: 2
MA2025	Bridge to Advanced Mathematics	4	1
NW3230	Strategy & War	4	2

Quarter 1

Course	Title	Lecture	Lab
CS2011	Computing Systems Principles	4	0
CS3040	Low Level Programming	3	2
OS3307	Modeling Practices for Computing	4	1
CS3001	Foundations of Computer Science	3	2

Code	Title		
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 2

Code	Title		
CS3070	Operating Systems	3	2
CS3021	Introduction to Data Structures and Intermediate Programming	4	1
CS3200	Computer Architecture	3	2
CS3502	Computer Communications and Networks	3	2
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 3

Code	Title		
CS3101	Theory of Formal Languages and Automata	5	0
CS3310	Artificial Intelligence	4	1
CS3140	Low-level Programming II	3	2
CS3600	Introduction to Cybersecurity	4	1
CS4900	Technology and Transformation I	2	0

Quarter 4

Code	Title		
CS3060	Database Systems	3	1
CS3250	Introduction to Cyber Physical Systems	3	2
CS3150	Design and Analysis of Algorithms	5	0
SW3460	Software Methodology	4	1
CS4903	Research Methods in Computer Science	2	0

Quarter 5

Code	Title		
CS0810	Thesis Research	0	8
ELECT	Breadth Elective		
CS3315	Introduction to Machine Learning and Big Data	3	1
CS3004	Human-Computer Interaction	3	2
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 6

Code	Title		
CS0810	Thesis Research Specialization Requirement Specialization Requirement	0	8
NW3275	Joint Maritime Operations - part 1	4	0

Quarter 7

Code	Title		
CS0810	Thesis Research Specialization Requirement Specialization Requirement	0	8
NW3276	Joint Maritime Operations - part 2	2	2
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 8

Code	Title		
CS0810	Thesis Research Specialization Requirement	0	8
ELECT	Specialization Elective		
NW3285	Theater Security Decision Making	4	0
MN3331	Principles of Acquisition and Program Management	5	1
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

*JPME Requirements for Navy students only.

**PME Requirement for USMC students only.

Specialization Options

Specialization Core Requirement courses will be determined by the selection of one of the following specialization options.

- **Cyber Security and Defense (CSD)** - provides knowledge in all areas of Information Security (INFOSEC) and develops the necessary skills for those who will be involved in development, evolution, or implementation of secure computer systems.
- **Network and Mobility (N&M)** - provides fundamental and advanced knowledge in network architecture and system software for real-time and multicomputer systems and in the rapidly growing areas of wireless networking, mobile devices, and related topics, including mobile computing and wireless security.
- **Artificial Intelligence and Autonomous Systems (AI&AS)** - provides an understanding of artificial intelligence and human factors techniques for creating highly capable software agents that interact effectively with human users.
- **Software Engineering (SwE)** - provides knowledge of all aspects of software development and develops skills needed to efficiently and reliably implement military

systems and application software using the best available tools and techniques.

- **Cyber Operations (CO)** - provides knowledge in all areas of security provisions, information assurance and situational awareness for computer systems, networks and ICS, and their integration with Defensive Cyber Operations, Offensive Cyber Operations, and DoD Global Information Grid Operations.
- **CS-MOVES** - Students interested in an MSCS degree with a focus on Modeling, Simulation, and Virtual Environments (MOVES) may choose the CS-MOVES specialization. Specialization course work will be coordinated by the student working with his/her MOVES thesis advisor, and must be approved as part of the thesis proposal.

Educational Skill Requirements (ESR)
Computer Science - Curriculum 368
Subspecialty Code: 6203P

The Computer Science and System Design subspecialty code (6203) is intended to serve the Navy by providing commands with officers who possess expertise related to the specification, development, installation, maintenance, evaluation, security, and mission assurance of hardware and software computer systems and networks. The officer must have the theoretical knowledge and practical expertise to perform technical and operational oversight responsibilities related to computer systems. This knowledge and expertise supports operating the network as a warfighting platform, conducting tailored signals intelligence, delivering warfighting effects through cyberspace, and creating shared cyber situational analysis. Particular skills and competencies that constitute this subspecialty are detailed below:

1. **Fundamental Computer Science:** Architectures, virtualization, operating systems, computer networks, high- and low-level languages and their translation, software systems, human-computer system interaction, and supporting mathematical foundations of Computer Science.
2. **Software Development:** Planning and development of large software projects to include specification of requirements, design, technical documentation, configuration management, implementation, risk analysis, testing, quality assurance, maintenance, process metrics, and measures of effectiveness through the use of modern software engineering techniques and tools.
3. **Analysis:** Application of scientific methods to determine reliability, efficiency and performance of computer systems; modeling, simulation, and analysis of algorithms, processes, and systems in support of Naval operations.
4. **Data Systems and Management:** Devices, interfaces and interconnects; storage architectures and data organizations, addressing and indexing; continuity, backup and recovery; resilience; models, analytics, and visualization; large data sets, and data mining.
5. **Autonomous Systems:** Design, construction, and operation of autonomous systems including unmanned vehicles; analysis tools for security, forensics and intelligence. Basic skills include artificial intelligence, knowledge management and representation, machine learning, heuristic search, and data mining.
6. **Cyber-Security and Cyber Operations:** Development, implementation and management of security provisions, information assurance and situational awareness, and risk management framework for computer systems, networks and control systems, cloud infrastructure, and their integration with Defensive Cyber Operations, Offensive Cyber Operations, and DoD Information Network (DODIN) Operations.
7. **Networking and Distributed Computing:** Modeling, design and implementation of network infrastructures for distributed and mobile systems. Application of distributed multi-core and multi-processor systems in High Performance Computing (HPC) and cloud computing configurations to support analysis, forensics, engineering, management, and other "big data" applications that apply to military operations.
8. **Specialization:** In addition to the breadth obtained from the collection of previous items, the officer will complete a series of advanced courses that integrate computer science in DOD systems, software, and operations. This in-depth study conveys essential real-world complexities and details that are required to make informed decisions during every stage of computer systems' lifecycles. Knowledge is deepened through thesis research in a framework that exercises the practices of innovation, problem solving, systems-thinking, and real-world application.

Joint Professional Military Education (JPME)

Per community requirements, the officer will have an understanding of warfighting within the context of operational art to include: strategy and war, theater security decision making, and joint maritime operations. Completing the Naval War College four-course series leading to Intermediate Level Professional Military Education and JPME phase I certification fulfills this requirement.

Identity Management and Cyber Security - Curriculum 378

(Resident - 12 months)

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Brief Overview

The Master of Arts in Identity Management and Cyber Security (MAIDMCS) degree provides individuals whose organizations depend upon cyberspace a broad overview of cyber security technology and how to create a balance between risks and benefits based upon the physical and virtual assets requiring protection. The program focuses on cyber security as enabling technology for a broad range of enterprise initiatives and is intended for leaders in a wide range of government activities regardless of organizational specialization. The MAIDMCS program consists of 12 courses selected to provide breadth and depth in the latest security technologies.

Designed to accommodate busy individuals, the Master of Arts degree program is offered in a hybrid mode that requires participants to be in residence (at the Naval Postgraduate School in Monterey, California or possibly another location to be determined) two weeks each quarter (for a total of 12 weeks). Participants complete the balance of their coursework via network-based distance learning methods. The program can also be taken entirely at NPS and is of shorter duration in this mode. Participants complete an applications project for which a written report is required.

Requirements for Entry

A baccalaureate degree, or the equivalent, resulting in an academic profile code (APC) of at least 344 is required. While previous academic or practical experience in computer science or a related field is not a prerequisite. Active/Active Duty Reserve U.S. military, DoD civilian, and US Government civilian personnel are eligible.

Convenes

The MAIDMCS degree is designed to be either a 6-quarter (two courses per quarter) hybrid mode or a 4-quarter fully resident model, convening in the Fall. For further information, contact the Program Manager or Academic Associate for this curriculum.

Degree

Master of Arts in Identity Management and Cyber Security

The Master of Arts in Identity Management and Cyber Security degree is awarded after the satisfactory completion of a program that satisfies, as a minimum, the following degree requirements:

1. At least 40 quarter-hours of graduate-level work, per NPS requirements.
2. Completion of the specific sequence of courses satisfying the breadth and subject matter requirements of Identity Management and Cyber Security.
3. Completion of an applications project.

Subspecialty

None currently assigned.

The degree provides participants with the knowledge and skills to:

- Understand the synergistic nature of many aspects of cyber security. These include the interrelationships between cyber defense, cyber operations, cyber attack, and cyber exploitation, as well as major security objectives for next generation cyber systems.
- Develop strategies and plans for securing information assets on IT systems in the face of cyber attacks.
- Understand the impact of acquisition and architectural decisions on the security of information and systems.
- Appreciate the nature of cyber threats and how coherent and holistic choices can support requirements for sharing and productivity.
- The MAIDMCS degree is fully accredited and taught by the NPS faculty.

Typical Course of Study

(The typical 6 quarter (18-month) hybrid course of study is shown below.)

Quarter 1

Course	Title	Lecture	Lab
CS3699	Biometrics	3	0
IS3710	Identity Management Operations	3	0
CS3621	Applications Project and Research for Identity Management and Cyber Security Students	0	V

Quarter 2

Course	Title	Lecture	Lab
CS3686	Identity Management Infrastructure	3	0
IS3720	Identity Management Policy	3	0
CS3621	Applications Project and Research for Identity Management and Cyber Security Students	0	V

Quarter 3

Course	Title	Lecture	Lab
CS3600	Introduction to Cybersecurity	4	1
CS3505	Introductory Computer Communications	3	2

CS3621	Applications Project and Research for Identity Management and Cyber Security Students	0	V

Quarter 4

CS3670	Secure Management of Systems	3	2
CS3610	Information Ethics, Crime, and Law -or-	4	0
DA3105	Conflict and Cyberspace	4	1
CS3621	Applications Project and Research for Identity Management and Cyber Security Students	0	V

Quarter 5

CS3636	Data Fusion with Online Information Systems	3	0
CS3633	Data Security	3	2
CS3621	Applications Project and Research for Identity Management and Cyber Security Students	0	V

Quarter 6

CS3640	Analysis of DoD Critical Infrastructure Protection	3	1
CS3645	Cyber Threats and Mitigation	3	0
CS3621	Applications Project and Research for Identity Management and Cyber Security Students	0	V

Typical Course of Study

(Accelerated 12-month Format Hypothetical Schedule.)

Quarter 1

Course	Title	Lecture	Lab
CS3699	Biometrics	3	0
IS3710	Identity Management Operations	3	0
CS3505	Introductory Computer Communications	3	2
CS3621	Applications Project and Research for Identity Management and Cyber Security Students	0	V
ELECT	Elective		

Quarter 2

CS3686	Identity Management Infrastructure	3	0
IS3720	Identity Management Policy	3	0

CS3621	Applications Project and Research for Identity Management and Cyber Security Students	0	V
CS3600	Introduction to Cybersecurity	4	1
ELECT	Elective		

Quarter 3

CS3670	Secure Management of Systems	3	2
CS3610	Information Ethics, Crime, and Law -or-	4	0
DA3105	Conflict and Cyberspace	4	1
CS3621	Applications Project and Research for Identity Management and Cyber Security Students	0	V
CS3633	Data Security	3	2
ELECT	Elective		

Quarter 4

CS3640	Analysis of DoD Critical Infrastructure Protection	3	1
CS3636	Data Fusion with Online Information Systems	3	0
CS3645	Cyber Threats and Mitigation	3	0
CS3621	Applications Project and Research for Identity Management and Cyber Security Students	0	V

Computer Science PhD - Curriculum 384

PhD Committee Chair

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Brief Overview

The Ph.D. is the highest degree awarded by universities in

the United States and represents the pinnacle of academic achievement. The mission of the Ph.D. degree program in Computer Science is to provide an advanced education in Computer Science to both U.S. and international military personnel and government civilians, advance the basic understanding of the theory and practices of computing, and contribute to the creation and consolidation of knowledge in computer science for the U.S. Department of Defense. We equip our students with the expertise necessary to independently perform state-of-the art research, to formulate and develop creative solutions to novel and existing problems, and to intelligently manage the research of others. In addition to a resident curriculum, the program also supports distance learning options to accommodate special circumstances of military or government civilian students who cannot leave their duty stations on a long-term basis.

Requirements for Entry

U.S. military officers, foreign military officers, U.S. government civilians and employees of foreign governments may apply. An applicant should have a master's degree (or in progress of getting a master's degree) in Computer Science. Generally, an acceptable Ph.D. applicant must have above-average grades in a typical master's degree program. The Computer Science Ph.D. Committee will also take other evidence of research or academic ability into account in making a recommendation as to whether to admit an applicant.

Specifics on the Ph.D. in Computer Science program are found in the linked CS Department Ph.D. Handbook.

Convenes

Fall, Spring

Modeling, Virtual Environments, and Simulation (MOVES) PhD - Curriculum 398

PhD Committee Chair

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Brief Overview

The Modeling, Virtual Environments and Simulation (MOVES) Academic Program of the Naval Postgraduate School provides the Ph.D. student both fundamental and specialized courses in applied visual simulation technology, combat models and systems, and the application of quantitative analyses to training and simulation technology. Areas of special strength amongst the MOVES Academic Faculty are combat modeling and analysis, networked and web-based visual simulation, agents and cognitive modeling, training systems and human factors, and discrete-event simulation.

Convenes

Fall

Doctorate in Modeling, Virtual Environments, and Simulation

The Ph.D. degree requires the equivalent of at least three academic years of study beyond the baccalaureate level (some of which may be for another post-baccalaureate degree), with at least one academic year (or its equivalent) being spent in residence at NPS. The student must complete, in order, the following steps, which are detailed at https://nps.edu/web/moves/doctor-of-philosophy.

1. Form a dissertation committee
2. Pass a written qualifying examination
3. Declare a secondary specialization
4. Pass an oral qualifying examination
5. Pass a final examination
6. Complete a dissertation

No courses are required for the Ph.D. degree besides the secondary specialization unless the student's doctoral committee so stipulates.

Ph.D. Minor in Modeling, Virtual Environments, and Simulation

A Ph.D. minor in Modeling, Virtual Environments, and Simulation consists of:

1. Three courses at the 4000 level that form a coherent sequence relating to Modeling, Virtual Environments, and Simulation.
2. The courses must be from at least two departments or academic groups.
3. The head of the MOVES Ph.D. program will write a letter attesting that the student has fulfilled the requirements upon request of the student.

Modeling, Virtual Environments, and Simulation (MOVES) - Curriculum 399

Program Officer

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Brief Overview

The Modeling, Virtual Environments and Simulation (MOVES) Academic Program of the Naval Postgraduate School provides the MS student both fundamental and specialized courses in applied visual simulation technology, combat models and systems, and the application of quantitative analyses to training and simulation technology.

The MS program is an eight-quarter program whose core covers the fundamentals of modeling and simulation, data analysis, visual simulation, intelligent systems, training, and human performance. These topics include object-oriented programming, probability, statistics, stochastic modeling, data analysis, acquisition and program management, artificial intelligence, computer graphics, simulation and training, and combat modeling systems. The MS student demonstrates depth by the completion of a written thesis.

Requirements for Entry

A baccalaureate degree, or the equivalent, with above average grades in mathematics (including differential and integral calculus), resulting in an APC of at least 325 is required for entry. Undergraduate degrees in applied science or engineering are highly desirable. Students lacking these prerequisites may be acceptable for the program, through the 12-week technical refresher or 12-week Engineering Science program, providing their undergraduate records and/or other indicators of success, such as the Graduate Record Examination (GRE), indicate an ability to work in quantitative subjects. While previous academic or practical experience in modeling, virtual environments, and simulation is certainly helpful and can enhance the applicant's potential for admission, such experience is not a prerequisite.

Convenes

MOVES is an eight-quarter course of study starting annually in July. If further information is needed, contact the MOVES Academic Associate or the MOVES Program Officer for this curriculum.

Degree

Master of Science in Modeling, Virtual Environments, and Simulation

The degree of Master of Science in Modeling, Virtual Environments, and Simulation is awarded after satisfactory completion of a program which satisfies, as a minimum, the following degree requirements:

1. At least 40 quarter-hours of graduate-level work, of which at least 12 quarter-hours must be at the 4000 level.
2. Completion of an approved sequence of courses constituting specialization in an area of Modeling, Virtual Environments, and Simulation.
3. Completion of an acceptable thesis in addition to the required course work.

Requirements for the Master of Science in Modeling, Virtual Environments, and Simulation are met as a milestone en-route to satisfying the Educational Skill Requirements established by the sponsor for the curricular program.

Completion of the eight-quarter sequence of courses specified below is required to satisfy the Educational Skill Requirements for the Navy 6202P code and Marine MOS 8825.

Subspecialty

Completion of this curriculum qualifies an officer as a modeling, virtual environments, and simulation subspecialist with a Navy subspecialty code of 6202P or Marine Corps MOS 8825.

Marine Corps MOS 8825.

Typical Subspecialty Jobs

TBD

Course of Study

(MOVES (399) Matrix, All Students)

Quarter 1

CS2020	Introduction to Programming	3	2
MA1113	Single Variable Calculus I	4	0
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
MV3101	Introduction to Department of Defense Modeling and Simulation	4	0
MV2921	Introduction to Modeling, Virtual Environments and Simulation	2	0

Quarter 2

CS2072	Fundamental Object Oriented Programming in JavaScript	4	1
OS3111	Probability and Statistics for HSI and MOVES	4	0
MA2025	Bridge to Advanced Mathematics	4	1
SE3100	Fundamentals of Systems Engineering	3	2

Quarter 3

Course	Title	Lecture	Lab
CS2173	Java as a Second Language	4	1
OS3113	Data Analysis for HSI and MOVES	4	1
MV3025	Artificial Intelligence for Simulations	4	1
MV3202	Introduction to Computer Graphics	3	2
MV3922	Introduction to Virtual Environment Technology	2	0

Quarter 4

Course	Title	Lecture	Lab
OS3112	Statistics and Design of Experiments	4	2
MV3203	Graphical Simulation	3	2
MV3302	Introduction to Discrete Event Simulation Modeling	4	1
MV3923	Introduction to Research in Modeling, Virtual Environments & Simulation	2	0
MV4002	Simulation and Training	4	1

Quarter 5

Course	Title	Lecture	Lab
MV4025	Cognitive and Behavioral Modeling for Simulations	3	2
MV4502	Simulation Development Practicum	2	4
MV3500	Internetwork Communications and Simulation	3	2
MV4501	Simulation Application Practicum	2	4
MV4924	Current Topics in Modeling, Virtual Environments & Simulation	1	1

Quarter 6

Course	Title	Lecture	Lab
OA4655	Introduction to Joint Combat Modeling	4	0
MV0810	Thesis Research	0	8
MV4001	Human Factors of Virtual Environments	4	1
MV4503	Simulation Interoperability Practicum	2	4
MV4924	Current Topics in Modeling, Virtual Environments & Simulation	1	1

Quarter 7

Course	Title	Lecture	Lab
MN3331	Principles of Acquisition and Program Management	5	1
MV0810	Thesis Research	0	8
MV4504	Design and Implementation of Live, Virtual, Constructive (LVC) Events	2	4
MV4920	Advanced Topics in Advanced Modeling, Virtual Environments and Simulation	V	V
MV4924	Current Topics in Modeling, Virtual Environments & Simulation	1	1

MN3331: DOD students only. Non-DOD students take MN3031 instead.

Quarter 8

Course	Title	Lecture	Lab
MV0810	Thesis Research	0	8
MV0810	Thesis Research	0	8
OA4604	Wargaming Applications	3	2
MV4460	Management of Modeling & Simulation Development	4	0
MV4924	Current Topics in Modeling, Virtual Environments & Simulation	1	1

Educational Skill Requirements (ESR)
Modeling, Virtual Environments, and Simulation (MOVES) - Curriculum 399
Subspecialty Code: 6202P / MOS: 8825

The MOVES curriculum prepares students to be the Department of Defense's experts in Modeling, Virtual Environments and Simulation. They are able to provide both technical and managerial leadership in all areas of simulation development, sustainment, and application. Their rigorous technical background enables them to quickly adapt to a rapidly evolving technical landscape.

1. **Modeling and Simulation (M&S) Foundations:** The graduate will understand the capabilities, limitations, history, and terminology of the M&S domain. The graduate will understand the concepts and applicability of wargaming, simulation tools, conceptual models, statistical models, discrete modeling, artificial intelligence, physics-based modeling, visual representation, and data standards to complex problems within the military domain. This understanding will be based in probability theory, calculus, linear algebra, and data analysis techniques that will enable the graduate to fully understand modeling of uncertainty and randomness within these complex domains.

2. **M&S in the DoD:** The graduate will have a thorough understanding of the DoD M&S organizations, current policies, and M&S trends at both the DoD and individual Service levels. Moreover, the graduate will understand and be able to apply the capabilities and limitations of simulations across the DoD M&S application domains. In addition, the graduate will understand the process of verification, validation and accreditation (VV&A), particularly current industry best practices. Finally, the graduate will have a solid understanding of information assurance and cyber security policies, organizations, requirements, and vulnerabilities, with particular emphasis on who is responsible for cyber security in the military structure and how M&S interfaces with that structure.

3. **Models and Modeling Techniques:** The graduate will understand the various modeling systems in current military use (e.g. queuing theory, discrete event simulation, detection and engagement models, and environmental models) with an emphasis on ballistic, weapon, terrain, vegetation, cultural, and weather effects on military concepts (i.e., mobility, survivability, and firepower) that achieve military objectives. The graduate will be able to practically apply techniques (both designing and programming) such as: event graphs; aggregate versus entity-level modeling; weapons effect modeling (e.g., blast, thermal, acoustic); high fidelity, destructible terrain within a virtual 3D environment. The graduate will understand the state of the art of abstract representations of culture, social relationships, and information structures in the military context including human communication and stability models in a political, military, economic, social, information, and infrastructure (PMESII) environment. Furthermore, the graduate will understand how physics can be modeled at varying degrees of resolution and the tradeoffs inherent to more simplified models. Finally, the graduate will understand the fundamentals of intelligent systems and machine learning in the context of agent-based systems.

4. **Simulation Software Development:** The graduate will understand and have demonstrated the ability to: use systems engineering processes to specify operational, functional, and technical requirements; program and analyze software-intensive systems; incorporate traditional and non-traditional human system interface devices to include augmented reality un-occluded heads up displays (HUD) and motion capture. Additionally, they will be able to design and document conceptual models with the appropriate analysis of alternatives, and plan and execute both developmental and operational testing events in support of VV&A.

5. **Military Applications:** The graduate will understand the capabilities and limitations of and have demonstrated the ability to apply M&S to training and analysis applications using simulations in current use by DoD Services, as practical. This understanding will include task-condition-standards methodologies for skills and staff actions within the appropriate training environment, including interfacing with (C4I) systems. The graduate will be able to plan, prepare, execute, and conduct after-action review training exercises using human performance evaluation techniques that ensure positive training transfer occurs. In addition, the graduate will be able to apply analysis simulations to answer a commander's critical information requirements, including via wargaming (both seminar and simulation supported).

6. **Simulation Interoperability:** The graduate will understand and be able to design distributed simulations in a net-centric environment, while considering hardware and software requirements, simulation data, control data, voice data, and technical standards for connectivity. In addition, the graduate will have a detailed understanding of simulation federations within LVC environments, with particular emphasis on capabilities, limitations, strengths, and weaknesses of modern single and mixed architectures. The graduate's understanding will also include augmented reality, C4I stimulation, basic networking architectures and communication protocols, and standards for data and communication networks as well as the technical development processes, and open-source standard capabilities and limitations' impacts on interoperability.

7. **Business Practices:** The graduate will understand the underlying concepts, fundamentals and philosophies of the Department of Defense systems acquisition process and the practical application of program management methods within that process. Specifically, they will understand management characteristics and competencies, control policies and techniques, systems analysis methods, and functional area concerns. The graduate will gain a program management perspective on the evolution and current state of: systems acquisition management; the system acquisition life cycle; requirements analysis; contract management; resource management; test and evaluation; user-producer acquisition management disciplines and activities; and program planning, organizing, staffing, directing and controlling processes.

8. **Thesis:** The graduate will demonstrate the ability to conduct independent research and analysis in the area of M&S and proficiency in presenting the results in writing by means of a thesis appropriate to this curriculum.

Curriculum Sponsor and ESR Approval Authority

USN - Director, Navy Modeling and Simulation Office (NMSO); USMC - Deputy Commandant for Combat Development and Integration (CD&I).

Department of Defense Analysis

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* The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

John Arquilla, Distinguished Professor (1993); Ph.D., Stanford University, 1991.

Leo Blanken, Associate Professor (2008); Ph.D., University of California, Davis, 2006.

Douglas Borer, Associate Professor (2004); Ph.D., Boston University, 1993.

Robert Burks, Associate Professor (2015); Ph.D., Air Force Institute of Technology, 2006.

Daniel Cunningham, Lecturer (2010); M.S., Middlebury Institute of International Studies, 2009.

Dorothy Denning, Distinguished Professor Emerita (2002); Ph.D., Purdue University, 1975.

Michael Donovan, National Intelligence Chair (2019); Ph.D., University of Edinburgh, 2000.

Sean Everton, Professor (2007); Ph.D., Stanford University, 2007.

Michael Freeman, Professor (2005); Ph.D., University of Chicago, 2001.

Frank Giordano, Professor Emeritus (2002); Ph.D., University of Arkansas, 1975.

Brian Greenshields, Senior Lecturer (2009); M.A., Naval Postgraduate School, 1989.

Shannon Houck, Assistant Professor (2020); Ph.D., University of Montana, 2015.

Ryan Maness, Assistant Professor (2017); Ph.D., University of Illinois, 2013.

Gordon McCormick, Professor (1992); Ph.D., Johns Hopkins University, 1986.

Siamak Naficy, Senior Lecturer (2011); Ph.D., UCLA, 2010.

Wayne Porter, Senior Lecturer (2015); Ph.D., Naval Postgraduate School, 2014.

Nancy Roberts, Professor Emerita (1986); Ph.D., Stanford University, 1983.

Glenn Robinson, Associate Professor (1991); Ph.D., University of California at Berkeley, 1992.

Kalev Sepp, Senior Lecturer (2003); Ph.D., Harvard University, 2002.

Anna Simons, Professor Emerita (1998); Ph.D., Harvard University, 1992.

Bradley Strawser, Associate Professor (2012); Ph.D., University of Connecticut, 2012.

Kristen Tsolis, Lecturer (1999); M.S., Middlebury Institute of International Studies, 1999.

Tristan Volpe, Assistant Professor (2017); Ph.D., George Washington University, 2015.

Timothy Camber Warren, Associate Professor (2012); Ph.D., Duke University, 2008.

Brief Overview

The Department of Defense Analysis is an interdisciplinary association of faculty, representing a wide range of academic and operational specialties. The Department has three curricula: the Special Operations/Irregular Warfare curriculum; the Information Strategy and Political Warfare curriculum; and the Applied Design for Innovation curriculum.

The Special Operations/Irregular Warfare curriculum provides a focused course of instruction in irregular warfare, sub-state conflict, terrorism and counterterrorism, and other "high leverage" operations in U.S. defense and foreign policy. The core program also provides every student with a strong background in strategic analysis, decision modeling, organization theory, and formal analytical methods. The student's program is built around a common set of core courses and a selected specialty track. Currently the tracks offered are: Irregular Warfare, Information Operations, Terrorist Operations and Financing, Strategic Forecasting and Decision making, Operations Analysis, Combat Systems, Financial Management, C4I Systems, and National Security Affairs

(Regional Studies). The individual student, depending on his or her interests and academic background, chooses the specialty track. In selected cases, students are also able to develop a tailored area of specialization to satisfy a particular interest or requirement. Graduates are awarded a Master of Science in Defense Analysis, with their specialty track so specified.

While the Special Operations/Irregular Warfare curriculum is sponsored by U.S. Special Operations Command, the curriculum actively solicits student participation from across the services, regardless of branch or specialty code. International students are an important element of the program. Students are encouraged to apply for the Winter or Summer Quarter, permitting them to take maximum advantage of the program's sequenced course of instruction. Exceptions are approved by the Academic Associate. The program is 18 months long and requires a completed thesis.

The goal of the Information Strategy and Political Warfare curriculum is to educate military personnel and civilian officials of the United States and its Allies in the strategic and operational dimensions of information relative to the use of force as an instrument of statecraft.

The curriculum is designed for both the specialist who will be assigned to an information operations position and the generalist who will be assigned to an operations directorate. The curriculum includes a core of military art and operations, the human dimension of warfare emphasizing psychological warfare and military deception, analytical methods, and a technical sequence customized for each student that may include concentrations in cyber systems and operations, electronic warfare, intelligence support to Information Strategy and Political Warfare and computer network operations. Additional areas of concentration are available to meet specific student and organizational requirements. Finally, each student will write a thesis relevant to the field of information operations. The Information Strategy and Political Warfare curriculum is designed to develop the following competencies in its graduates:

- Analyze the global information environment and assess its impact on national security strategy.
- Analyze the role of information operations in national military strategy and maximize it contributions to national military power.
- Analyze information operations' role in national information strategy and maximize its contributions to the non-military elements of national power.
- Evaluate the relationships, linkages and dependencies between intelligence and information operations.
- Analyze the contributions of the interagency community to information operations and vice versa.
- Analyze non-US approaches to, capabilities, and doctrines for information operations.
- Analyze the use of information operations to achieve

desired effects across the spectrum of national security threats.
- Analyze how information operations are integrated to support the national military and security strategies and the interagency process.
- Analyze how information operations apply at the operational and strategic levels of war and how they support the operations of a networked force.
- Evaluate the national security technological environment as an enabler for current and future competitive advantage.
- Detect enemy cyber fires and plan defensive and offensive cyber operations.
- Analyze the principles, capabilities and limitations of information operations across the range of military operations, to include pre and post-conflict operations.

This program is open to all branches of the military, federal employees, international military officers and government sponsored civilians.

The goal of the Applied Design for Innovation curriculum is to provide students with experiential learning around the challenges of innovation. Students will use a blend of design-thinking and analytic social science methods to engage in the problem-framing, ideation, creative collaboration, and stakeholder engagement necessary for successful innovation. This curriculum is designed to meet the changing needs of Naval Special Warfare in the context of rapidly changing technology and Great Power Competition.

Army, Air Force, Navy, and USMC graduates who also complete the approved 4-course Naval War College JPME curriculum also receive credit for JPME 1 and their Service-particular Intermediate Level Education (ILE/IDE).

Degree

Master of Science in Defense Analysis

Master of Science in Information Strategy and Political Warfare

Master of Science in Applied Design for Innovation

Defense Analysis Course Descriptions

DA Courses (p. 351) (p.362) (p.343)

SOF Support to Regional Governance Certificate - Curriculum 108

Academic Associate

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Program Officer

David Hawk, LTC, U.S. Army

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Brief Overview

SOF Support to Regional Governance certificate integrates academic study with Special Operation Forces governance study on the application of theories, methods, and practices of governance-based support in competition, conflict, austere, denied, and politically sensitive environments. Review of US National policies guide principles for shaping USG objectives in civil-military operations and help inform decisions to support local and national governance efforts. Comprised of classes from the Defense Analysis and National Security Affairs Departments, this certificate further integrates ARSOF officers and Foreign Area Officers through governance studies and regional classes preparing for mutually supportive relationships in a specific COCOM.

Convenes

Winter

Program Length

18 months

The SOF Support to Regional Governance Certificate provides students with a Master's level education on the interplay and dynamic variables impacting the establishment and functionality of governance norms within a given region. This Regional Certificate aligns the study of Special Operational Forces capabilities with NSA Department regional courses to enable students the opportunity to analyze and apply the viability of Special Operations activities to achieve desired end states and objectives within their region of study. The focused study of the history, cultural norms, geographic impacts, and foreign influences on the development of power dynamics within a region from the local to the transnational levels will inform the student on the viability of various governance practices within a given region and the appropriate USG resources to apply.

Course Requirements

Note: Each Quarter represents a different sub-group. All three classes can be taken in one quarter or extended over the course of a student's study at NPS.

Quarter 1 - Mandatory DA4038 course Group 1

Course	Title	Lecture	Lab
DA4038	SOF Support to Governance	4	0

Quarter 2 - representing all classes available in Group 2

A student must choose one of these courses:

NS3021	Defense Capability Development	4	0
NS3025	Introduction to Civil-Military Relations	4	0
NS3235	Civil Wars	4	0

NS3900	International Law and Organizations	4	0
NS4225	Civil-Military Relations and Transitions to Democracy	4	0
NS4260	Hybrid Warfare	4	0
NS4332	Ethnicity and Ethnic Conflict in the Developing World	4	0

Quarter 3 - Courses for Group 3

A student must choose one regional course. These regional courses are based on Combatant Command (COCOM) affiliation. Students can choose one course from their assigned COCOM from the lists below.

INDOPACOM

NS3412	Government and Security in the Central Asian Republics	4	0
NS3620	Survey of Asian Politics	4	0
NS3645	Political Economy of Asia	4	0
NS3661	Politics in China	4	0
NS3662	Government and Security in Japan	4	0
NS3664	Government & Security in Southeast Asia	4	0
NS4641	Political and Ethnic Violence in South East Asia	4	0
NS4642	Chinese Foreign Policy	4	0
NS4667	Political Economy and Security in South Asia	4	0

CENTCOM

NS3315	Modern Arab History	4	0
NS3330	Comparative Politics of the Middle East	4	0
NS3802	Counter-terrorism Policy in Comparative Perspective	4	0
NS4315	Security and Politics in Iran	4	0
NS4326	Social Mobilization and Conflict in the Middle East and Africa	4	0
NS4663	Politics and Security in Pakistan and Afghanistan	4	0

AFRICOM

NS3040	The Politics of Global Economic Relations	4	0
NS3301	African History and Cultures	4	0
NS3311	Government and Politics in Sub-Saharan Africa	4	0

| NS3321 | U.S. Foreign Policy towards Africa | 4 | 0 |
| NS3802 | Counter-terrorism Policy in Comparative Perspective | 4 | 0 |

EUCOM

NS3040	The Politics of Global Economic Relations	4	0
NS3400	History of Russia and Eurasia	4	0
NS3401	Contemporary Politics of Russia	4	0
NS3412	Government and Security in the Central Asian Republics	4	0

SOUTHCOM

NS3040	The Politics of Global Economic Relations	4	0
NS3510	Government and Politics in Latin America	4	0
NS3520	Latin American International Relations	4	0
NS3580	Comparative Border Security	4	0
NS3802	Counter-terrorism Policy in Comparative Perspective	4	0
NS4550	Government and Politics in Mexico	4	0

NORTHCOM

NS3040	The Politics of Global Economic Relations	4	0
NS3520	Latin American International Relations	4	0
NS3580	Comparative Border Security	4	0
NS3802	Counter-terrorism Policy in Comparative Perspective	4	0
NS4550	Government and Politics in Mexico	4	0

Social Network Analysis, Research, and Practice Certificate - Curriculum 239

Program Officer

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Academic Associate

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Brief Overview

The new ESRs (educational skills requirements) for SOF graduates includes a focus on transnational dark networks. Since 2007 the CORE Lab, which is embedded in the Defense Analysis Department, has focused on offering students the opportunity to develop the analytical skills for disrupting dark networks. The purpose of this certificate program is to recognize students who have developed such skills. By completing the program they will acquire the theoretical and methodological tools for applying social network analysis to situations that many will encounter in the field after they graduate.

Convenes

Fall, Winter, Spring, Summer

Program Length

Six quarters

Provide students with social network analysis's methodological, theoretical, and analytical tools for:

1. Tracking and disrupting dark networks (e.g., terrorist networks, drug cartels, violent extremist organizations)
2. Enhancing the robustness of light networks (e.g., Counter WMD, SOCOM, Civil Affairs)
3. Examining key regional and global networks at the forefront of great power competition in order to improve operational effectiveness
4. Influencing resistance (social) movements (e.g., insurgencies, social revolutions)
5. Deriving "narratives" from social media networks (e.g., Twitter, YouTube)
6. Fusing social network analysis with spatial and temporal analyses because social networks operate spatially and are dynamic in nature
7. Accounting for the complexity of social networks in decision-making by considering non-linear, emergent, and evolutionary processes in real-world contexts

Certificate Requirements

Students will be required to take three or more classes that are methodologically and/or theoretically related to social network analysis.

Students will need to take at least 2 of the following 3 courses:

Course	Title	Lecture	Lab
DA3610	Visual Analytics	4	0
DA4600	Dark Networks	4	0
DA4610	Dynamic Network Analysis	4	0

DA4610 - Dynamic Network Analysis (R for SNA)

And at least 1 of the following 2 courses:

DA3721	Networks and Religion	4	0
DA4106	Trust, Influence and Networks	4	0

Masters of Science in Applied Design for Innovation - Curriculum 697

Academic Associate

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Brief Overview

This curriculum provides students with experiential learning around the challenges of innovation. Students will use a blend of design-thinking and analytic social science methods to engage in the problem-framing, ideation,& creative collaboration, and stakeholder engagement necessary for successful innovation. This curriculum is designed to meet the changing needs of Naval Special Warfare in the context of rapidly changing technology and Great Power Competition.

Convenes

Summer

Program Length

18 months

Subspecialty

2500P

Typical course of study

There are two sets of required courses for the 697 degree. One is the "common core" of DA courses (shared by DA 699 and 698); the second set of requirements are specific for 697 students.

Common Core (for all DA curricula)

Course	Title	Lecture	Lab
DA2010	Technical Writing and Composition	4	0
DA2410	Modeling for Military Decision Making, I	4	0
DA4710	Critical Thinking and Ethical Decision Making	4	0
DA3410	Modeling for Special Operations II	4	0
DA4460	Alternate Research Methods and Defense Analysis	4	0
DA3880	History of Special Operations	4	0

697 Requirements

DA4302	Coping with Wicked Problems	4	0
DA4104	Militaries and Technological Change	4	0
DA3301	Principles of Strategic Design	4	0
DA3302	Navigating Innovation Ecosystems	4	0
DA3304	Rapid Prototyping for the Warfighter	3	2

Educational Skill Requirements:

1. **Military Art and Operations:** Graduates will understand the organization, formulation, and execution of national security strategy and national military strategy; the effects of technical developments on warfare; the capabilities and roles of military forces throughout the entire spectrum of conflict; and current defense issues.

2. **Special Operations Doctrine, Concepts, Capabilities and Institutions:** Graduates will have a detailed and conceptual understanding of the development of doctrine for special operations. Work in this area should focus, first, on the defining events and experiences that have stimulated doctrinal and institutional innovations in Special Operations (SO) and, second, on the forms these innovations have taken. This examination should cover the period from the end of World War II through the post-Cold War era. These and related issues should be explored creatively in an effort to uncover the appropriate roles, missions, strengths, and limitations of military power in the emerging multipolar environment.

3. **Revolution in Military Affairs:** Students will understand how new technologies are changing the shape of modern warfare. An important aspect of this requirement is to examine the likely impact of these developments on the dynamics and characteristics of twenty-first century warfare across operational environments, ranging from irregular warfare to peer competition. The student will examine major technological developments and trends and how technology interacts with issues of strategy, doctrine, organizations, and human agency.

4. **Strategic and Operational Complexity:** Special Operations is a style of warfare. No traditional single academic discipline can adequately address the educational requirements of the SO community, so an interdisciplinary approach is required. Each student will develop a course of study that permits him or her to pursue a disciplinary orientation that best suits their particular academic background and interests within the substantive limits of the other ESRs.

5. **Analytical Methods and Applications:** Graduates will have a foundation in analytical methods and their application to military modeling, simulations, and gaming. Close attention will be given to the ways in which such analytical techniques can be used in heuristic and decision-making tools for strategic and operational planning. Attention will be given to both historical and contemporary military applications with particular focus

on the ways in which such techniques can be used to address issues of interest to the joint information operations community.

6. **Ethics and Standards of Conduct:** The graduate will have an ability to manage and provide leadership in the ethical considerations of special operations, including the strategic environment, organizational culture, and risk management, as well as defense acquisition, including the provisions of procurement integrity, and to appropriately apply defense acquisition standards of conduct.

7. **Innovation Networks and Systems:** Graduates will have a systems-level understanding of innovation ecosystems, including defense, government, academic, private, and foreign. As divergent perspectives on problem framing and design constraints have proven benefit for solving difficult problems, students are expected to explore, engage, and partner with organizations and individuals external to the Naval Postgraduate School.

8. **Utilization of Design Approaches:** Students will absorb and use design methodologies within the program. These methodologies are intended to generate creative innovative solutions and manage stakeholder relations, while leveraging other scientific and engineering disciplines where appropriate. Graduates will be educated in design thinking, innovation theory, and innovation adoption theory, and know how to cultivate a culture within the DoD that embraces innovation in our research, development, and acquisition programs, industry engagement, rapid-prototyping and non-traditional contractual agreements.

9. **Innovation and Technology Adoption:** Students will become intimately familiar with all of the challenges associated with the process of innovation. This will range from topic curation, problem framing, ideation, prototyping, field experimentation, technology transition and solution adoption. This educational experience will be woven through both the classroom experience, as well as the innovation project upon which they will be working. In this manner, the concepts and theories of innovation can be questioned, modified, and challenged as they are employed by the student, in particular through external engagement with relevant users who would be likely potential adopters of the student's innovation.

10. **Capstone/Thesis:** Graduates will demonstrate their ability to conduct independent research and analysis, and demonstrate proficiency in presenting the results in writing by means of capstone project or thesis appropriate to this curriculum.

Special Operations - Curriculum 699

Information Strategy and Political Warfare

Academic Associate

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Brief Overview

The objective of this curriculum is to educate military personnel and civilian officials of the United States and its Allies to better defend the nation and prevent, prepare for, and prevail in conflicts by operating effectively in the information environment.

The curriculum is designed for both the specialist who will be assigned to an information related position and the generalist who will be assigned to a command or staff billet. The curriculum includes a core of military art and operations, emerging security challenges, intelligence and network analyses, the psychological and social dimensions of war emphasizing information strategy, political warfare, military deception, defense support to public diplomacy analytical methods, and regional studies.

In addition to the core curriculum, the program includes customizable elective sequences for each student. These sequences draw on courses throughout the Naval Postgraduate School. Each customized sequence must be approved by the academic associate.

This flexibility allows for individual sequences which may include concentrations in cyber systems and operations, electronic warfare, intelligence support to operations in the information environment, regional studies or computer network operations. Additional areas of concentration are available to meet specific student and organizational requirements. Finally, each student will write a thesis or complete a capstone project relevant to operating in the information environment. The Information Strategy and Political Warfare curriculum is designed to develop the following competencies in its graduates:

- Evaluate the global information environment and assess its impact on National Security Strategy.
- Analyze the role of information to inform, persuade and influence in national military strategy and maximize its contributions to national military power.
- Create a role for information operations in national information strategy in order to maximize its contributions to the non-military elements of national power.
- Create relationships, linkages, and dependencies between intelligence and information operations.
- Analyze the contributions of the interagency community to operations in the information environment.
- Evaluate non-US approaches to, capabilities, and doctrines for information operations.
- Evaluate the role of information operations for achieving desired effects across the spectrum of national security threats.

- Evaluate how information operations are integrated to support the national military and security strategies and the interagency process.
- Analyze how information operations apply at the operational and strategic levels of war and how they support the operations of a networked force.
- Evaluate the national security information environment as an enabler or vulnerability for current and future comparative advantage.
- Evaluate adversary information threats and create defensive and offensive information operation counters.
- Analyze the principles, capabilities and limitations of information operations across the range of military operations, to include pre and post-conflict operations.

Requirements for Entry

The Information Strategy and Political Warfare curriculum is open to all branches of the military, federal employees, international military officers and government sponsored civilians. U.S. officers must be eligible for a TOP SECRET clearance with access to Sensitive Compartmented Information based on a Special Background Investigation completed within the last five years. A baccalaureate degree earned with above average academic performance and a minimum APC of 265 is required.

Convenes

The Information Strategy and Political Warfare curriculum is a six-quarter course of study with entry dates in January and July. If further information is needed, contact the Academic Associate or the Program Officer for this curriculum.

Degree

The Master of Science in Information Strategy and Political Warfare degree will be awarded in accordance with the following degree requirements:

1. This degree requires 45 quarter-hours of graduate-level work, of which 15 hours must represent courses at the 4000 level.
2. Completion of an acceptable thesis or capstone project.

The Chairman of the Defense Analysis Department and the Academic Associate of the Information Strategy and Political Warfare curriculum approve each individual program.

Subspecialty

Completion of the 699 curriculum qualifies officers in multiple information related specialties. The curriculum sponsor is the Office of the Undersecretary of Defense for Policy (OSD-P).

Typical Subspecialty Jobs

Command and staff positions at the LTC/CDR level and above on service staffs, JTFS, and combatant commands.

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
DA3882	Coercion and Competition in World Politics	4	0
DA2010	Technical Writing and Composition	4	0
MN3121	Organizational Design for Special Operations	4	0
DA2410	Modeling for Military Decision Making, I	4	0

Quarter 2

DA3410	Modeling for Special Operations II	4	0

Quarter 3

DA4107	Psychological Influence	4	0
DA4106	Trust, Influence and Networks	4	0
DA3104	Computer Network Attack and Defense	4	1
DA3802	Seminar in Guerrilla Warfare	4	0

Quarter 4

DA3180	Warfare in the Electromagnetic Spectrum: Principles and Applications	4	0
DA4108	Deception, Denial, Surprise, and Counterdeception	4	0
DA3750	Anthropology of Conflict	4	0
DA3120	Jihadi Information Operations	4	0

Quarter 5

DA3801	International Terrorism	4	0
DA3720	The Rise of Religious Violence	4	0
ELECT	Emphasis Elective		
DA4600	Dark Networks	4	0

Quarter 6

DA4105	Special Topics in Information Operations	4	0
DA4104	Militaries and Technological Change	4	0
DA3105	Conflict and Cyberspace	4	1
DA4710	Critical Thinking and Ethical Decision Making	4	0

Educational Skill Requirements (ESR)
Information Strategy and Political Warfare
Subspecialty Code: None

1. **Military Art and Operations:** Graduates will understand the organization, formulation, and execution of national security strategy and national military strategy; the effects of technical developments

on warfare; the capabilities and roles of military forces throughout the entire spectrum of conflict; and current defense issues.

2. **Emerging Security Challenges:** Graduates will explore major security issues among states and between states and non-state actors, with emphasis placed on examining the sources of instability and violence including ethnic conflict, insurgency, and terrorism.

3. **Information Strategy:** Graduates will understand the role of information in winning wars and achieving favorable political outcomes. To operate effectively in the information environment, graduates need to competently integrate information-related capabilities in concert with other lines of operations to:

   • engage and inform allied and friendly audiences about national and military objectives: Who we are, what we're doing, why it matters

   • engage, inform, persuade and influence neutral audiences: Convert them to allies, or dissuade them from aiding or joining adversaries

   • influence adversary decision-making: Discourage, demoralize, confuse, deceive and corrupt, disrupt or usurp their ability to communicate and make decisions that will hurt us

   • protect US/Allied/Coalition communications, information systems and decision-making from adversary attempts to influence, corrupt, disrupt or usurp them via manipulation of the information environment

4. **Analytical Methods and Applications:** Graduates will have a foundation in analytical methods and their application to military modeling, simulations, and gaming. Close attention will be given to the ways in which such analytical techniques can be used in heuristic and decision-making tools for strategic and operational planning. Attention will be given to both historical and contemporary military applications with particular focus on the ways in which such techniques can be used to address issues of interest to the joint information operations community.

5. **Information Systems:** Graduates will have a systems-level understanding of information systems and their vulnerabilities as well as capabilities.

6. **Intelligence Processes and Applications:** Graduates will know intelligence, targeting, and assessment processes, and their applications to joint warfare through the national level, with particular emphasis given to the role of intelligence in planning, executing, and terminating information operations.

7. **Thesis/Capstone:** Graduates will demonstrate their ability to conduct independent research and analysis, and demonstrate proficiency in presenting the results in writing by means of a thesis or capstone project appropriate to this curriculum.

SOF Support to Governance

Academic Associate

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Brief Overview

This curriculum educates military personnel and civilian officials of the United States, its Allies, and Partners to better defend the national interests and prevent, prepare for, and prevail in conflicts by effectively assessing and influencing governance capacity in semi-permissive, denied environments and conflict regions. The SOF-G curriculum develops an understanding of how adversarial nation-states, third party malign state actors and guerilla groups undermine established government systems and supplant with their own governance activities as part of a larger UW campaign.

Requirements for Entry

The SOF Support to Governance curriculum is open to all branches of the military, federal employees, international military officers, and government-sponsored civilians. A baccalaureate degree earned with above-average academic performance and a minimum APC of 265 is required. US officers must be eligible for a TOP SECRET clearance with access to Sensitive Compartmented Information based on a Special Background Investigation completed within the last five years.

Convenes

The SOF Support to Governance curriculum is a six-quarter course of study with entry dates in January and July. If further information is needed, contact the Academic Associate.

Degree

The Master of Science in Defense Analysis - SOF Support to Governance, degree will be awarded in accordance with the following degree requirements:

1. This degree requires forty-five quarter-hours of graduate-level work, of which 15 hours must represent courses at the 4000 level.

2. Completion of an acceptable thesis or capstone project.

The Chairman of the Defense Analysis Department and the Academic Associate of the Information Strategy and Political Warfare curriculum approve each individual program.

Subspecialty

Completion of the degree program qualifies officers in multiple special operations governance support and Foreign Area specialties. The curriculum sponsor is the Office of the Undersecretary of Defense for Policy (OSD-P) and the United States Army Special Warfare Center and School.

Typical Subspecialty Jobs

Command and staff positions at the MAJ/LCDR level and above on service staffs, SOJTFs, JTFs, and combatant commands.

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
DA3882	Coercion and Competition in World Politics	4	0
DA2010	Technical Writing and Composition	4	0
MN3121	Organizational Design for Special Operations	4	0
DA2410	Modeling for Military Decision Making, I	4	0

Quarter 2

DA3101	Conflict in the Information Age	4	0
DA3410	Modeling for Special Operations II	4	0
DA4038	SOF Support to Governance	4	0
NW3230	Strategy & War	4	2

DA4038 ought to be taken before other government/governance focused classes. This is to act as a foundational class to help engage future classes in the DA and NSA Departments.

Quarter 3

DA4107	Psychological Influence	4	0
DA4106	Trust, Influence and Networks	4	0
NS4225	Civil-Military Relations and Transitions to Democracy	4	0
NW3285	Theater Security Decision Making	4	0

Quarter 4

DA3750	Anthropology of Conflict	4	0
NS3235	Civil Wars	4	0
NS3620	Survey of Asian Politics	4	0
NS4260	Hybrid Warfare	4	0

Quarter 5

DA3801	International Terrorism	4	0
DA4600	Dark Networks	4	0
NS4667	Political Economy and Security in South Asia	4	0
NW3275	Joint Maritime Operations - part 1	4	0

Quarter 6

DA4104	Militaries and Technological Change	4	0

DA4710	Critical Thinking and Ethical Decision Making	4	0
NS4642	Chinese Foreign Policy	4	0
NW3276	Joint Maritime Operations - part 2	2	2

Educational Skill Requirements (ESR)
SOF Support to Governance
Subspecialty Code: None

1. **Military Art and Operations:** Graduates will understand the organization, formulation, and execution of national security strategy and national military strategy; the effects of technical developments on warfare; the capabilities and roles of military forces throughout the entire spectrum of conflict; and current defense issues.

2. **Emerging Security Challenges:** Graduates will explore major security issues among states and between states and non-state actors, with emphasis placed on examining the sources of instability and violence including ethnic conflict, insurgency, and terrorism.

3. **Special Operations Support to Governance:** Graduates will understand the role of governance and post-military end state political objects in winning wars and achieving favorable political outcomes. To operate effectively in the Civil environment, graduates need to competently integrate governance-related capabilities in concert with other lines of operations to:

   a. Analyze how transitional governance and governance support operations influence at the operational and strategic levels of war and how they impact both military and political outcomes of war and conflict.

   b. Evaluate the principles, capabilities, and limitations of Special Operations Forces' support to governance across the range of military operations, to include during competition, conflict and consolidation of gains.

   c. Creating relationships, linkages, and dependencies between intelligence and governance operations.

   d. Analyze the contributions of the interagency community to operations in the civil and governance environment.

   e. Employ a deep cultural and historical understanding of governance vs government systems through the paradigm of regional examples and case studies.

   f. Utilize research methods such as statistical analysis, anthropology, and geographic models and apply those methods towards governance implementation, to include resources in austere, developing, and developed environments.

   g. Apply the principles of effective governance, including regional/geographic models of governance based on historical case studies and best practices.

   h. Develop governance execution priorities for

functions such as revenue, services, dispute resolution, and feedback mechanisms.

    i. Employ the principles of adapting governance advising and assisting to local population characteristics to enhance existing governance functions and characterize shortfalls.

4. **Information Strategy:** Graduates will understand the role of information in winning wars and achieving favorable political outcomes. To operate effectively in the information environment, graduates need to competently integrate information-related capabilities in concert with other lines of operations to:

5. **Analytical Methods and Applications:** Graduates will have a foundation in analytical methods and their application to military modeling, simulations, and gaming. Close attention will be given to the ways in which such analytical techniques can be used in heuristic and decision-making tools for strategic and operational planning. Attention will be given to both historical and contemporary military applications with particular focus on the ways in which such techniques can be used to address issues of interest to the joint information operations community.

6. **Information Systems:** Graduates will have a systems-level understanding of information systems and their vulnerabilities as well as capabilities.

7. **Intelligence Processes and Applications:** Graduates will know intelligence, targeting, and assessment processes, and their applications to joint warfare through the national level, with particular emphasis given to the role of intelligence in planning, executing, and terminating information operations.

8. **Thesis/Capstone:** Graduates will demonstrate their ability to conduct independent research and analysis, and demonstrate proficiency in presenting the results in writing by means of a thesis or capstone project appropriate to this curriculum.

Special Operations/Irregular Warfare

Academic Associate

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Brief Overview

The Special Operations/Irregular Warfare curriculum is designed to provide a focused course of study of the conflict spectrum below general conventional war. Graduates of this curriculum will possess a thorough knowledge of the broad range of factors involved in the planning and conduct of these forms of conflict and a detailed understanding of the role of special operations and related forces in U.S. foreign and defense policy. The curriculum examines the sources and dynamics of inter-state and intra-state conflict; the challenge these forms of

conflict have posed and are likely to increasingly pose for U.S. security planning; the doctrinal and institutional evolution of the U.S. special operations community; the recent history of political violence and "small wars"; the history of irregular warfare; and contemporary perspectives on low-intensity conflict resolution. The curriculum provides the graduate with a strong background in the areas of strategic analysis, decision making, organization theory, the technological revolution in military affairs, and advanced analytical methods.

Requirements for Entry

The Special Operations/Irregular Warfare curriculum is open to all branches of the U.S. military, civilian employees of the U.S. Government, and international military and government officials. U.S. officers must be eligible for a TOP SECRET clearance with access to Sensitive Compartmented Information based on a Special Background Investigation completed within the last five years. A baccalaureate degree earned with above average academic performance and a minimum academic profile code (APC) of 265 is required.

Convenes

The Special Operations/Irregular Warfare curriculum is a six-quarter course of study with entry dates in January and June. If further information is needed, contact the Academic Associate or the Program Manager/Officer for this curriculum.

Degree

Requirements for the Master of Science in Defense Analysis degree are met as a milestone en route to satisfying the Educational Skill Requirements of the curricular program. The program currently offers 10 specialty tracks. Other specialty tracks can be tailored to meet student interests. The current tracks include Irregular Warfare, Information Operations, Terrorist Operations and Financing, Strategic Forecasting and Decision Making, Operations Analysis, C4I Systems, Combat Systems, Financial Management, National Security Affairs (Regional Studies) and National Security Affairs (Stability/Reconstruction).

Master of Science in Defense Analysis

The Master of Science in Defense Analysis degree will be awarded in accordance with the following degree requirements:

1. This degree requires 45 quarter-hours of graduate-level work, of which 15 hours must represent courses at the 4000 level in at least two disciplines. Within the course program there must be a specialization sequence consisting of at least six courses.

2. In addition to the 45 hours of course credit, an acceptable thesis must be completed.

The Chairman of the Defense Analysis Department approves each individual program.

Subspecialty

Completion of the 699 curriculum qualifies an officer as a Special Operations Subspecialist with a subspecialty code of 2500P. The curriculum sponsor is the Commanding General, Special Operations Command.

U.S. Marine Corps officers completing this curriculum fulfill the requirements for MOS 8870.

Typical Subspecialty Jobs

Command Positions at the LTC/CDR level
Assistant Operations Officer, U.S. Army Special Forces Group
Staff Officer, Plans or Operations: USSOCOM
Action Officer, Counterterrorism Directorate, ASD (SO/LIC)
Staff Officer, Plans or Operations: Theater Special Operations Commands
Special Warfare Plans: CINCLANT/CINCPAC/NAVEUR
Chief, Intelligence/Plans: COMNAVSPECWARCOM
Joint Plans/Doctrine: COMNAVSPECWARCOM
Joint Staff Action Officer: J-3, Special Operations Directorate (J-3, DDSO)

Typical Course of Study

(Irregular Warfare Track)

Quarter 1

Course	Title	Lecture	Lab
DA3802	Seminar in Guerrilla Warfare	4	0
MN3121	Organizational Design for Special Operations	4	0
DA2410	Modeling for Military Decision Making, I	4	0
ELECT	Emphasis Elective (4-0)		

Quarter 2

DA3882	Coercion and Competition in World Politics	4	0
DA3410	Modeling for Special Operations II	4	0
DA3880	History of Special Operations	4	0
DA3101	Conflict in the Information Age	4	0

Quarter 3

DA3750	Anthropology of Conflict	4	0
DA4410	Models of Conflict	4	0
DA48XX	Regional Seminar in Low-Intensity Conflict (1st)		

Quarter 4

DA3801	International Terrorism	4	0
DA3102	Psychological Warfare and Deception	4	0
DA3260	Human Intelligence in Irregular Warfare	4	0

Quarter 5

DA4760	The Military Advisor	4	0
DA4500	Special Topics in Strategic Analysis	4	0
DA4106	Trust, Influence and Networks	4	0
DA0810	Thesis Research	0	8

Quarter 6

DA4710	Critical Thinking and Ethical Decision Making	4	0
DA48XX	Regional Seminar in Low-Intensity Conflict (2nd)		
ELECT	Emphasis Elective (4-0)		
DA0810	Thesis Research	0	8

DA48XX: Five courses in Low-Intensity Conflict covering different regions of the world will be offered; students will select two of the three.

Educational Skill Requirements (ESR)
Special Operations/Irregular Warfare
Subspecialty Code: 2500P

1. **Strategy and Policy:** Graduates will develop an ability to think strategically, analyze past operations, and apply historical lessons to future joint and combined operations, in order to discern the relationship between a nation's political interests and goals and the ways military power may be used to achieve them. This requirement is fulfilled by completing the first of three Naval War College courses leading to Service Intermediate-level Professional Military Education (PME) and Phase I Joint PME credit. (Required only for USN and USMC students.)

2. **The Dynamics of Inter-State and Intra-State Conflict:** Graduates will have an understanding of the political, ethnic, and cultural dynamics that explain the outbreak of war between and within modern states. Particular attention should be given to the issues of intra-state conflict; unconventional forms of inter-state military rivalry; the integrated role of force and diplomacy in crisis management operations short of war; problems of escalation in a crisis environment; military alliance behavior; the dynamic differences between zero-sum and nonzero-sum conflicts; the special problems associated with suppressing and resolving zero-sum engagements; and military and nonmilitary approaches to conflict resolution. Students must have a close understanding of the prevailing analytical literature on these and related subjects and be able to apply this literature to a broad range of contemporary and historical cases.

3. **Terrorism, Social Revolution, and Unconventional Warfare:** Graduates will have a detailed understanding of the problems of domestic and international terrorism, social revolution, and other forms of irregular conflict. Close attention must be given to problems of both threat and response. The student

must have a close knowledge of the prominent contending theoretical perspectives on the problems of terrorism and social revolution; a detailed knowledge of the operational and organizational dynamics underlying each of these forms of conflict; and a strong working understanding of the ways in which these and similar forms of irregular conflict have been countered historically. Where appropriate, the courses designed to satisfy this requirement should survey the U.S. experience in irregular warfare as well as that of other states that have been prominently engaged in such actions in the past, such as Great Britain, France, Israel, and the former Soviet Union.

4. **Historical and Comparative Perspectives on Special Operations:** Graduates will have a close understanding of the historical use of special operations forces, to include how these and similar forces have been organized, trained, equipped, directed, and employed. Attention should be given not only to the U.S. experience, but to other national experiences as well, such as those of Great Britain, Germany, Italy, and the former Soviet Union. Similarly, this examination should not be restricted to contemporary history alone, but should extend back into the historical record to examine the ways in which special operations and related forces have been employed creatively to support state objectives in the more distant past. Throughout this inquiry, attention should be given to the contemporary lessons that can be drawn from historic experience.

5. **Special Operations Doctrine, Concepts, and Institutions:** Graduates will have a detailed and conceptual understanding of the development of doctrine for special operations. Work in this area should focus, first, on the defining events and experiences that have stimulated doctrinal and institutional innovations in SO and, second, on the forms these innovations have taken. This examination should cover the period from the end of World War II through the post-Cold War era. These and related issues should be explored creatively in an effort to uncover the appropriate roles, missions, strengths, and limitations of military power in the emerging multipolar environment.

6. **Crisis Management and the Contingent Use of Military Power:** Graduates will have an understanding of the political role played by military power in operations short of war, the problem of military crisis management, and the contingent use of force in support of local U.S. policy objectives. Attention should be given to the "signaling" role that can be played by military force, the special problems of deterrence and coercion in a crisis environment, and the military consequences of deterrence failure. The student should have a close knowledge of the historical record of "armed diplomacy" throughout the post-war period. This should include knowledge of the individual cases of

U.S. military intervention in the Third World, from Lebanon (1958) to Somalia (1993). Attention should be given to both the theoretical and empirical literature on these subjects to provide the student with an understanding of the special political and operational issues associated with operating in a crisis environment.

7. **Comparative Cases of and Responses to Regional Conflict:** Graduates will have a close knowledge of historical and contemporary "small wars" and other forms of low-intensity conflict in Latin America, Asia, and the Middle East. The courses that satisfy this requirement should examine the pertinent theoretical literature on political violence in the region in question, review the recent history of regionally-based terrorism, insurgency, and communal conflict, the regional and international implications of these conflicts, and any functional issues that are of particular interest or concern in the particular area under investigation, such as the religious or communal sources of political violence or the relationship between narcotics and insurgency.

8. **Special Operations and the Revolution in Military Affairs:** Graduates will have an understanding of the ways in which the proliferation of new and emerging technologies is changing the shape of modern warfare. An important aspect of this requirement is to examine the likely impact of these developments on the dynamics and characteristics of twenty-first century warfare within both the inter-state and intra-state arena. The student must have a working knowledge of the major technological developments and trends in this area (both lethal and nonlethal) and their conflict implications.

9. **Special Operations and Information Warfare:** Graduates will have an understanding of the likely and potential implications of information warfare on future special operations. An important aspect of this requirement is to examine the principles of information warfare and examine the ways in which SOF can contribute to U.S. information dominance on the twenty-first century battlefield. This examination should address the problem of information dominance at the inter-state and intra-state level of war.

10. **Weapons of Mass Destruction (WMD) Proliferation and Counter-Proliferation:** Graduates will have an understanding of the developing problem of WMD proliferation and counter-proliferation. Students may have a technical or operational perspective on WMD. The student must have an understanding of the political dynamics of WMD proliferation and an understanding of recent and possible future trends in these areas. Close attention should also be given to the problem of counter-proliferation and the ways in which SOF might approach this task. Students having a technical focus should have a working knowledge of nuclear and non-nuclear WMD technologies.

11. **Analytical Methods and Applications:** Each student will receive grounding in analytical methods and their application to military modeling, simulations, and gaming. Close attention will be given to the ways in which such analytical techniques can be used as heuristic and decision-making tools for strategic and operational planning. Attention will be given to both historical and contemporary military applications, with particular focus on the ways in which such techniques can be used to address issues of interest to the special operations community.

12. **Strategic and Operational Complexity:** Special Operations (SO) is a style of warfare. No traditional single academic discipline can adequately address the educational requirements of the SO community, so an interdisciplinary approach is required. Each student will develop a course of study that permits him or her to pursue a disciplinary orientation that best suits their particular academic background and interests within the substantive limits of the other ESRs.

Department of Defense Management

Website

www.nps.edu/web/ddm

Chair

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The Department of Defense Management includes:

Acquisition Management (Contract Management) Academic Area
Acquisition Management (Program Management) Academic Area
Financial Management Academic Area
Manpower and Economics Academic Area
Operations and Logistics Management Academic Area
Strategic Leadership and Management Academic Area

Vision

To be recognized as the nation's premier school for defense-focused business management and public policy education and research. To be the institution that national leaders look to for education, research, information, and innovation in the management of the business of defense. To be recognized by our students, alumni, and other stakeholders for our excellence in defense-focused education and research.

Mission

To serve our Nation by educating US and allied military officers as well as defense civilians in defense-focused business and public policy, by conducting research in defense management and public policy, and by providing intellectual resources for leaders and organizations concerned with defense business management practices and policies.

Means

We pursue our vision and perform our mission through graduate education, research, and professional service.

- In Education: Through resident and distance learning degree and non-degree programs, we develop students' abilities to analyze, think critically, and take intelligent actions so they can more effectively carry out their future professional responsibilities to manage organizations, resources, people, and programs in complex, sometimes life-threatening environments.

- In Research: Conduct research, using the scholarships of discovery, application, integration, or teaching, that supports defense enterprise decision-making, problem solving, and policy setting; improves business management processes and practices; contributes knowledge to academic disciplines via dissemination in high-quality refereed research journals or suitable practitioner-oriented journals; and advances the development of graduate education.

- In Professional Service: Provide professional expertise that advances knowledge and business management within DDM, NPS, the Department of Navy, the Department of Defense, and other government agencies, as well as in our professional and academic organizations.

Areas of Excellence

Master of Science Degrees Program

The Department of Defense Management awards Master of Science degrees in Defense Contracting Management (815), Systems Acquisition Management (816), Defense Logistics Management (819), Defense Financial Management (837), and the Master of Science in Management (817, 847). Each of the Master of Science degrees is accredited by the Association to Advance Collegiate Schools of Business - International (AACSB).

Distance learning Programs: "Reaching out to Serve Defense Community Needs

DDM is a leader in developing and providing off-campus education for the Defense community. DDM has developed faculty, facilities and capabilities to deliver graduate programs using Web-enhanced modes of instruction. Currently, DDM offers two unique distance learning degrees to serve Defense community needs.

Master of Science in Program Management: Developed to respond to the need for professional education for the Defense Acquisition workforce, the MSPM integrates

Defense Acquisition Workforce Improvement Act (DAWIA) functional training requirements within the context of a graduate-level degree program.

Master of Science in Contract Management: Developed to respond to the need for professional education for the Defense Acquisition workforce, the MSCM integrates Defense Acquisition Workforce Improvement Act (DAWIA) functional training requirements within the context of a graduate-level degree program.

Management Development Programs "Continuing Education for Professional Success"

DDM provides Continuing Education in the form of Executive and Management Development programs by DDM faculty with both academic and professional experience in their respective discipline areas. Programs are provided in residence using Web-enhanced modes of instruction, and by faculty travelling to both national and international locations. DDM offers unique programs to serve Defense community and broader public sector needs.

Advanced Acquisition Program (AAP): The AAP provides graduate education while integrating DAWIA training to DoD's acquisition workforce, including Army, Navy and Air Force acquisition commands.

Acquisition Management Distance Learning Program (AMDLP): DDM provides this educational outreach program to the Defense acquisition community, offering acquisition management courses to Defense agencies across the country.

Defense Specialty Curricula: "Education Responsive to Sponsor Requirements"

DDM provides graduate management education in six curricular areas of direct relevance to military educational needs. All curricula have a senior leader from one of the services who sponsors the program. Sponsors are actively involved in the design and review of programs. These reviews, in conjunction with NPS and DDM assessments, result in high quality, unique, and military-relevant programs. Collectively, the curricula encompass all aspects of Resource Management, including the management of Human Resources, Physical Resources, Financial Resources, and Information Resources.

Logistics Management: Designed for military officers who will be responsible for managing the various segments of a military system's life cycle from initial planning for support to fielding the system, through sustaining operations to phase-out. Emphasizes all of the aspects of providing integrated logistics support of military systems.

Acquisition Management: Develops the knowledge, skills and competencies necessary for graduates to assume leadership roles in the acquisition workforce and efficiently manage the resources allocated to the acquisition process.

Manpower Management: Serves the Navy Human Resource Community of Interest by developing leaders in the design, analysis, and management of Manpower, Personnel, Training and Education Systems to maximize fleet readiness.

Financial Management: Designed to prepare military officers for effectively managing financial resources to achieve the goals and objectives of the defense forces. Graduates are prepared for assignment to positions in budgeting, accounting, financial management, cost management, cost analysis, internal control and auditing, and financial analysis.

Defense Management and Analysis: Designed to prepare military officers broadly for positions of leadership and management responsibility in defense organizations, and to develop the knowledge and abilities necessary for the analysis of policies and problems in defense organizations.

Information Systems Management: Designed to provide both technical skills and business acumen. This curriculum provides the knowledge to: acquire and manage information systems and infrastructure; address IS engineering and management problems; assimilate new technologies and transform organizations, processes, and strategies to compete in the marketplace or on the battlefield in the constantly changing digital world.

Professional Development Program: The Department of Defense Management also administers several non-degree programs consisting of graduate education or professional courses taught in residence or via distance learning modes. These programs support professional development for managers in DoD. Current programs emphasize acquisition and financial management, and include: Advanced Acquisition Program, and Advanced Comptroller Course.

Faculty: "A Unique Blend to Perform DDM's Academic Mission"

The DDM faculty is unique in its composition, combining individuals with varying academic, professional, practitioner, and service backgrounds to provide relevant graduate instruction and research programs.

Academics and Professionals: DDM's faculty are drawn from a wide variety of academic disciplines. A majority of the faculty holds doctoral degrees from the nation's distinguished universities. In addition to the academics, practitioners are an integral part of the faculty. In keeping with the mission, DDM employs highly qualified practitioners on a full-time basis to enhance the relevance and quality of programs. All full-time practitioners have at least a master's degree and have been recognized as accomplished professionals in their fields.

Civilian and Military: A combination of top notch civilian faculty combined with active and retired military officers provides DDM with expertise both within and beyond the Department of Defense. The civilian faculty provides the theoretical and academic expertise enhanced by numerous contacts throughout the Navy and Defense community, while the military faculty provides recent DoD

experience, and professional and operational expertise.

Business and Government: The DDM faculty blends backgrounds from both the private and public sectors. More than half of the faculty come with academic and/or professional experience from the business world. More than half come with academic and/or professional experience in the public sector.

Instruction and Research: DDM faculty are expected to excel in teaching as well as conduct significant research that is relevant to the Department of Defense. Faculty members maintain high degree of connectivity with sponsors of instructional and research programs. Almost all faculty work year round, teaching two quarters and conducting research and/or engaging in administrative work for the other two quarters.

Defense Management Research: "Scholarship Analysis Relevant to Defense Problems"

Research Mission: Research is an important component of DDM's mission. The primary goal of DDM's research programs to provide the Navy and DoD with the capability of managing defense organizations, systems, and processes both efficiently and effectively. DDM recognizes the importance of both basic and applied research to the Navy and DoD; and seeks to create a balance of both types of research in its research program. DDM's research programs can be grouped into six functional areas:

Acquisition (Program Management and Contracting)

Logistics and Transportation

Financial Management

Manpower Systems and Human Resources

Organization and Management

Economic and Policy Analysis

Research Relevance: In-depth knowledge of military problems allows the faculty to provide assistance to DoD decision makers. Expertise in private sector business practices enables the faculty to assist DoD organizations in adopting best business practices. Research in military-relevant issues additionally allows the faculty to develop unique and relevant instructional material for education of military officers.

DoD sponsorship of DDM research comes from several commands and areas, such as: ASN(RDA), ONR, OSD, SPAWAR, NAVSUP, AIRPAC, DAU, NETSAFA, NPRST, PERSEREC, USMC, N82, Manpower, Acquisition, and Logistics.

Research Excellence: DDM faculty include nationally and internationally recognized experts in simulation modeling, supply chain management, work motivation, knowledge management, military manpower, public sector management, change management, public budgeting, managerial communications, conflict management, acquisition, defense economics, information technology and other defense-relevant fields.

Research Centers and Programs

Acquisition Research Program: Established in 2002, Naval Postgraduate School's Acquisition Research Program provides leadership in innovation, creative problem solving and an on-going dialogue, contributing to the evolution of Department of Defense acquisition strategies. Objectives of the NPS Acquisition Research Program include: Establishing NPS acquisition research as an integral part of policy-making for Departments of Defense and Navy officials. Creating a stream of relevant information concerning the performance of DoD acquisition policies with viable recommendations for continuous process improvement, preparing the workforce to participate in the continued evolution of the defense acquisition process, collaborating with other universities, think tanks, industry and Government in acquisition research.

Human Resources Center of Excellence: Established in October 2007 by the Chief of Naval Personnel, the Human Resources Center of Excellence (HRCOE) serves as a focal point for the lifelong career learning for the Human Resources (HR) community. In support of this goal, the Center is responsible for the development and execution of programs that promote professional development for all active duty and reserve HR officers to include formal education opportunities for new and experienced HR officers, a robust mentoring program, and a resources and learning tools repository. Center activities and efforts to enrich the professional development and abilities of the HR Community will be aligned with the Manpower, Personnel, Training and Education mission to anticipate warfighting needs, identify associated personnel capabilities, and recruit, develop, manage and apply those capabilities in an agile and cost effective manner.

Programs Offered

The Department of Defense Management (DDM) has responsibility for graduate academic programs and awards graduate degrees in defense management. DDM offers specialized Master of Science degree programs focused on defense management fields, and non-degree professional development programs. These programs are:

Master of Science Degree Programs

- MS in Management
- MS in Systems Acquisition Management
- MS in Defense Contract Management
- MS in Defense Logistics Management
- MS in Defense Financial Management
- MS in Program Management
- MS in Contract Management
- MS in Financial Management

Graduate Certificate Programs

- Strategic Leadership
- Leadership for Public Administrators
- Principles of Analytic Management

- Advanced Acquisition Studies
- Acquisition Logistics
- Managerial Logistics
- DoD Financial Management
- Basic Contract Management
- Advanced Contract Management
- Cost-Benefit and Program Evaluation

Professional Development Programs

- Acquisition Management Distance Learning Program
- HRCOE/VA

DDM Degree Programs and Curricula Summary

Brief Overview

To prepare graduates for public service in management and leadership roles in the defense establishments of the United States or allied nations. The program prepares graduates to manage organizations, resources, people, and programs in complex environments.

The Master of Science (MS) degree program has been designed to meet four objectives:

- To provide a defense-focused graduate management education program of specific relevance to U.S. military officers and DoD civilians.
- To satisfy educational requirements for military subspecialties or occupational and functional areas.
- To meet the accreditation standards of Association to Advance Collegiate Schools of Business International (AACSB).
- To allow officers to complete JPME requirements, if desired.

The graduate will have the ability to apply state-of-the art concepts, tools, and methodologies from public management and business to manage DoN/DoD organizations. This ability will be developed in course work that includes economic, statistical, mathematical, operational, organizational, strategic, communication, auditability, and financial theories and techniques.

Core Competencies - Our graduates will be:

1. Critical thinkers
2. Ethical leaders and persons of integrity.
3. Effective problem solvers in complex environments.
4. Effective and efficient managers of resources.
5. Effective communicators.

- Our students will write effective documents for diverse audiences.
- Our students will deliver effective oral briefings for diverse audiences.

Curricular Area	Curriculum Title	Curric #	Degree	Mode	P-Code	Entry	Qtrs

Master of Science Program

Curricular Area	Curriculum Title	Curric #	Degree	Mode	P-Code	Entry	Qtrs
Logistics	Logistics Mgmt	827	MS	Res	13 12	Jan/ Jul	6
Acquisition	Defense Contract Mgmt	815	MS	Res	13 06	Jan/ Jul	6
	Program Mgmt	816	MS	Res	n/a	Jan/ Jul	6
Financial Mgmt	Defense Financial Mgmt	837	MS	Res	31 10	Jan/ Jul	6

Master of Science in Management Program

Curricular Area	Curriculum Title	Curric #	Degree	Mode	P-Code	Entry	Qtrs
Manpower	Manpower Systems Analysis	847	MSM	Res	31 30	Jul	7
Defense	Defense Systems Analysis	817	MSM	Res	n/a	Jul	7

Master of Science Degree Programs

Curricular Area	Curriculum Title	Curric #	Degree	Mode	P-Code	Entry	Qtrs
Acquisition	Contract Management	835	MSCM	Online	n/a	July	8
	Program Management	836	MSPM	Online	65 02	July	8
	Systems Eng. Mgmt ***	721	MSSEM	VTE	n/a	Sept	8

*Joint program with NSA Dept.
**Joint program with IS Dept.
***Joint program with SE Dept. PD21 Program

DDM Administration

Associate Chairs

Associate Chair for Research

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Acquisition System Management Curriculum (816)

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Defense Financial Management Curriculum (837)

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Defense Systems Analysis Curriculum (817)

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Manpower Systems Analysis Curriculum (847)

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Logistics Management Curriculum (827)

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Master of Science in Contract Management (835)

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Master of Science in Program Management (836)

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Ray Jones, COL, USA (Ret.), Professor of Practice (2012); M.S., Industrial College of the Armed Forces, 2003.

Professor Emeriti:

David V. Lamm, Associate Professor of Acquisition and Contract Management (1978); D.B.A., George Washington University, 1976.

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E. Cory Yoder, Senior Lecturer of Acquisition and Contracting (2004); M.S., Naval Postgraduate School, 1993.

Michael Schilling, CDR, USN, Lecturer of Acquisition Management (2021); M.B.A., Naval Postgraduate School, 2011.

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Amilcar A. Menichini, Associate Professor of Finance (2011); Ph.D., University of Arizona.

Juanita M. Rendon, CPA, CFE, Lecturer of Accounting (2006); D.B.A., Argosy University, 2012.

Chong Wang, Associate Professor of Accounting (2007); Ph.D., Iowa State University, 1998.

Professor Emeritus:

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Jesse Cunha, Associate Professor of Economics (2010); Ph.D., Stanford University, 2010.

Maxim Massenkoff, Assistant Professor of Economics (2020); Ph.D., University of California at Berkeley, 2020.

Chad Seagren, Senior Lecturer of Manpower and Economics (2003); Ph.D., George Mason University, 2010.

Simona L. Tick, Senior Lecturer of Manpower and Economics; (2011); Ph.D. University of Arizona, 2005.

Yu-Chu Shen, Professor of Economics (2004); Ph.D., Harvard University, 2001.

Professors Emeriti:

Mark J. Eitelberg, Professor of Public Policy (1982); Ph.D., New York University, 1979.

William R. Gates, Professor of Economics (1988); Ph.D., Yale University, 1984.

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Operations and Logistics Management Academic Area

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Eddine Dahel, Senior Lecturer of Operations Management (2015) Ph.D., Illinois Institute of Technology, 1988

Geraldo L. Ferrer, Professor of Supply Chain Management (2004); Ph.D., INSEAD, 1997.

Bryan J. Hudgens, Senior Lecturer in Operations and Logistics Management (2005); M.S., Air Force Institute of Technology, 1997.

Eva Regnier, Professor Management Sciences (2001); Ph.D., Georgia Institute of Technology, 2001.

Ira Lewis, Associate Professor of Operations and Logistics (1998); Ph.D. Arizona State University, 1992.

Harrison Scramm, Senior Lecturer (2010); M.S., Naval Postgraduate School (2006)

Organizations and Management Academic Area

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Patricia J. Cook, Visiting Assistant Professor of Ethics and Public Policy (2010), Ph.D., Emory University, 1992.

Nicholas Dew, Professor of Management (2003); Ph.D., University of Virginia, 2003.

Marco S. DiRenzo, Associate Professor of Management (2010) ; Ph.D., Drexel University, 2010.

Mitchell Friedman, Senior Lecturer (2016); Ed.D., University of San Francisco, 2011.

Deborah E. Gibbons, Associate Professor of Management (2004); Ph.D., Carnegie Mellon University, 1996.

Erik Helzer, Assistant Professor of Management (2019); Ph.D., Case Western Reserve University, 2005.

Paul B. Lester, Associate professor of Management (2019); Ph.D., University of Nebraska-Lincoln, 2006.

Edward H. Powley, Associate Professor of Management (2006); Ph.D., Case Western Reserve University, 2005.

Professor Emeritus:

Frank J. Barrett, Professor of Organization and Management (1990); Ph.D., Case Western Reserve University, 1989.

DDM Resident Programs and Curricula

DDM Course Descriptions

GB Courses (p. 382)

GC Courses (p. 383)

 (p. 383)GE Courses (p. 384)

MN Courses (p. 411)

Defense Contract Management - Curriculum 815

Program Officer

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Brief Overview

The Defense Contract Management curriculum is an interdisciplinary program which integrates management theory, accounting, economics, finance, behavioral science, management theory, operations/systems analysis, and specific courses in acquisition and contracting. The 815 curriculum includes a concentration option in strategic purchasing. Student input includes officers and civilians from all DoD services, other federal agencies and allied nations. The curriculum is designed to provide officers and civilians with the skills to serve effectively in systems buying offices, field contracting offices, contract administration offices, and contracting policy offices. The program can be delivered in 12 to 18-months, by adding Joint Professional Military Education courses or elective academic certificates as required. The program contributes to Defense Acquisition Workforce Improvement Act (DAWIA) certification in the Contract Management career field. Additionally, the curriculum is aligned with the competencies established in the National

Contract Management Association (NCMA) Contract Management Body of Knowledge (CMBOK) and the Contract Management Standard (CMS). The curriculum supports preparation for the NCMA professional certification examinations including the Certified Federal Contract Manager (CFCM) and the Certified Professional Contract Manager (CPCM).

Competency: Our graduates will be effective contract managers.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of at least two semesters of college algebra or trigonometry is considered to be the minimum mathematical preparation. An APC of 345 is required for entry. International students should refer to the Admissions section for current TOEFL and entrance requirements.

Convenes

January and July.

Program Length

Four to Six Quarters.

Degree

Requirements for the Master of Science (MS) in Defense Contract Management degree are met en route to satisfying the Educational Skills Requirements.

Acquisition and Contract Management Subspecialty

Completion of this curriculum qualifies naval officers as Acquisition and Contract Management Subspecialists with a subspecialty code of 1306P, Army officers as Functional Area 51C, and Marine Corps officers with a 9656 MOS. The curriculum satisfies mandatory Defense Acquisition University (DAU) contracting courses required by the Defense Acquisition Workforce Improvement Act (DAWIA).

Typical Subspecialty Jobs

Contract Specialists
Contracting Officer
Director of Contracts
Contracts and Business Policy Staff Officer

Curriculum Sponsor

Deputy Assistant Secretary of the Navy (Procurement)

Degree Requirements

Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 hours of which are at the 4000 level.
Completion of an approved sequence of courses in the student's area of concentration with a minimum of 20 credit hours.
Completion of an acceptable capstone project.
Approval of the candidate's program by the Chair, DDM.

Typical Course of Study: Curriculum 815

US Navy students also complete an additional four courses leading to the Naval War College Command and Staff program diploma.

International students take IT1500 American Life and Institutions and IT1600 Communication Skills for International Officers in Quarters one and two.

Quarter 1

Course	Title	Lecture	Lab
MN3010	Leading Innovative Organizations and People	4	0
MN3070	Fundamentals of Cost Benefit Analysis	4	0
MN3156	Financial and Managerial Accounting	4	0
MN3303	Principles of Acquisition and Contract Management	4	0

Quarter 2

MN3301	Acquisition of Defense Systems	4	0
MN3312	Government Contracts Law	4	0
MN3315	Acquisition Management and Contract Administration	4	0
MN4014	Competitive Strategy and Innovation	4	0

Quarter 3

MN3320	Contract Cost and Price Analysis	3	0
MN3321	Federal Contract Negotiations	3	0
MN4053/GE4053	Defense Budget and Financial Management Policy	4	0
ELECT	Elective		

Quarter 4

MN4044	Defense-Focused Managerial Inquiry and Innovation Lab	3	2
MN4999	Elective	4	0

Quarter 5

MN4090	Capstone Applied Project	0	6
MN4602	Acquisition Test and Evaluation Decision Science	3	2
MN4999	Elective	4	0
MN4999	Elective	4	0

Quarter 6

MN4090	Capstone Applied Project	0	6

MN4307	Defense Acquisition Program Management Case Studies	4	0
MN4371	Acquisition and Contracting Policy	4	0
MN4999	Elective	4	0

MN4090 or Thesis or Innovation Lab Capstone.

Educational Skills Requirements (ESR)
Master of Science in Defense Contract Management Curriculum 815

1. **Advanced Management Concepts:** The graduate will have the ability to apply advanced management and operations research techniques to defense problems. This includes policy formulation and execution, strategic planning, defense resource allocation, cost benefit and cost effectiveness analysis, federal fiscal policy, computer-based information and decision support systems, and complex managerial situations requiring comprehensive integrated decision making.

2. **Acquisition and Contracting Principles:** The graduate will have an understanding of and will be able to apply the principles and fundamentals of acquisition and contracting within the federal government, including knowledge of the acquisition laws and regulations, particularly the Federal Acquisition Regulation (FAR) and the DoD FAR Supplement (DFARS); the unique legal principles applied in government contract law and the Uniform Commercial Code; and the application of sound business principles and practices to defense contracting problems. Further, the graduate will be able to apply innovative and creative approaches not only to resolve difficult acquisition and contracting issues but to significantly influence the legal and regulatory structure within which acquisition decision making occurs. Finally, the graduate will have the ability to conceptualize, develop and execute strategic business alliances and relationships necessary to the successful acquisition of goods and services.

3. **Acquisition and Contracting Policy:** The graduate will have an ability to formulate and execute acquisition policies, strategies, plans and procedures; a knowledge of the legislative process and an ability to research and analyze acquisition legislation; and a knowledge of the government organization for acquisition, including Congress, the General Accounting Office, the Office of Federal Procurement Policy, the federal and military contracting offices, the Boards of Contract Appeals, and the court system.

4. **Contracting Process:** The graduate will understand the theory of and have the ability to manage the field contracting, contingency contracting, supplies and services contracting, system acquisition, and contract administration processes. This involves a knowledge of the defense system life cycle processes, including requirements determination, funding, contracting, ownership, and disposal; an ability to evaluate military requirements, specifications, and bids and proposals; an ability to utilize the sealed bid, competitive proposals and simplified acquisition methodologies; a comprehensive knowledge of all contract types and their application in defense acquisition; an ability to conduct cost and price analyses; and an ability to negotiate various contracting actions, including new procurement, contract changes and modifications, claims, equitable adjustment settlements, and noncompliance issues.

5. **Business Theory and Practices:** The graduate will have an understanding of the business philosophy, concepts, practices, and methodologies of the global commercial industrial base, and the ability to apply these to the federal government acquisition environment.

6. **Federal and Defense Budgeting:** The graduate will have an ability to apply economic and accounting principles, including monetary and fiscal theories, to defense acquisition and contracting issues.

7. **Program Management:** The graduate will have an understanding of the basic principles and fundamentals of Program Management, with particular emphasis on the Procuring Contractor Officer's and Administrative Contracting Officer's roles and relationships with the Program Manager.

8. **Acquisition Workforce:** The graduate will satisfy all requirements of the Defense Acquisition Workforce Improvement Act (DAWIA) and mandatory contracting courses required by the Defense Acquisition University (DAU) at Levels I, II, III.

9. **Ethics and Standards of Conduct:** The graduate will have an ability to manage and provide leadership in the ethical considerations of military acquisition, including the provisions of procurement integrity, and to appropriately apply defense acquisition standards of conduct.

10. **Strategy and Policy:** Officers develop a graduate-level ability to think strategically, critically analyze past military campaigns, and apply historical lessons to future joint and combined operations, in order to discern the relationship between a nation's policies and goals and the ways military power may be used to achieve them. This is fulfilled by completing the first of the Naval War College course series leading to Service Intermediate-level Professional Military Education (PME) and Phase I Joint PME credit.

11. **Analysis, Problem Solving, and Critical Thinking:** The graduate will demonstrate the ability to conduct research and analysis, and proficiency in presenting the results in writing and orally by means of an applied project and a command-oriented briefing appropriate to this curriculum.

Defense Program Management - Curriculum 816

Defense Program Management - Track 816

Program Officer

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Brief Overview

Defense Program Management is an interdisciplinary program within the Acquisition Sciences area designed to integrate business principles, program leadership and management theory, operations analysis, and systems engineering applications. It is uniquely tailored to federal government acquisition management and intensive exposure to the fundamental principles of the acquisition environment. The courses in this program apply business analysis and problem-solving techniques essential to effective major system program management within the structure of DoD acquisition management. It further focuses on the decisions and problems facing the acquisition manager, the various forces at work within industry and government, and the impact of acquisition policies and strategies. Student input includes officers and civilians from all DoD Services, other federal agencies, and allied nations. The program can be delivered in 12 to 18-months, by adding Joint Professional Military Education courses or elective academic certificates as required.

Competency: Our graduates will be effective program managers and leaders of people and resources within DoD organizations.

Program Objective: graduates will lead people and organizations to balance program costs, schedule, performance, risk and supportability requirements to effectively delivery warfighting capability at the speed of relevance.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of at least two semesters of college algebra or trigonometry is considered to be the minimum mathematical preparation. An APC of 355 is required for entry. International students should refer to the Admissions section for current TOEFL and entrance requirements.

Convenes

January and July

Program Length

Four to Six Quarters

Degree

Requirements for the Master of Science (MS) in Defense Program Management degree are met en-route to satisfying the Educational Skills Requirements.

Defense Program Management Subspecialty

Completion of this program qualifies an Army officer for Functional Area 51 and a Marine Corps officer for MOS 9657, and Navy officers are awarded subspecialty code 6502P Systems Acquisition Management. Department of Defense civilians are typically members of the acquisition work force as specified by the Defense Acquisition Workforce Improvement Act (DAWIA). This program integrates the Advanced Acquisition Studies and the Basic Contract Management certificates - graduates are awarded fulfillment for DAWIA required training from the Defense Acquisition University (DAU) for the Practitioner level of program management and the Professional level of contracting.

Typical Subspecialty Jobs

Program Manager/Deputy Program Manager/Program Office:

Army/Air Force/Navy/Marine Corps Acquisition Category I through III (ACAT I - III) Programs

Program Executive Officer (PEO) staff

Matrix Organization Staff

Army Materiel Command (AMC)

Naval Air Systems Command (NAVAIR)

Naval Sea Systems Command (NAVSEA)

Air Force Systems Command

Army Communications - Electronics Command (CECOM)

Marine Corps Systems Command (MARCORSYSCOM)

Force Development Officer

Test and Evaluation Officer

Acquisition Logistics Officer

Program Sponsor

Chief of Naval Operations (OPNAV) N9I

Subspecialty Code 6502: Defense Program Management

Degree Requirements

Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 hours of which are at the 4000 level.
Completion of an approved sequence of courses in the student's area of concentration with a minimum of 20 credit hours.
Completion of an acceptable capstone project.
Approval of the candidate's program by the Chair, DDM.

Typical Course of Study:

The 6-quarter matrix below is for US Army and USAF students.

USN, USMC and international students follow a 7-quarter program. USN students may add JPME courses.

International students also take IT1500 American Life and Institutions and IT1600 Communication Skills for International Officers in quarters one and two.

Quarter 1

Course	Title	Lecture	Lab
GB3010	Managing for Organizational Effectiveness	4	0
MN3303	Principles of Acquisition and Contract Management	4	0
MN3070	Fundamentals of Cost Benefit Analysis	4	0
MN3331	Principles of Acquisition and Program Management	5	1

Quarter 2

MN3384	Acquisition Production, Quality and Manufacturing Decision Science	3	2
MN3315	Acquisition Management and Contract Administration	4	0
SE3100	Fundamentals of Systems Engineering	3	2

Quarter 3

MN3309	Software Acquisition Management for Defense Systems	3	2
MN4053/GE4053	Defense Budget and Financial Management Policy	4	0
MN3320	Contract Cost and Price Analysis	3	0
MN3321	Federal Contract Negotiations	3	0

Quarter 4

GB4044	Defense-Focused Managerial Inquiry	3	0
MN4014	Competitive Strategy and Innovation	4	0
MN4470	Strategic Planning and Policy for the Acquisition Logistics Manager	4	0

Quarter 5

MN3302	Advanced Project Management	3	0
MN4090	Capstone Applied Project	0	6
MN4602	Acquisition Test and Evaluation Decision Science	3	2
MN4999	Elective	4	0

Quarter 6

MN4307	Defense Acquisition Program Management Case Studies	4	0
MN4090	Capstone Applied Project	0	6
MN4999	Elective	4	0

MN4090 or Thesis or Innovation Lab Capstone.

Educational Skills Requirements (ESR)

Defense Program Management - Curriculum 816

1. **Management Fundamentals:** The graduate will understand the theory of and have an ability to apply accounting, economic, mathematical, statistical, managerial and other state-of-the-art management techniques and concepts to problem solving and decision-making responsibilities as Department of Defense managers. The graduate will have the ability to think creatively, addressing issues and problems in a dynamic, challenging environment.

2. **Advanced Leadership and Management Concepts:** The graduate will have the ability to apply advanced leadership, management and operations research techniques to defense problems. This includes policy formulation and execution, strategic planning, defense resource allocation, project leadership, cost benefit and cost effectiveness analysis, federal fiscal policy, computer-based information and decision support systems, and complex managerial situations requiring comprehensive integrated leadership abilities.

3. **Program Leadership and Management Principles:** The graduate will have an understanding of and will be able to apply the principles, concepts, and techniques of Program Leadership and Program Management to the acquisition of major defense weapon systems. This includes the principles of risk management and tradeoff decision analysis using Total Ownership Cost, schedule and performance dynamics from a total life cycle management perspective.

4. **Program Management Policies:** The graduate will have an ability to formulate and execute defense acquisition policies, strategies, plans and procedures; an understanding of the policy-making roles of various federal agencies of the executive, legislative and judicial branches of the U.S. government, particularly the Department of Defense (DoD), the General Accounting Office (GAO), congressional committees, the Office of Management and Budget (OMB); and an understanding of the strategies necessary to influence policy development and implementation.

5. **Systems Acquisition Process:** The graduate will understand the theory of and have an ability to lead program teams and manage the systems acquisition process. This involves the system life cycle process for requirements determination, research and development, funding and budgeting, procurement, systems engineering, including systems of systems, test and evaluation, manufacturing and quality control,

integrated logistics support, ownership and disposal; the interrelationship between reliability, maintainability and logistics support as an element of system effectiveness in defense system and equipment design; and embedded weapon system software, particularly related to current policies and standards, software metrics, risk management, inspections, testing, integration, and post-deployment software support.

6. **Contract Management:** The graduate will understand the role of the contracting process within the acquisition environment, including financial, legal, statutory, technical, and managerial constraints in the process.

7. **Business Theory and Practices:** The graduate will have an understanding of the business and operating philosophies, concepts, practices and methodologies of defense industry with regard to major weapon systems acquisition, particularly the application of sound business practices.

8. **Government and Industry Budgeting and Financial Management:** The graduate will have an understanding of and an ability to apply the principles of government and private organizational financing, including corporate financial structures, cost and financial accounting, capital budgeting techniques, financial analysis, and Defense financial management and budgeting processes to include the Planning, Programming, Budgeting Execution System (PPBES).

9. **Acquisition Work force:** The graduate will have a mastery of the acquisition management, program management and leadership fundamentals satisfy all requirements of the required for Defense Acquisition Workforce Improvement Act (DAWIA) acquisition professionals.

10. **Ethics and Standards of Conduct:** The graduate will have an ability to manage and provide leadership in the ethical considerations of defense acquisition, including the provisions of procurement integrity, and to appropriately apply defense acquisition standards of conduct.

11. **Analysis, Problem Solving, and Critical Thinking:** The graduate will demonstrate the ability to conduct research and analysis, and proficiency in presenting the results in writing and orally by means of an applied project and a command-oriented briefing appropriate to this curriculum.

Logistics Information Technology - Track 870

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Brief Overview

The Logistics Information Technology graduate shall have the knowledge skills and competencies to: 1) Manage the acquisition of Information Systems; 2) Manage Information Systems and infrastructure support afloat and ashore; 3) Solve Information Systems engineering and management problems individually and in teams; 4) Effectively manage and lead in today's constantly changing digital world; 5) Develop and implement effective strategies and policies to take advantage of technological opportunities and mitigate risk; 6) Assimilate new technologies and transform organizations, processes, and strategies to compete in the marketplace or on the battlefield. These general education skill requirements are supported by the following topical educational skill requirements.

Competency: Our graduates will be able to effectively manage logistics information technology resources.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of at least two semesters of college algebra or trigonometry is considered to be the minimum mathematical preparation. An APC of 345 is required for entry. International students should refer to the Admissions section for current TOEFL and entrance requirements.

Convenes

July

Program Length

Six Quarters

Degree

Requirements for the degree are met enroute to satisfying the Educational Skills Requirements.

Subspecialty

Completion of this program qualifies a U.S. Navy officer as a Logistics - Information Technology subspecialist (subspecialty code 1309P). The 1309P code is applicable only to Supply Corps Officers (3100/3105/3107).

Typical Subspecialty Jobs

Project /Program Manager, Hardware Systems Command
Business Systems Center, Project Officer
Business Manager, PEO
CIO, Acquisition Office

Program Sponsor

Naval Supply Systems Command

Typical Course of Study:

Quarter 1

Course	Title	Lecture	Lab
MN3014	Ethics	1	0
GB3010	Managing for Organizational Effectiveness	4	0
MN3050	Financial Reporting and Analysis	4	0
GB3070	Economics of the Global Defense Environment	4	0
IS3001	Information Sciences for Defense	3	0
GB1000	Quantitative Skills for Graduate Management Studies	0	3

Quarter 2

MN3051	Cost Management	3	0
MN4052	Managerial Finance	3	0
MN4071	Advanced Economic and Defense Policy Analysis	4	0

Quarter 3

GB3012	Communication for Managers	3	0
MN3442	Process Analytics	4	0
GB4043	Decision Modeling Methods	3	0
GB4053	Defense Budget Policy and Financial Management Systems	4	0
IS3502	Network Operations I	4	2

Quarter 4

GB4014	Strategic Management	4	0
IS4220	Technology Enabled Process Improvement	3	2
IS4300	Project Management for Enterprise Systems	3	2

Quarter 5

IS3200	Enterprise Systems Analysis and Design	3	2
IS3201	Enterprise Database Management Systems	4	2
NW3230	Strategy & War	4	2
GB4090	Capstone Project	0	6

Quarter 6

CS3600	Introduction to Cybersecurity	4	1
MN3331	Principles of Acquisition and Program Management	5	1
IS4182	Enterprise Information Systems Strategy and Policy	4	0
GB4090	Capstone Project	0	6

* NW3230 required for USN and USMC; students completing JPME take all four Naval War College classes.

GB4090: Students may elect to complete a thesis.

International students take American Life and Institutions (IT1500) and Communication Skills for International Officers (IT1600) in quarters 1 and 2.

Logistics Information Technology - Track 870

Program Officer

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Academic Associate

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Brief Overview

The Logistics Information Technology graduate shall have the knowledge skills and competencies to: 1) Manage the acquisition of Information Systems; 2) Manage Information Systems and infrastructure support afloat and ashore; 3) Solve Information Systems engineering and management problems individually and in teams; 4) Effectively manage and lead in today's constantly changing digital world; 5) Develop and implement effective strategies and policies to take advantage of technological opportunities and mitigate risk; 6) Assimilate new technologies and transform organizations, processes, and strategies to compete in the marketplace or on the battlefield. These general education skill requirements are supported by the following topical educational skill requirements. This program integrates the 217 Advanced Acquisition Studies and 197 Chief Information Officer (CIO) certificates. Graduates are awarded fulfillment for DAWIA required training from the Defense Acquisition University (DAU) for the Practitioner level of program management. The program integrates opportunities to earn the Project Management Professional (PMP) certification if desired.

Competency: Our graduates will be able to effectively manage logistics information technology resources.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of at least two semesters of college algebra or trigonometry is considered to be the minimum mathematical preparation. An APC of 345 is required for entry. International students should refer to the Admissions section for current TOEFL and entrance requirements.

Convenes

July

Program Length

Six Quarters

Degree

Requirements for the degree are met enroute to satisfying the Educational Skills Requirements.

Subspecialty

Completion of this program qualifies a U.S. Navy officer as a Logistics - Information Technology subspecialist (subspecialty code 1309P). The 1309P code is applicable only to Supply Corps Officers (3100/3105/3107).

Typical Subspecialty Jobs

Project /Program Manager, Hardware Systems Command

Business Systems Center, Project Officer

Business Manager, PEO

CIO, Acquisition Office

Program Sponsor

Naval Supply Systems Command

Typical Course of Study:

Quarter 1

Course	Title	Lecture	Lab
IS3001	Information Sciences for Defense	3	0
MN3010	Leading Innovative Organizations and People	4	0
MN3070	Fundamentals of Cost Benefit Analysis	4	0
NW3230	Strategy & War	4	2

Quarter 2

CS3600	Introduction to Cybersecurity	4	1
IS3201	Enterprise Database Management Systems	4	2
MN3301	Acquisition of Defense Systems	4	0
NW3285	Theater Security Decision Making	4	0

Quarter 3

IS3502	Network Operations I	4	2
IS3200	Enterprise Systems Analysis and Design	3	2
MN3302	Advanced Project Management	3	0
MN3309	Software Acquisition Management for Defense Systems	3	2

Quarter 4

IS4220	Technology Enabled Process Improvement	3	2
MN4045	Defense-Focused Managerial Inquiry	3	0
MN4470	Strategic Planning and Policy for the Acquisition Logistics Manager	4	0
NW3275	Joint Maritime Operations - part 1	4	0

Quarter 5

IS4205	Big Data Management, Architecture, and Applications	3	2
IS4300	Project Management for Enterprise Systems	3	2
MN4053/GE4053	Defense Budget and Financial Management Policy	4	0
MN4090	Capstone Applied Project	0	6
NW3276	Joint Maritime Operations - part 2	2	2

Quarter 6

IS4182	Enterprise Information Systems Strategy and Policy	4	0
MN4014	Competitive Strategy and Innovation	4	0
MN4090	Capstone Applied Project	0	6
MN4307	Defense Acquisition Program Management Case Studies	4	0

* NW3230 required for USN and USMC; students completing JPME take all four Naval War College classes.

International students take American Life and Institutions (IT1500) and Communication Skills for International Officers (IT1600) in quarters 1 and 2.

Educational Skills Requirements (ESR)

Logistics Information Technology

Subspecialty 1309P

1. **Information Systems Technology:** The officer will have a thorough knowledge of information systems management to include: 1) computer system components; 2) computer networks: network architectures, protocols and standards; 3) database management systems: database technologies, object-oriented databases, data warehouses, OLAP, technical and administrative issues involved in the design, implementation and maintenance of database management systems.

2. **Decision Support and Knowledge Management Systems:** The student will have a thorough knowledge of problem identification, formulation, and application of systems to support decision making. The student will understand the purpose of executive information systems, group decision support systems, and contingency management systems and their potential

impacts on public organizations and missions. The student will also be familiar with knowledge collection technologies designed to capture, categorize, store, retrieve and present knowledge.

3. **Computer Security:** The student will gain fundamental knowledge of the methods for ensuring integrity, confidentiality, authentication, and availability of computer resources, distributed databases, and networks.

4. **Information Systems Analysis and Management:** The officer will have a thorough knowledge of the following concepts to effectively manage the application of information systems to organizational goals: 1) Managerial Concepts: decision-making theory, microeconomics, marketing, operations analysis, statistics, financial management, organizational development, and research methodologies; 2) Evaluation of Information Systems: cost-performance (effectiveness) analysis; selection, evaluation, acquisition, installation and effective utilization of information systems hardware and software risk assessment; 3) Systems Analysis and Design: information systems feasibility, life cycle management, system requirements determination, system performance evaluation, conversion and maintenance of legacy systems, post-implementation evaluation; 4) Management of Information Systems: metrics evaluation, monitoring, capacity planning, human resource management, budgeting and financial control of computer centers, design of effective organization structure, understanding architectural constraints, control and security (INFOSEC) policies, and training requirements for both the user and support staff; 5) Adapting to Technological, Organizational, and Economic Changes: Evaluation of potential impacts of new technology on information systems and organizational strategy.

5. **Military Applications:** The officer must be able to combine analytical methods and technical expertise with operational experience for effective military applications to include: 1) DoD Decision-Making Process on Information Systems: DoD, DoN, OMB, and congressional decision making on information systems matters; 2) Information Technology Acquisition Management: Acquisition policies and procedures of the DoD, including: statutory framework, acquisition planning, contracting, and the planning, programming, and budgeting system; 3) Joint Professional Military Education (JPME) Level 1.

6. **Acquisition Sciences:** the student will apply the principles, concepts, and techniques of Program Leadership and Management to lead program teams and manage the systems acquisition process. This involves the system life cycle process for requirements determination, research and development, funding and budgeting, procurement, systems engineering, test and evaluation, integrated logistics support; the

interrelationship between reliability and logistics support as an element of system effectiveness in information systems and embedded weapon system software, particularly related to current policies and standards, software metrics, risk management, inspections, testing, integration, and post-deployment software support.

7. **Independent Research:** The graduate will demonstrate the ability to conduct independent research analysis and proficiency in communicating the results in writing and orally by means of a field application study. The research in information technology and its management will include problem formulation, decision criteria specification, decision modeling, data collection and experimentation, analysis, and evaluation.

Educational Skills Requirements (ESR)
Logistics Information Technology
Subspecialty 1309P

1. **Information Systems Technology:** The officer will have a thorough knowledge of information systems management to include: 1) computer system components; 2) computer networks: network architectures, protocols and standards; 3) database management systems: database technologies, object-oriented databases, data warehouses, OLAP, technical and administrative issues involved in the design, implementation and maintenance of database management systems.

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information systems hardware and software risk assessment; 3) Systems Analysis and Design: information systems feasibility, life cycle management, system requirements determination, system performance evaluation, conversion and maintenance of legacy systems, post-implementation evaluation; 4) Management of Information Systems: metrics evaluation, monitoring, capacity planning, human resource management, budgeting and financial control of computer centers, design of effective organization structure, understanding architectural constraints, control and security (INFOSEC) policies, and training requirements for both the user and support staff; 5) Adapting to Technological, Organizational, and Economic Changes: Evaluation of potential impacts of new technology on information systems and organizational strategy.

5. **Military Applications:** The officer must be able to combine analytical methods and technical expertise with operational experience for effective military applications to include: 1) DoD Decision-Making Process on Information Systems: DoD, DoN, OMB, and congressional decision making on information systems matters; 2) Information Technology Acquisition Management: Acquisition policies and procedures of the DoD, including: statutory framework, acquisition planning, contracting, and the planning, programming, and budgeting system; 3) Joint Professional Military Education (JPME) Level 1.

6. **Independent Research:** The graduate will demonstrate the ability to conduct independent research analysis and proficiency in communicating the results in writing and orally by means of a field application study. The research in information technology and its management will include problem formulation, decision criteria specification, decision modeling, data collection and experimentation, analysis, and evaluation.

Logistics Information Technology - Track 870

Program Officer

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Brief Overview

The Logistics Information Technology graduate shall have the knowledge skills and competencies to: 1) Manage the acquisition of Information Systems; 2) Manage

Information Systems and infrastructure support afloat and ashore; 3) Solve Information Systems engineering and management problems individually and in teams; 4) Effectively manage and lead in today's constantly changing digital world; 5) Develop and implement effective strategies and policies to take advantage of technological opportunities and mitigate risk; 6) Assimilate new technologies and transform organizations, processes, and strategies to compete in the marketplace or on the battlefield. These general education skill requirements are supported by the following topical educational skill requirements. This program integrates the 217 Advanced Acquisition Studies and 197 Chief Information Officer (CIO) certificates. Graduates are awarded fulfillment for DAWIA required training from the Defense Acquisition University (DAU) for the Practitioner level of program management. The program integrates opportunities to earn the Project Management Professional (PMP) certification if desired.

Competency: Our graduates will be able to effectively manage logistics information technology resources.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of at least two semesters of college algebra or trigonometry is considered to be the minimum mathematical preparation. An APC of 345 is required for entry. International students should refer to the Admissions section for current TOEFL and entrance requirements.

Convenes

July

Program Length

Six Quarters

Degree

Requirements for the degree are met enroute to satisfying the Educational Skills Requirements.

Subspecialty

Completion of this program qualifies a U.S. Navy officer as a Logistics - Information Technology subspecialist (subspecialty code 1309P). The 1309P code is applicable only to Supply Corps Officers (3100/3105/3107).

Typical Subspecialty Jobs

Project /Program Manager, Hardware Systems Command

Business Systems Center, Project Officer

Business Manager, PEO

CIO, Acquisition Office

Program Sponsor

Naval Supply Systems Command

Typical Course of Study:

Quarter 1

Course	Title	Lecture	Lab
IS3001	Information Sciences for Defense	3	0
MN3010	Leading Innovative Organizations and People	4	0
MN3070	Fundamentals of Cost Benefit Analysis	4	0
NW3230	Strategy & War	4	2

Quarter 2

CS3600	Introduction to Cybersecurity	4	1
IS3201	Enterprise Database Management Systems	4	2
MN3301	Acquisition of Defense Systems	4	0
NW3285	Theater Security Decision Making	4	0

Quarter 3

IS3502	Network Operations I	4	2
IS3200	Enterprise Systems Analysis and Design	3	2
MN3302	Advanced Project Management	3	0
MN3309	Software Acquisition Management for Defense Systems	3	2

Quarter 4

IS4220	Technology Enabled Process Improvement	3	2
MN4045	Defense-Focused Managerial Inquiry	3	0
MN4470	Strategic Planning and Policy for the Acquisition Logistics Manager	4	0
NW3275	Joint Maritime Operations - part 1	4	0

Quarter 5

IS4205	Big Data Management, Architecture, and Applications	3	2
IS4300	Project Management for Enterprise Systems	3	2
MN4053/GE4053	Defense Budget and Financial Management Policy	4	0
MN4090	Capstone Applied Project	0	6
NW3276	Joint Maritime Operations - part 2	2	2

Quarter 6

IS4182	Enterprise Information Systems Strategy and Policy	4	0
MN4014	Competitive Strategy and Innovation	4	0
MN4090	Capstone Applied Project	0	6
MN4307	Defense Acquisition Program Management Case Studies	4	0

* NW3230 required for USN and USMC; students completing JPME take all four Naval War College classes.

International students take American Life and Institutions (IT1500) and Communication Skills for International Officers (IT1600) in quarters 1 and 2.

Educational Skills Requirements (ESR)

Logistics Information Technology

Subspecialty 1309P

1. **Information Systems Technology:** The officer will have a thorough knowledge of information systems management to include: 1) computer system components; 2) computer networks: network architectures, protocols and standards; 3) database management systems: database technologies, object-oriented databases, data warehouses, OLAP, technical and administrative issues involved in the design, implementation and maintenance of database management systems.

2. **Decision Support and Knowledge Management Systems:** The student will have a thorough knowledge of problem identification, formulation, and application of systems to support decision making. The student will understand the purpose of executive information systems, group decision support systems, and contingency management systems and their potential impacts on public organizations and missions. The student will also be familiar with knowledge collection technologies designed to capture, categorize, store, retrieve and present knowledge.

3. **Computer Security:** The student will gain fundamental knowledge of the methods for ensuring integrity, confidentiality, authentication, and availability of computer resources, distributed databases, and networks.

4. **Information Systems Analysis and Management:** The officer will have a thorough knowledge of the following concepts to effectively manage the application of information systems to organizational goals: 1) Managerial Concepts: decision-making theory, microeconomics, marketing, operations analysis, statistics, financial management, organizational development, and research methodologies; 2) Evaluation of Information Systems: cost-performance (effectiveness) analysis; selection, evaluation, acquisition, installation and effective utilization of

information systems hardware and software risk assessment; 3) Systems Analysis and Design: information systems feasibility, life cycle management, system requirements determination, system performance evaluation, conversion and maintenance of legacy systems, post-implementation evaluation; 4) Management of Information Systems: metrics evaluation, monitoring, capacity planning, human resource management, budgeting and financial control of computer centers, design of effective organization structure, understanding architectural constraints, control and security (INFOSEC) policies, and training requirements for both the user and support staff; 5) Adapting to Technological, Organizational, and Economic Changes: Evaluation of potential impacts of new technology on information systems and organizational strategy.

5. **Military Applications:** The officer must be able to combine analytical methods and technical expertise with operational experience for effective military applications to include: 1) DoD Decision-Making Process on Information Systems: DoD, DoN, OMB, and congressional decision making on information systems matters; 2) Information Technology Acquisition Management: Acquisition policies and procedures of the DoD, including: statutory framework, acquisition planning, contracting, and the planning, programming, and budgeting system; 3) Joint Professional Military Education (JPME) Level 1.

6. **Acquisition Sciences:** the student will apply the principles, concepts, and techniques of Program Leadership and Management to lead program teams and manage the systems acquisition process. This involves the system life cycle process for requirements determination, research and development, funding and budgeting, procurement, systems engineering, test and evaluation, integrated logistics support; the interrelationship between reliability and logistics support as an element of system effectiveness in information systems and embedded weapon system software, particularly related to current policies and standards, software metrics, risk management, inspections, testing, integration, and post-deployment software support.

7. **Independent Research:** The graduate will demonstrate the ability to conduct independent research analysis and proficiency in communicating the results in writing and orally by means of a field application study. The research in information technology and its management will include problem formulation, decision criteria specification, decision modeling, data collection and experimentation, analysis, and evaluation.

Defense Systems Analysis - Curriculum 817

Program Officer

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Brief Overview

This curriculum provides officers with the fundamental interdisciplinary techniques of quantitative problem-solving methods, behavioral and management science, economic analysis, and financial management. The curriculum educates students to evaluate others' research and analysis and to develop in them sound management and leadership skills. This curriculum is an interdisciplinary program that integrates mathematics, accounting, economics, behavioral science, management theory, operations/systems analysis, and a subspecialty into an understanding of the process by which the defense mission is accomplished.

Competency: Our graduates will be able to analyze complex military problems.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of at least two semesters of college algebra or trigonometry is considered to be the minimum mathematical preparation. An APC of 345 is required for entry. International students should refer to the Admissions section for current TOEFL and entrance requirements.

Convenes

January and July

Program Length

Six Quarters

Degree

Requirements for the Master of Science in Management (MSM) degree are met en route to satisfying the Educational Skills Requirements.

Subspecialty

U.S. Marine Corps officers completing this curriculum fulfill the requirements for MOS 8852.

Curriculum Sponsor

Programs and Resources, Headquarters Marine Corps

Typical Course of Study: Curriculum 817

Quarter 1

Course	Title	Lecture	Lab
GB1000	Quantitative Skills for Graduate Management Studies	0	3
MN3056	Financial and Managerial Accounting	4	0
MN3010	Leading Innovative Organizations and People	4	0
MN3070	Fundamentals of Cost Benefit Analysis	4	0

Quarter 2

MN3040	Data Management and Statistics for Manpower Analysis	4	0
MN2039	Basic Quantitative Methods in Management	4	0
MN4071	Advanced Economic and Defense Policy Analysis	4	0
MN4011/GC4011	Ethical Leadership in Public Organizations	3	2

Quarter 3

MN4043	Business Modeling and Analysis	3	0
MN4053/GE4053	Defense Budget and Financial Management Policy	4	0
MN4110	Multivariate Manpower Data Analysis I	4	1
MN3221	Principles of Acquisition and Program Management I	3	0

Quarter 4

MN4014	Competitive Strategy and Innovation	4	0
MN4045	Defense-Focused Managerial Inquiry	3	0
MN4111	Multivariate Manpower Data Analysis II	4	1
MN3222	Principles of Acquisition and Program Management II	3	0

Quarter 5

OA4702	Cost Estimation	4	0
MN4999	Elective	4	0

MN4999	Elective	4	0
MN0810	Thesis Research for Systems Management Students	0	8

Quarter 7

MN0810	Thesis Research for Systems Management Students	0	8
MN4999	Elective	4	0
MN4460	Business Risk Management	4	0

Quarter 7

MN0810	Thesis Research for Systems Management Students	0	8
MN4999	Elective	4	0
MN0810	Thesis Research for Systems Management Students	0	8
MN4128	Advanced Topics in Manpower Policy Evaluation	3	0

Logistics Management - Curriculum 827

Program Officer

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Brief Overview

The 12-Month Logistics Management program provides foundational education in all aspects of the logistics function. Students can extend their program to 15 months, 18 months, or longer by adding Joint Professional Military Education courses or elective academic certificates. The curriculum is comprised of a brief management core, a logistics concentration, and a capstone project. The management core addresses defense acquisition, budgeting, and finance, as well as organizational innovation and transformation. The logistics courses address significant components of the military supply chain, each providing unique and defense relevant education that meets the critical needs of the armed services. The specialized logistics courses concentrate on studies in data and process analytics, modeling methods for defense decision making, supply

chain management, logistics engineering and integrated logistics support, risk management, the defense distribution system, and logistics strategic planning. The objective of this program is to provide a foundational education that prepares graduates to operate successfully across the spectrum of defense logistics, from the industrial base and our Naval installations, through inter-theater and intra-theater distribution, to the last tactical mile in direct support of combat forces in contested environments.

Competency: Our graduates will be able to apply state-of-the-art logistics concepts in supply chain management to solve relevant problems across the spectrum of defense logistics.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of at least two semesters of college algebra or trigonometry is the minimum mathematical preparation. An APC of 345 is required for entry. International students should refer to the Admissions section for current TOEFL and entrance requirements.

Convenes

Winter, Summer

Program Length

Four to Six Quarters

Degree

Requirements for the Master of Science in Defense Logistics Management degree are met en route to satisfying the Educational Skills Requirements.

Subspecialty

Completion of this program provides a naval officer with a specialization in Supply Chain Management (1302P) or Materiel Logistics Support Management (subspecialty code 3121P) U.S. Marine Corps officers completing this program fulfill the requirements for MOS 8862.

Typical Subspecialty Jobs (various positions at each Command)

Naval Air Stations, Naval Bases and other installations

Naval Supply Systems Command, Naval Air Systems Command, Naval Sea Systems Command, Space and Naval Warfare Systems Command (Headquarters and components)

Fleet and Industrial Supply Centers

DLA Defense Supply Centers: Dayton, OH, Philadelphia, PA, and Richmond, VA

DLA Distribution Depots

Fleet Commands

Aircraft Intermediate Maintenance Departments (ashore and afloat)

Air Terminals and Detachments

NAVCHAPGRU

MSCHQ offices and MSC field activities

Military Surface Deployment and Distribution Command

Naval Submarine Support Facility, New London, CT

Unified Combatant Commands and Defense Agencies

Bureau of Medicine, Washington, DC

Marine Corps Logistics Base, Albany, GA

Marine Corps Systems Command, Quantico, VA

MAJCOM or HQ USAF level: A7 (Mission Support) staff action officer

MAJCOM or HQ USAF level: A4 (Logistics) staff action officer

Maintenance or Logistics Readiness Squadron commander, operations officer, or flight commander

Joint Staff or Joint Command (TRANSCOM, CENTCOM, etc.): J4 staff action officer

Program Stakeholders

Naval Supply Systems Command Headquarters

Naval Air Systems Command Headquarters

Typical Course of Study:

Quarter 1

Course	Title	Lecture	Lab
MN3010	Leading Innovative Organizations and People	4	0
MN3041	Managerial Data Analysis	4	0
MN3442	Process Analytics	4	0
MN4970	Seminar in Systems Management	V	0
MN3070	Fundamentals of Cost Benefit Analysis	4	0

Quarter 2

MN4410	Logistics Engineering and Sustainment	3	0
MN4043	Business Modeling and Analysis	3	0
MN4480	Supply Chain Management	3	0
MN4045	Defense-Focused Managerial Inquiry	3	0
MN4044	Defense-Focused Managerial Inquiry and Innovation Lab	3	2

Quarter 3

MN4460	Business Risk Management	4	0
MN4485	Supply Chain Strategy	3	0
MN4053/GE4053	Defense Budget and Financial Management Policy	4	0
NW3230	Strategy & War	4	2

NW3230: Required for USN and USMC only. International

students take American Life and Institutions (IT1500) and Communication Skills for International Officers (IT1600) in quarters 1 and 2. USN students may add JPME classes in Quarters 5 and 6.

Quarter 4

MN4450	Logistics Strategy	3	0
MN3301	Acquisition of Defense Systems	4	0
MN4430	Defense Distribution System	4	0
NW3285	Theater Security Decision Making	4	0

USN Supply Corps and USMC must replace MN3301 with MN3331. International students must replace MN3301 with MN3031.

Quarter 5

MN4999	Elective	4	0
MN4999	Elective	4	0
MN4090	Capstone Applied Project	0	6
NW3275	Joint Maritime Operations - part 1	4	0

MN4090 or Thesis or Innovation Lab Capstone.

Quarter 6

MN4999	Elective	4	0
MN4999	Elective	4	0
MN4090	Capstone Applied Project	0	6
NW3276	Joint Maritime Operations - part 2	2	2

MN4090 or Thesis or Innovation Lab Capstone.

Educational Skills Requirements (ESR)
Supply Chain Management Track - Subspecialty code 1302P
Materiel Logistics Support Management - Subspecialty code 3121P

1. **Management Fundamentals:** The graduate will have the ability to apply state-of- the-art concepts, tools, and methodologies from public management and business to manage DoN/DoD organizations. This ability will be developed in course work that includes economic, statistical, mathematical, operational, organizational, strategic, communication, audit ability, and financial theories and techniques.

2. **Integrated Logistics Support Management:** The graduate will have a detailed understanding of the processes associated with designing an integrated logistics support system for a new weapon system. The graduate will also have a detailed knowledge about the DoD processes for contracting for and acquiring a new weapon system.

3. **Budgeting and Financial Control:** The graduate will have an understanding of the financial management and financial controls practices of the DoD, will be able to conduct cost/benefit analyses, and participate in the budgetary planning by a hardware systems command for the support of both old and new weapon systems.

4. **Operations Management:** The graduate will be able to apply the techniques of production/operations management at Navy Fleet Readiness Centers, Navy Fleet Logistics Centers, and other DoD maintenance and logistics support.

5. **Materiel and Physical Distribution Management:** The graduate will be able to apply the techniques of materials management and physical distribution management in designing and operating of fleet and troop support systems, both during peacetime and during rapidly developing wartime contingencies. This will include acquiring material and transportation assets to ensure that the distribution of material is both cost-effective and efficient. The graduate will also have an in-depth understanding of domestic, international, and defense transportation systems including the various modes, types of carriers within each mode, and the regulations affecting material movement by each type of carrier.

6. **Joint and Maritime Strategic Planning:** The graduate will have knowledge of the development and execution of military strategy and the effects of technical effects on warfare, an understanding of the means of formulation of U.S. policy, the roles of military forces and joint planning, and current issues in the defense organization. The graduate will also have a detailed understanding of the plans and processes of the DoD for providing support of strategic sealift and mobilization.

7. **Capstone Project:** The graduate will demonstrate the ability to conduct independent research and analysis, and proficiency in presenting the results in writing by means of a capstone project appropriate to this curriculum.

Defense Financial Management - Curriculum 837

Program Officer

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Academic Associate

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Brief Overview

The objective of the Defense Financial Management Curriculum is to prepare officers for management, financial, and analysis positions within the DoN and DoD.

Financial Managers assist the DoN's decision-making processes at all levels by providing accurate, timely and relevant information and analysis. They are concerned with the optimal allocation of human, physical and financial resources to achieve the DoN's goals and objectives while assuring efficient and effective expenditure of public funds. Graduates of the Defense Financial Management Curriculum will be prepared for assignment to positions in strategic planning, management analysis, financial analysis, budgeting, accounting, business and financial management, and internal control systems and auditing.

Graduate courses cover topics such as financial reporting standards, cost standards, cost analysis, budgeting and financial management, internal control, auditing, management planning and control systems, strategic resource management, quantitative techniques used in planning and control, system acquisition and program management, and the Planning Programming, Budgeting Execution System (PPBES) used within the Department of Defense. The program can be delivered in 12 to 18-months, by adding Joint Professional Military Education courses or elective academic certificates as required.

Competency: Graduates will be able to apply state-of-the-art financial management concepts to military management problems.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of at least two semesters of college algebra or trigonometry is considered to be the minimum mathematical preparation. An APC of 345 is required for entry. International students should refer to the Admissions section for current TOEFL and entrance requirements.

Convenes

Winter, Summer

Program Length

Four to Six Quarters

Degree

Requirements for the Master of Science (MS) in Defense Financial Management degree are met en route to satisfying the Educational Skills Requirements.

Financial Management Subspecialty

Completion of this curriculum qualifies a U.S. Navy officer as a Defense Financial Management Subspecialist, subspecialty code 3110P. Completion qualifies a U.S. Marine Corps officer for MOS 8844.

Typical Subspecialty Jobs

Comptroller: Naval Bases/Naval Air Stations/SYSCOMs
Budget Analyst: Office of Budget, N-82 SYSCOMS, U.S. STRATCOM
Public Works Officer: CONUS/OUTCONUS
Comptroller: Naval Hospitals

Business Financial Managers: Program Offices
Action Officer/Program Analyst: OSD
Budget Analyst: OPNAV
Fiscal Officer: BUMED
Budget Officer: CINPACFLT/CINCLANTFLT

Curriculum Sponsor

N-82, Director, Office of Budget and Fiscal Management Division.

Degree requirements

Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 hours of which are at the 4000 level.
Completion of an approved sequence of courses in the student's area of concentration with a minimum of 20 credit hours.
Completion of an acceptable capstone project.
Approval of the candidate's program by the Chair, DDM.

Typical Course of Study: Curriculum 837

Quarter 1

Course	Title	Lecture	Lab
MN3041	Managerial Data Analysis	4	0
MN3050	Financial Reporting and Analysis	4	0
MN4053/GE4053	Defense Budget and Financial Management Policy	4	0
MN3070	Fundamentals of Cost Benefit Analysis	4	0

Quarter 2

MN3051	Cost Management	3	0
MN3510	Defense Financial Management Practice	3	0
MN4052	Managerial Finance	3	0
MN3301	Acquisition of Defense Systems	4	0

MN3301: Equivalent to DAU courses ACQ101 & ACQ102. May be replaced by MN3331. May be replaced by MN3031 for international students.

Quarter 3

MN4520	Internal Control & Audit	3	0
MN3010	Leading Innovative Organizations and People	4	0
NW3230	Strategy & War	4	2
NW3285	Theater Security Decision Making	4	0

Quarter 4

MN4045	Defense-Focused Managerial Inquiry	3	0

MN4510	Strategic Resource Management	4	0
MN4530	Management Control Systems	4	0
MN4014	Competitive Strategy and Innovation	4	0
MN4044	Defense-Focused Managerial Inquiry and Innovation Lab	3	2

Quarter 5

MN4540	Conrad Seminar	2	2
MN4999	Elective	4	0
MN4090	Capstone Applied Project	0	6
NW3275	Joint Maritime Operations - part 1	4	0

GB4999 or JPME.

MN4090 or Thesis or Innovation Lab Capstone.

Quarter 6

MN4999	Elective	4	0
MN4999	Elective	4	0
MN4090	Capstone Applied Project	0	6
NW3276	Joint Maritime Operations - part 2	2	2

GB4999 or JPME.

MN4090 or Thesis or Innovation Lab Capstone.

Educational Skills Requirements (ESR)
Defense Financial Management - Curriculum 837
Subspecialty Code 3110P

1. **Management Fundamentals**: The graduate will have the ability to apply quantitative techniques, accounting, economics, finance, organization theory, information technology, and other state-of-the-art management techniques and concepts to military management problems. In addition, the graduate will know basic management theory and practice, embracing leadership, ethics, written and oral communication, organization design, team building, human resource management, conflict resolution, quality assurance, cost-benefit analysis, risk analysis, stakeholder analysis, and planning within military organizations, as well as military sub-units and activities. This ensures internal and external constituencies are considered in resource management.

2. **Strategic Vision and Defense Budgeting**: The graduate will understand the roles the executive and legislative branches in strategic planning, setting federal fiscal policy, allocating resources to national defense, budget formulation, budget negotiation, budget justification, and budget execution strategies, including the principles of Federal Appropriations Law. In addition, the graduate will have knowledge of all aspects of the federal, Defense, and Navy budget cycles including the Planning, Programming, Budgeting, and Execution system with emphasis on budget formulation and execution.

3. **Funds Management**: In support of approved programs, the graduate will be able to manage appropriated, revolving, and non-appropriated funds in compliance with regulations of the Comptroller of the Navy and the federal government. In addition, the graduate will be able to develop and review financial reports, analyze budget execution against operating and financial plans, develop alternate plans based on analyses of an activity's financial performance, and prepare recommendations or make decisions regarding the reallocation or reprogramming of funds. The guidelines of the Defense Finance and Accounting System and the Federal Accounting Standards Advisory Board are relevant.

4. **Accountability, Control, and Auditing**: The graduate will be able to acquire and analyze financial data and communicate the results to a diverse audience, including maintaining an integrated financial information system and appropriate internal controls to ensure timely, accurate, and consistent financial information. In accordance with the auditing standards of the U.S. Government Accountability Office, the Defense and Navy audit organizations, and the professional standards of the American Institute of Certified Public Accountants, the graduate will learn to apply audit techniques that enforce sound internal accounting, and administrative controls, safeguard defense assets and assure the completeness and integrity of financial reports.

5. **Acquisition and Program Management**: The graduate will understand the purpose and concepts, fundamentals and philosophies of the defense systems acquisition process, and the practical application of program management methods within this process. This includes systems acquisition management; the systems acquisition life cycle; user-producer acquisition management disciplines and activities; and program planning, organizing, staffing, directing, and controlling. This satisfies the Defense Acquisition University education equivalency requirements for defense acquisition professionals as specified in Congress' Defense Acquisition Workforce Improvement Act (DAWIA).

6. **Economy, Efficiency, and Effectiveness**: The graduate will have the skills for solving complex and unstructured management problems in which alternatives must be identified, evaluated, and selected in accordance with economical procurement of resources, and effective accomplishment of overall Defense and Navy goals and objectives. This includes cost/benefit analysis, systems analysis, cost estimation, value engineering, business process reengineering, and application of relevant OMB and Defense regulations.

7. **Cost Management and Analysis**: The graduate will be able to design, implement, and evaluate different

costing systems encountered within Defense and Navy organizations and activities, as well as those found in private sector organizations conducting business with the federal government. In addition to private sector cost management policies and practices, the graduate will understand the application of Defense unit costing guidelines to functional business areas, and the Office of Management and Budget 's Cost Accounting Standards for major suppliers of goods and services to the federal government.

8. **Strategic Resources Management**: The graduate will use knowledge of strategic vision and strategic core competency concepts for setting long-range goals, objectives and funding; designing programs to achieve objectives; assigning individual responsibility for resource management, actions, and decision making; measuring performance; reporting results; and evaluating and incentivizing performance. This includes assessing customer needs and customer satisfaction, making recommendations, and implementing improvements in the effective delivery of goods and services to customers or users.

9. **Innovation and Creativity**: The graduate will demonstrate innovation and creativity in developing solutions to complex financial, budget, and program management issues that increase program effectiveness and customer satisfaction, while controlling the efficient utilization of financial, physical, and human resources. This involves the ability to identify problems and potential concerns, providing leadership, and teaming with others in the decision making process, and obtaining support for recommended decisions or courses of action.

10. **Strategy and Policy**: Officers develop a graduate-level ability to think strategically, critically analyze past military campaigns, and apply historical lessons to future joint and combined operations, in order to discern the relationship between a nation's policies and goals and the ways military power may be used to achieve them. This is fulfilled by completing the first of the Naval War College series leading to Service Intermediate-level Professional Military Education (PME) and Phase I Joint PME credit

Curriculum Sponsor and Educational Skill Requirements Approval Authority:

Defense Financial Management (837)
Chief of Naval Operations (N8/N82)

Manpower Systems Analysis - Curriculum 847

Program Officer

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Brief Overview

The Manpower Systems Analysis Curriculum (MSA) leading to the MSM degree is designed for U.S. and international officers. Officers enrolled in the Manpower Systems Analysis curriculum at the Naval Postgraduate School undertake the challenge of an academic program designed to fill leadership and analytical roles in military manpower personnel, training, and education management. MSA subspecialists are responsible for developing and analyzing policies to ensure that the Navy and DoD are recruiting, training, utilizing and retaining personnel in the most efficient and effective ways possible. MSA is an analytical curriculum intended to develop skills necessary to perform and evaluate manpower analyses and manage the Navy's Human Resource community of interest. As such, the curriculum emphasizes mathematical, statistical, and other quantitative and qualitative analysis methods. Successful completion of the curriculum yields an officer skilled in conducting manpower personnel, training, and education policy analysis. The areas covered in the MSA curriculum include an understanding of manpower, personnel, training, education policy development, managing diversity, compensation systems, enlistment supply and retention models, manpower training models, manpower requirements determination processes, career mix, enlistment and reenlistment incentives, training effectiveness measures, and hardware/manpower trade-offs. Students gain familiarity with current models and methods of manpower analysis and economics as well as military manpower organizations, information systems and issues. The curriculum directly supports the Navy Human Resource Community of Interest.

Competency: Our graduates will be able to analyze military manpower or personnel problems.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of at least two semesters of college algebra or trigonometry is considered to be the minimum mathematical preparation. Additional preparation in calculus and statistics is advisable. An APC of 345 is required for entry. International students should refer to the Admissions section for current TOEFL and entrance requirements. Prospective students electing MSA as a curriculum must be adequately prepared by their undergraduate course work and comfortably oriented to a quantitatively and analytically rigorous graduate curriculum.

Convenes

July

Program Length

Seven quarters

Degree

Requirements for the Master of Science in Management (MSM) degree are met en route to satisfying the Educational Skills Requirements.

Subspecialty

Completion of this curriculum qualifies an officer as a Manpower Systems Analysis Subspecialist, subspecialty code 3130P. U.S. Marine Corps officers completing this curriculum fulfill the requirements for MOS 8840.

Curriculum Sponsors

OPNAV, N-1, Chief of Naval Personnel and Subject Matter Expert, OPNAV, N14, Director of Strategic Planning and Analysis

Military Personnel Plans and Policy and Headquarters - United States Marine Corps (Manpower & Reserve Affairs)

Typical Subspecialty Jobs

Military Personnel Policy and Career Progression (N13)
Joint Manpower Management Branch, JCS (J-1)
Manpower Resources Branch, Director Total Force Programming/Manpower (N12)
Manpower and Training Analyst, DCNO (Resources, Warfare Requirements and Assessment (N801D)
Manpower Plans, COMCDRPAC/COMCDRLANT (N1)
Naval Manpower Analysis Center (NAVMAC)
Bureau of Medicine and Surgery, BUMED
Marine Corps MCCDC and M&RA
Headquarters - United States Marine Corps Manpower & Reserve Affairs (M&RA)
Marine Corps Combat Development Command (MCCDC)

Typical Course of Study: Curriculum 847

All U.S. Marine Corps students are required to take MN4015, MN4128, and OA4801 in lieu of curriculum electives.

Quarter 1

Course	Title	Lecture	Lab
MN3010	Leading Innovative Organizations and People	4	0
MN3070	Fundamentals of Cost Benefit Analysis	4	0
GB1000	Quantitative Skills for Graduate Management Studies	0	3
MN2039	Basic Quantitative Methods in Management	4	0
MN3056	Financial and Managerial Accounting	4	0

Quarter 2

MN3040	Data Management and Statistics for Manpower Analysis	4	0
MN4071	Advanced Economic and Defense Policy Analysis	4	0
MN2111	Navy Manpower, Personnel, and Training Systems I	2	0
MN4011/GC4011	Ethical Leadership in Public Organizations	3	2
MN4115	Foundations of Education and Learning in DoD Organizations	3	0

Quarter 3

MN4043	Business Modeling and Analysis	3	0
MN4053/GE4053	Defense Budget and Financial Management Policy	4	0
MN4760	Manpower Economics I	4	0
MN4110	Multivariate Manpower Data Analysis I	4	1

Quarter 4

MN4014	Competitive Strategy and Innovation	4	0
MN4111	Multivariate Manpower Data Analysis II	4	1
MN3111	Analysis of Human Resource Management	4	0
NW3230	Strategy & War	4	2

Quarter 5

MN4119	Navy Manpower Requirements Process	3	0
	-or-		
MN4130	Marine Manpower Management	3	0
OS4701	Manpower and Personnel Models	4	0
MN4761	Applied Manpower Analysis	4	0
MN2112	Seminar in Manpower, Personnel, and Training Issues II	2	0
NW3275	Joint Maritime Operations - part 1	4	0

Quarter 6

MN0810	Thesis Research for Systems Management Students	0	8

MN4106	Manpower/Personnel Policy Analysis	4	0
NW3276	Joint Maritime Operations - part 2	2	2
ELECT	Elective		
ELECT	Elective		
Quarter 7			
MN0810	Thesis Research for Systems Management Students	0	8
MN0810	Thesis Research for Systems Management Students	0	8
MN0810	Thesis Research for Systems Management Students	0	8
NW3285	Theater Security Decision Making	4	0

NW3275, NW3276, NW3230, NW3285: Not required for International students, US Army or USAF. International students take American Life and Institutions (IT1500) and Communication Skills for International Officers (IT1600) in quarters 1 and 2. USN students can complete JPME by taking four Naval War College courses.

Course Elective Options

MN4015	Management of Change	4	0
MN4480	Supply Chain Management	3	0
IS3210	Information and Knowledge Management Issues in Defense	4	0
IS4520	Systems Thinking and Modeling for a complex World	4	0
MN3400	Critical Thinking for Strategic Leadership	4	0
MN3441	Technology for Managerial Data Analysis	3	0
MN4128	Advanced Topics in Manpower Policy Evaluation	3	0
MV4002	Simulation and Training	4	1
NW3230	Strategy & War	4	2
OA3411	Introduction to Human Systems Integration	3	0

MN4119: International only

Educational Skills Requirements (ESR)

Manpower Systems Analysis - Curriculum 847 Subspecialty Code 3130P

1. **Budgeting and Financial Controls:** The graduate will have an understanding of basic financial management practices of DoN/DoD and will be able to conduct cost benefit analyses and participate in the budgetary planning of commands and/or DoN programs. The graduate will have an understanding of the Planning, Programming, Budgeting Execution System (PPBES) and the ability to analyze the impact of budgetary changes on DoN/DoD manpower and personnel programs and policies.

2. **Automated Data Analysis:** The graduate will possess the skills in data manipulation, statistics, and exploratory data analysis to be able to formulate and execute analyses of a wide variety of manpower, personnel, and training issues. The graduate will have proficiency in computing and interactively apply a variety of methods to large-scale DoN and DoD databases. The graduate will have a working understanding of the manpower information systems.

3. **Management Fundamentals - Analytical Techniques:** The graduate will be able to apply mathematical, statistical, accounting, economic and other analytical techniques and concepts to day-to-day military management issues. The graduate will be able to gather and analyze qualitative data. The graduate will also be able to use these techniques and concepts as a participant in the long-range strategic planning efforts of the Navy and DoD.

4. **Advanced Quantitative and Qualitative Analysis:** The graduate will have the ability to apply a wide range of advanced organizational, economics, statistical, and mathematical techniques and concepts to manpower and personnel policies and issues. These include the use of econometric techniques in the quantitative analysis of large-scale DoN/DoD manpower and personnel databases, of qualitative techniques in the analysis of survey and personnel data, of manpower decision support systems, and of Markov models in the analysis of force structure and manpower planning, forecasting, and flow models.

5. **Manpower Systems Analysis Fundamental Concepts:** The graduate will have an understanding of the fundamental concepts and basic functional areas of manpower, personnel, training, and education (MPT&E) within DoN/DoD as listed below, as well as an understanding of the MPT&E systems and their interrelationships.
   a. **Manpower:** Requirements determination; billet authorizations; billet costs; end strength planning; and total force planning and programming.
   b. **Personnel:** Recruiting; accession plans and policies; officer and enlisted community management; attrition; retention; compensation; and readiness.
   c. **Training:** Applications of theories of learning; instructional technologies; the systems approach to training; evaluation of training effectiveness and cost; and the relationship between training and fleet readiness.

6. **Manpower Systems Policy Analysis:** The graduate will have the ability to analyze critically the strengths and weaknesses of proposed manpower, personnel, and training policies and to suggest alternatives that

recognize the potential impact on DoN/DoD program planning, resources, and objectives.

7. **Joint Military Strategic Planning:** The graduate will have an understanding of the development and execution of military strategy, the effects of technical developments on warfare, and the processes for formulating U.S. policy, the roles of military forces, joint planning, and current issues in the defense organization. This understanding will include expertise on the combined use of active and reserve forces in joint warfare.

8. **Evaluation, Innovation, and Creativity:** The graduate will demonstrate individual initiative and creativity in the application of the skills and knowledge gained from the Manpower Systems Analysis program. The graduate will select a manpower, personnel, training, or education policy or management issue of importance to DoN/DoD, develop a plan to investigate the issue, analyze all of its aspects, suggest a solution as appropriate, and report the significant findings and recommendations in writing by means of a thesis.

Curriculum Sponsor and ESR Approval Authority

Chief of Naval Operations (N14)

Non-Resident Degree Programs and Curricula

Program Officer

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Master of Science in Contract Management - Curriculum 835 (DL)

Program Officer

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Brief Overview

The Master of Science in Contract Management (MSCM) degree provides an advanced education in the concepts, methodologies and analytical techniques necessary for successful management of acquisition and contracting within complex organizations. The MSCM degree is a 24-month, part-time distance learning program open to active duty Navy and Marine Corps personnel, active duty military personnel from other Services, federal employees, international students and defense contractor personnel. The program contributes to Defense Acquisition Workforce Improvement Act (DAWIA) certification in the Contract Management career field. Additionally, the curriculum is aligned with the competencies established in the National Contract Management Association (NCMA) Contract Management Body of Knowledge (CMBOK) and the Contract Management Standard (CMS). The curriculum supports preparation for the NCMA professional certification examinations including the Certified Federal Contract Manager (CFCM) and the Certified Professional Contract Manager (CPCM).

Competencies: Our graduates will be effective contract managers.

Requirements for Entry

Candidates for the program must have achieved a baccalaureate degree with a minimum undergraduate quality point rating (QPR) of 2.20 and completion of at least one semester of college algebra or trigonometry is considered to be the minimum mathematical preparation. Applicants without previous contracting experience are eligible for admission.

Convenes

Summer

Program Length

Eight quarters with two courses per quarter

Degree

The Master of Science in Contract Management degree requires:

• Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 that are at the 4000 level. (Credit hour requirement does not include 3 hours assigned for the Joint Applied Project.)

• Completion of an acceptable Capstone Applied Project, with at least one advisor from the Department of Defense Management.

Subspecialty

1306P

Typical Course of Study: Curriculum 835

Quarter 1

Course	Title	Lecture	Lab
MN3301	Acquisition of Defense Systems	4	0

Course	Title	Lecture	Lab
MN3303	Principles of Acquisition and Contract Management	4	0
Quarter 2			
MN3070	Fundamentals of Cost Benefit Analysis	4	0
MN3315	Acquisition Management and Contract Administration	4	0
Quarter 3			
MN3156	Financial and Managerial Accounting	4	0
MN4474	Organizational Analysis	3	1
Quarter 4			
MN3320	Contract Cost and Price Analysis	3	0
MN3321	Federal Contract Negotiations	3	0
Quarter 5			
MN3172	Resourcing National Security: Policy and Process	3	0
MN3312	Government Contracts Law	4	0
Quarter 6			
MN4105	Strategic Management	3	0
GB4044	Defense-Focused Managerial Inquiry	3	0
Quarter 7			
MN4311	Contracting for Services	3	0
MN4090	Capstone Applied Project	0	6
Quarter 8			
MN4371	Acquisition and Contracting Policy	4	0
MN4090	Capstone Applied Project	0	6

Educational Skills Requirements (ESR)

1. Advanced Management Concepts - The graduate will have the ability to apply advanced management theory and techniques to problems in both the public and private sectors. This includes policy formulation and execution, strategic planning, resource allocation, federal fiscal policy, computer-based information and decision support systems, and complex managerial situations requiring comprehensive integrated approaches. The graduate will have the ability to apply state-of-the-art management concepts and practices to problem solving and decision-making responsibilities as middle and senior managers.

2. Acquisition and Contracting Principles - The graduate will have an understanding of and will be able to apply the principles and fundamentals of acquisition and contracting within the federal government including knowledge of the acquisition laws and regulations, particularly the Federal Acquisition Regulation (FAR) and the Defense FAR Supplement (DFARS); the unique legal principles applied in government contract law and the Uniform Commercial Code; and the application of sound business principles and practices to Defense contracting problems. Further, the graduate will be able to apply innovative and creative approaches not only to resolve difficult acquisition and contracting issues but to significantly influence the legal and regulatory structure within which acquisition decision making occurs. Finally, the graduate will have the ability to conceptualize, develop and execute strategic business alliances and relationships necessary to the successful acquisition of goods and services.

3. Contracting Process - The graduate will understand the theory of and have the ability to manage the field contracting, contingency contracting, supplies and services contracting system acquisition and contract administration processes. This involves a knowledge of the defense system life cycle processes, including requirements determination, funding, contracting, ownership, and disposal; an ability to evaluate military requirements, specifications, and bids and proposals; an ability to utilize the sealed bid, competitive proposals and simplified acquisition methodologies; a comprehensive knowledge of all contract types and their application in Defense application; an ability to conduct cost and price analyses; and an ability to negotiate various contracting actions including new procurement, contract changes and modifications, claims, equitable adjustment settlements, and noncompliance issues.

4. Acquisition and Contracting Policy - The graduate will have an ability to formulate and execute acquisition policies, strategies, plans and procedures; a knowledge of the legislative process and an ability to research and analyze acquisition legislation; and a knowledge of the government organization for acquisition, including Congress, the General Accounting Office , the Office of Federal Procurement Policy, the federal and military contracting offices, the Boards of Contract Appeals, and the court system.

5. Business Theory and Practices - The graduate will have an understanding of the business philosophy, concepts, practices and methodologies of the commercial industrial base (both domestic and global) and the ability to apply these to the federal government acquisition environment.

6. Defense Financial Management and Budgeting - The graduate will have an ability to apply sound financial management theories, principles and practices to defense acquisition and contracting issues, including fiscal and monetary policy.

7. Production and Quality Management - The graduate will have an understanding of principles and fundamentals of Production and Quality Management, with particular emphasis on the Procuring Contracting Officer's and Administrative Contracting Officer's roles and

relationships with industry and the Government Program Manager.

8. Analysis and Application - The graduate will demonstrate an ability to apply acquisition, contracting and management principles in dealing with the significant issues encountered in managing the contracting process in one of the following areas: (1) major weapon systems acquisition (2) research and development, (3) field procurement, and (4) facilities contracting.

9. Ethics and Standards of Conduct - The graduate will have an ability to manage and provide leadership in the ethical considerations of military acquisition, including the provisions of procurement integrity, and to appropriately apply Defense acquisition standards of conduct.

10. Acquisition Workforce - The graduate will satisfy all training requirements of the Defense Acquisition Workforce Improvement Act (DAWIA) contracting certification.

11. Analysis, Problem Solving and Critical Thinking - The graduate will demonstrate the ability to conduct independent research and analysis, and proficiency in presenting the results in writing and orally by means of a thesis and a command–oriented briefing appropriate to this curriculum.

Master of Science in Program Management - Curriculum 836 (DL)

Program Officer

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Program Manager

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Brief Overview

The Master of Science in Program Management (MSPM) degree is an advanced education in the concepts, methodologies and analytical techniques necessary for successful management of programs/projects within complex organizations. The MSPM degree is a 24-month, part-time distance learning program open to qualified active duty Navy and Marine Corps personnel, active duty personnel from other Services, federal employees, international students, and DoD contractor personnel.

Navy officers are awarded subspecialty code 6502P Systems Acquisition Management. The curriculum focuses on leadership, problem solving and decision making within the acquisition environment utilizing case studies, teaming exercises, hands-on applications, active participation and integrative exercises. Lecture and laboratory tasks require the application of critical thinking to problem solving within notional and actual situations. The curriculum is designed to provide graduates with the knowledge, skills and abilities to manage and lead effectively in the federal government acquisition environment. The MSPM program incorporates the Advanced Acquisition Studies academic certificate. Graduates earn fulfillment credit for the Defense Acquisition Workforce Improvement Act (DAWIA) required Defense Acquisition University (DAU) training for the Program Management Practitioner level certification.

Program Competency: graduates will be effective program managers and leaders of people and resources within DoD organizations.

Program Objective: graduates will lead people and organizations to balance program costs, schedule, performance, risk and supportability requirements to effectively delivery warfighting capability at the speed of relevance.

Requirements for Entry

Candidates for the program must have achieved the following: a baccalaureate degree with a minimum undergraduate quality point rating (QPR) of 2.20, and completion of at least one semester of college algebra or trigonometry is considered to be the minimum mathematical preparation. Applicants without previous program management experience are eligible for admission.

Convenes

Summer

Program Length

Eight quarters with two courses per quarter

Degree

The Master of Science in Program Management degree requires:

- Completion of a minimum of 48 credit hours of graduate-level courses, at least 12 which are at the 4000 level.
- Completion of an acceptable Capstone Applied Project, with at least one advisor from the Department of Defense Management.

Subspecialty

6502P

Typical Course of Study: Curriculum 836

Quarter 1

Course	Title	Lecture	Lab
MN3301	Acquisition of Defense Systems	4	0
MN3302	Advanced Project Management	3	0

Quarter 2

MN3303	Principles of Acquisition and Contract Management	4	0
MN3070	Fundamentals of Cost Benefit Analysis	4	0

Quarter 3

MN4474	Organizational Analysis	3	1
MN4602	Acquisition Test and Evaluation Decision Science	3	2

Quarter 4

MN3384	Acquisition Production, Quality and Manufacturing Decision Science	3	2
SE4011	Systems Engineering for Acquisition Managers	3	2

Quarter 5

MN3172	Resourcing National Security: Policy and Process	3	0
MN3309	Software Acquisition Management for Defense Systems	3	2

Quarter 6

MN4105	Strategic Management	3	0
MN4045	Defense-Focused Managerial Inquiry	3	0

Quarter 7

MN4470	Strategic Planning and Policy for the Acquisition Logistics Manager	4	0
MN4090	Capstone Applied Project	0	6

Quarter 8

MN4307	Defense Acquisition Program Management Case Studies	4	0
MN4090	Capstone Applied Project	0	6

Educational Skills Requirements (ESR)

Program Management - Curriculum 836

1. **Management Fundamentals:** The graduate will understand the theory of and have an ability to apply accounting, economic, mathematical, statistical, managerial and other state-of-the-art management techniques and concepts to problem solving and decision-making responsibilities as Department of Defense managers. The graduate will have the ability to think creatively, addressing issues and problems in a dynamic, challenging environment.

2. **Advanced Leadership and Management Concepts:** The graduate will have the ability to apply advanced leadership, management and operations research techniques to defense problems. This includes policy formulation and execution, strategic planning, defense resource allocation, project leadership, cost benefit and cost effectiveness analysis, federal fiscal policy, computer-based information and decision support systems, and complex managerial situations requiring comprehensive integrated leadership abilities.

3. **Program Leadership and Management Principles:** The graduate will have an understanding of and will be able to apply the principles, concepts, and techniques of Program Leadership and Program Management to the acquisition of major defense weapon systems. This includes the principles of risk management and tradeoff decision analysis using Total Ownership Cost, schedule and performance dynamics from a total life cycle management perspective.

4. **Program Management Policies:** The graduate will have an ability to formulate and execute Defense acquisition policies, strategies, plans and procedures; an understanding of the policy-making roles of various federal agencies of the Executive, Legislative and Judicial branches of the Government, particularly the Department of Defense (DoD), the General Accounting Office (GAO), Congressional committees, the Office of Management and Budget (OMB); and an understanding of the strategies necessary to influence policy development and implementation.

5. **Systems Acquisition Process:** The graduate will understand the theory of and have an ability to lead program teams and manage the systems acquisition process. This involves the system life cycle process for requirements determination, research and development, funding and budgeting, procurement, systems engineering, including systems of systems, test and evaluation, manufacturing and quality control, integrated logistics support, ownership and disposal; the interrelationship between reliability, maintainability and logistics support as an element of system effectiveness in Defense system/equipment design; and embedded weapon system software, particularly related to current policies and standards, software metrics, risk management, inspections, testing, integration, and post-deployment software support.

6. **Contract Management:** The graduate will understand the role of the contracting process within the acquisition environment including financial, legal, statutory, technical and managerial constraints in the

process.

7. **Business Theory and Practices:** The graduate will have an understanding of the business and operating philosophies, concepts, practices and methodologies of the defense industry with regard to major weapon systems acquisition, particularly the application of sound business practices.

8. **Government and Industry Budgeting and Financial Management:** The graduate will have an understanding of and an ability to apply the principles of government and private organizational financing including corporate financial structures, cost and financial accounting, capital budgeting techniques, financial analysis, and Defense financial management and budgeting processes to include the Planning, Programming, Budgeting Execution System (PPBES).

9. **Acquisition Workforce:** The graduate will have a mastery of the acquisition management, program management and leadership fundamentals required for Defense Acquisition Workforce Improvement Act (DAWIA) acquisition professionals.

10. **Ethics and Standards of Conduct:** The graduate will have an ability to manage and provide leadership in the ethical considerations of defense acquisition, including the provisions of procurement integrity, and to appropriately apply defense acquisition standards of conduct.

11. **Analysis, Problem Solving and Critical Thinking:** The graduate will demonstrate the ability to conduct research and analysis, and proficiency in presenting the results in writing and orally by means of an applied project and a command-oriented briefing appropriate to this curriculum.

Leadership Education and Development - Curriculum 855 (DL)

Program Officer

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Academic Associate

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Brief Overview

This one-year program provides graduate education and preparation for Junior Officers and Select Senior Non-Commissioned Officers to serve as Company Officers and Senior Enlisted Leaders at the United States Naval Academy (USNA) and for continued future service in the Navy and Marine Corps. The coursework provides knowledge and skills that officers will use as Company

leaders at USNA and in other leadership roles in the military.

The program foundation develops students' abilities to think critically and analytically by providing essential skills and knowledge in management fundamentals such as organizational behavior, quantitative analysis, project management, strategic thinking, and social science research methods. Specialized courses address the knowledge, skills and abilities essential for leading organizations and developing leadership in others, such as mentoring, counseling and teaching subordinates, leading teams, leader communication, ethical leadership, and serving as positive role model at the United States Naval Academy.

Convenes

Fall, Winter, Spring, Summer

Subspecialty

Completion of this curriculum qualifies an officer for subspecialty code 4500P. The Primary Curriculum Sponsor is the United States Naval Academy.

There are 19 required courses to complete the program over a one year period

GE3011 (2-0) Leading Teams

GE3010 (3-0) Organization Systems

GE3040 (3-0) Statistics

GB4044 (3-0) Research methods

MN3012 (3-0) Communications for Leadership

GE4016 (4-0) Strategic Mgt

MN3392 (4-0) Systems & Project Mgt

GE3109 (3-0) Ethics & Moral Development

MN3401 (3-0) Academy & Brigade

MN4011 (3-2) Ethical Leadership

MN4125 (4-0) Change Management

GE4043 (3-0) Modelling

MN3404 (0-4) Teaching Practicum Part I

MN3406 (2-0) Counselling Practicum Part A

GE4017 (4-0) High Performance Decision Making

GB4090 (0-6) Thesis block

GB4090 (0-6) Thesis block

MN3405 (0-4) Teaching Practicum Part II

MN3407 (0-2) Counselling Practicum Part B

1. MANAGEMENT FUNDAMENTALS - LEADERSHIP, MANAGEMENT, AND ORGANIZATION: Officers will have the ability to apply basic management and leadership practices to organizational operations. Officers will understand the fundamental principles of leadership and management in military organizations. They will be able to implement appropriate structures for organizations and jobs; they will understand state-of-the-art information technologies and planning and budgeting tools; they will

become skilled in spoken and written communications; and they will understand the higher-level leadership skills and the systems perspective of organizations in which day-to-day organizational operations and strategy formulation occur.

2. EVALUATING AND IMPROVING GROUP PERFORMANCE: Officers will become skilled at analyzing and improving group morale, cohesion, and performance. Graduates of the program will have the ability to analyze and improve group effectiveness through leadership practices that also develop the leadership abilities of subordinates. This ability will be based on knowledge of managing people from diverse backgrounds, teambuilding, conflict management, group dynamics and management of change. Officers will be exposed to varied approaches for building strong shared values within the military.

3. MOTIVATING SUBORDINATES: Officers will effectively motivate subordinates to achieve high standards in all military endeavors. Program graduates will have the ability to motivate subordinates in order to provide focus and encouragement as they face the rigorous requirements and goals of the military. This ability requires an understanding of how effective leaders use goal setting, equitable discipline, reward systems, analysis of individual needs, empowerment, coaching, and high expectations to achieve peak performance from individuals.

4. EVALUATING AND IMPROVING INDIVIDUAL PERFORMANCE: Officers will become skilled in analyzing and improving the performance of individuals. The officers will have the ability to evaluate the performance of subordinates and provide appropriate feedback and counseling. This includes activities that range from formal performance appraisal to informal assessment on an ongoing basis. These skills require knowledge of basic performance measurement and giving feedback, as well as knowledge of how to deal with performance outside of the norms that may lead to violations of military rules and regulations.

5. BEING A ROLE MODEL FOR SUBORDINATES: Officers will model and otherwise communicate the information about the military that subordinates will need to know to successfully transition to Naval and Marine Corps Leaders. Officers will utilize the operational experience they bring to the job, in addition to a broader base of knowledge created through the program, to visibly embody the high standards and values of Naval and Marine Corps officers. The Officer will communicate knowledge of the military culture, current policy and operations, and future plans for the Navy and joint operations in the Department of Defense. These abilities are based on a knowledge of the military in a democratic society, managing organizational cultures, DoD policy, and the behaviors of good role models and mentors.

6. MANAGING EDUCATIONAL PROCESSES: Officers will have a foundation of knowledge about educational processes that will enable them to effectively teach and develop their subordinates. The program graduate will have the ability to formulate and answer research questions about educational experiences within the Navy and Marine Corps. Through the thesis process, the officer will explore important issues while concurrently broadening his/her knowledge of training and education in the military.

Financial Management - Curriculum 857 (DL)

Brief Overview

The Master of Science in Financial Management (MSFM) delivers a core of defense-focused courses to equip students with essential skills and knowledge to lead effectively in financial analysis and management positions within the DON and DoD. The MSFM is a 24-month, part-time distance learning program developed to meet the professional career needs of mid-career defense financial managers in accounting, budgeting, financial management, audit, and data analytics. The program supports continuous financial management reform initiatives mandated by Congress and senior leaders, with a focus on efficient and effective expenditure of public funds. The MSFM program is open to active duty Navy and Marine Corps personnel, active duty military personnel from other Services, federal agency civilians, international students, and defense contractors.

Convenes

Summer

Program Length

24 months

Course Requirements

Students will complete 2 courses per quarter except quarter 1 which includes 3 courses.

Quarter 1

Course	Title	Lecture	Lab
GE3011	Management of Teams	2	0
GE3050	Financial Reporting and Analysis	3	0
GE4016	Strategic Management	4	0

Quarter 2

GE4053	DoD Mission and Resource Determination	4	0
GE3070	Economics for Defense Managers	3	0

Quarter 3

GE3051	Cost Management	3	0
GE4052	Managerial Finance	3	0

Quarter 4

MN4520	Internal Control & Audit	3	0

MN3911	Introduction to Data Analytics for Defense Management	3	0
Quarter 5			
MN4510	Strategic Resource Management	4	0
MN4570	Advanced Finance	3	0
Quarter 6			
MN4912	Multivariate Data Analysis	3	0
MN4530	Management Control Systems	4	0
Quarter 7			
GE4101	Collaborative Problem Solving I	3	3
MN3301	Acquisition of Defense Systems	4	0
Quarter 8			
GE4102	Collaborative Problem Solving II	3	3
GE3010	Organizations as Systems and Structures	3	0

Educational Skills Requirements (ESR)
Master of Science in Financial Management (Curriculum 857)

- **ESR 1: Management Fundamentals.** The graduate will have the ability to apply quantitative techniques, accounting, economics, finance, organization theory, information technology, and other state-of-the-art management techniques and concepts to military management problems. In addition, the graduate will know basic management theory and practice, embracing leadership, ethics, written and oral communication, organization design, team building, human resource management, conflict resolution, quality assurance, cost-benefit analysis, risk analysis, stakeholder analysis, and planning within military organizations, as well as military sub-units and activities. This ensures internal and external constituencies are considered in resource management.

- **ESR 2: Strategic Vision and Defense Budgeting.** The graduate will understand the roles the executive and legislative branches in strategic planning, setting federal fiscal policy, allocating resources to national defense, budget formulation, budget negotiation, budget justification, and budget execution strategies, including the principles of Federal Appropriations Law. In addition, the graduate will have knowledge of all aspects of the federal, Defense, and Navy budget cycles including the Planning, Programming, Budgeting, and Execution system with emphasis on budget formulation and execution.

- **ESR 3: Funds Management.** In support of approved programs, the graduate will be able to manage appropriated, revolving, and non-appropriated funds in compliance with regulations of the Comptroller of the Navy and the federal government. In addition, the graduate will be able to develop and review financial reports, analyze budget execution against. operating and financial plans, develop alternate plans based on analyses of an activity's financial performance, and prepare recommendations or make decisions regarding the reallocation or reprogramming of funds. The guidelines of the Defense Finance and Accounting System and the Federal Accounting Standards Advisory Board are relevant.

- **ESR 4: Accountability, Control, and Auditing.** The graduate will be able to acquire and analyze financial data and communicate the results to a diverse audience, including maintaining an integrated financial information system and appropriate internal controls to ensure timely, accurate, and consistent financial information. In accordance with the auditing standards of the U.S. Government Accountability Office, the Defense and Navy audit organizations, and the professional standards of the American Institute of Certified Public Accountants, the graduate will learn to apply audit techniques that enforce sound internal accounting, and administrative controls, safeguard defense assets and assure the completeness and integrity of financial reports.

- **ESR 5: Acquisition and Program Management.** The graduate will understand the purpose and concepts, fundamentals and philosophies of the defense systems acquisition process, and the practical application of program management methods within this process. This includes systems acquisition management; the systems acquisition life cycle; user-producer acquisition management disciplines and activities; and program planning, organizing, staffing, directing, and controlling. This satisfies the Defense Acquisition University education equivalency requirements for defense acquisition professionals as specified in Congress' Defense Acquisition Workforce Improvement Act (DAWIA).

- **ESR 6: Economy, Efficiency, and Effectiveness.** The graduate will have the skills for solving complex and unstructured management problems in which alternatives must be identified, evaluated, and selected in accordance with economical procurement of resources, and effective accomplishment of overall Defense and Navy goals and objectives. This includes cost/benefit analysis, systems analysis, cost estimation, value engineering, business process reengineering, and

application of relevant OMB and Defense regulations.

- **ESR 7: Cost Management and Analysis.** The graduate will be able to design, implement, and evaluate different costing systems encountered within Defense and Navy organizations and activities, as well as those found in private sector organizations conducting business with the federal government. In addition to private sector cost management policies and practices, the graduate will understand the application of Defense unit costing guidelines to functional business areas, and the Office of Management and Budget 's Cost Accounting Standards for major suppliers of goods and services to the federal government.

- **ESR 8: Strategic Resources Management.** The graduate will use knowledge of strategic vision and strategic core competency concepts for setting long-range goals, objectives and funding; designing programs to achieve objectives; assigning individual responsibility for resource management, actions, and decision making; measuring performance; reporting results; and evaluating and incentivizing performance. This includes assessing customer needs and customer satisfaction, making recommendations, and implementing improvements in the effective delivery of goods and services to customers or users.

- **ESR 9: Innovation and Creativity.** The graduate will demonstrate innovation and creativity in developing solutions to complex financial, budget, and program management issues that increase program effectiveness and customer satisfaction, while controlling the efficient utilization of financial, physical, and human resources. This involves the ability to identify problems and potential concerns, providing leadership, and teaming with others in the decision making process, and obtaining support for recommended decisions or courses of action.

Non-Degree Professional Development Programs (Certificates)

The Department of Defense Management also administers several non-degree professional development programs consisting of both graduate education and professional courses taught in residence or via distance learning modes.

Defense Management Foundations - Curriculum 191 (Resident)

Brief Overview

This certificate delivers a core of defense-focused management courses to equip students with essential skills for management and leadership roles in the defense establishments of the United States or allied nations. The program prepares graduates to manage organizations, resources, and programs in complex environments. It provides students a defense-focused background in management fundamentals; financial management; economic analysis; operations and logistics, and acquisition management.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

Expand understanding about processes that occur in public organizations, apply qualitative and quantitative analysis skills

Demonstrate expertise to manage defense organizations

Develop knowledge, skills, and abilities that are most valuable for the student's career path

Four quarters

This certificate requires the completion of four courses (at least 12 credits) that were not counted for another certificate. Only one course from each academic area may be selected.

Acquisition Management - MN3301: Acquisition of Defense Systems

Organizations and Management - GB3010: Managing for Organizational Effectiveness

Manpower and Economics - GB3070: Economics of the Global Defense Environment

Process Analytics - MN3442: Process Analytics

Financial Management - GB4053: Defense Budget Policy and Financial Management Systems **or** MN3510: Defense Financial Management Practice

For Further Information

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Defense Management Foundations - Curriculum 192 (DL)

Brief Overview

The certificate in Defense Management Foundations

delivers a core of defense-focused management courses to equip students with essential skills for management and leadership roles in the defense establishments of the United States or allied nations. The program prepares graduates to manage organizations, resources, and programs in complex environments. Students choose among foundational courses in organizational leadership; financial management; manpower and economic analysis; operations and logistics; or acquisition management.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

- Expand understanding about processes that occur in public organizations, apply qualitative and quantitative analysis skills.
- Demonstrate expertise to manage defense organizations.
- Develop knowledge, skills, and abilities that are most valuable for the student's career path.

Four Quarter Certificate

This certificate requires the completion of four courses (at least 12 credits) that were not counted for another certificate and includes five academic areas that provide a variety of perspectives about managing defense organizations. Courses must be selected from at least two academic areas. You may choose four courses from the following options.

Acquisition Management Course Options:

Course	Title	Lecture	Lab
MN3301	Acquisition of Defense Systems	4	0
-or-			
MN3331	Principles of Acquisition and Program Management	5	1
-or-			
MN3221	Principles of Acquisition and Program Management I	3	0
-and-			
MN3222	Principles of Acquisition and Program Management II	3	0
MN3303	Principles of Acquisition and Contract Management	4	0
MN3309	Software Acquisition Management for Defense Systems	3	2
MN4307	Defense Acquisition Program Management Case Studies	4	0

Students can choose MN3301 or MN3331 or BOTH

MN3221 and MN3222.

Financial Management Course Options:

Students can choose GE4053 or MN3172 or MN4053.

Course	Title	Lecture	Lab
GE4053	DoD Mission and Resource Determination	4	0
-or-			
MN3172	Resourcing National Security: Policy and Process	3	0
-or-			
MN4053/GE4053	Defense Budget and Financial Management Policy	4	0
MN3911	Introduction to Data Analytics for Defense Management	3	0

Strategic Leadership and Management Course Options:

Course	Title	Lecture	Lab
GE3010	Organizations as Systems and Structures	3	0
-or-			
MN4474	Organizational Analysis	3	1
-or-			
MN3010	Leading Innovative Organizations and People	4	0
MN3118	Negotiation and Consensus Building	4	0
GE3109	Ethics and Moral Development	3	0
MN4017	High-performance Decision Practices	3	0
MN4012	Maneuver Warfare for the Mind: The Art and Science of Interdisciplinary Learning for Innovation and Warfighting Leaders	4	0

Manpower and Economics Course Options:

Course	Title	Lecture	Lab
GE3070	Economics for Defense Managers	3	0
-or-			
GB3070	Economics of the Global Defense Environment	4	0
-or-			
MN3070	Fundamentals of Cost Benefit Analysis	4	0
GE3040	Statistics for Executive Management	3	0
-or-			
MN3911	Introduction to Data Analytics for Defense Management	3	0

Operations and Logistics Course Options:

Course	Title	Lecture	Lab
GE3042	Process Analytics	4	0
-or-			

MN3042	Operations Management	3	0
	-or-		
MN3442	Process Analytics	4	0
MN3441	Technology for Managerial Data Analysis	3	0
MN3911	Introduction to Data Analytics for Defense Management	3	0

Leading Innovation in Requirements Development for Technology Transition - Curriculum 193

Brief Overview

Innovation and technology transition in defense organizations requires understanding of the DoD Decision Support System which includes the integration of requirements, PPBE, and acquisition. This certificate will examine the complex interactions of organizations, innovation, and technology transition in the context of the requirements generation process, which leads to formal requirements and sets the conditions for technological innovation of warfighting capability from concept to retirement.

This interdisciplinary certificate gives warfighters the skills and knowledge required to lead the development of requirements that result in more effective technology transition.

A case learning approach relies on NPS cases and student discussion to target current Navy needs and issues. Students select 4 courses from required and elective options to cover innovation and acquisition foundations and innovation systems.

Convenes

Summer

Program Length

Four quarters

- Explain forces influencing Navy innovation
- Explain forces of Navy technology adoption
- Analyze Navy requirements decision-making
- Assess future, team, and organization environments
- Analyze systems effects on innovation & technology
- Apply innovation & technology theories to generate requirements
- Evaluate technologies, identify adoption barriers
- Create implementation plans & acquisition strategies

Certificate Requirements

Students take one required innovation course and one required defense acquisition course. They select from one of three management courses focused on topics relevant to managing teams and organizations for innovation, and select from one of three courses focused on innovation

systems.

Required Courses

Course	Title	Lecture	Lab
MN3301	Acquisition of Defense Systems	4	0
MN3811	Innovation Adoption & Implementation	3	0

Select one elective from:

MN3400, GB/MN3010, or MN4017. These elective courses provide foundation knowledge in leading teams and organizations.

GB3010	Managing for Organizational Effectiveness	4	0
	-or-		
MN3010	Leading Innovative Organizations and People	4	0
	-and-		
MN3400	Critical Thinking for Strategic Leadership	4	0
MN4017	High-performance Decision Practices	3	0

Select one elective from:

IS4182, DA3302, or SE3910. These elective courses provide a systems perspective on technology transition.

IS4182	Enterprise Information Systems Strategy and Policy	4	0
DA3302	Navigating Innovation Ecosystems	4	0
SE3910	System Evolution and Technology Assessment	4	0

Data Analytics for Defense Management - Curriculum 194 (DL)

Brief Overview

This program empowers defense managers with basic tools to use data in decision making and an understanding of how data creates value in defense organizations. The program builds basic data literacy for defense managers, enabling them to do basic descriptive and prescriptive analytics with available tools and to better manage data-intensive projects and processes. Students learn how to identify and collect data that is informative for a given managerial context. The four courses take students from no prior data science background through understanding the terminology and concepts underlying complex data bases and algorithms in machine learning. They study specific applications in areas such as manpower, budgeting and logistics. Mathematical literacy is a requirement for entry, but no prior probability, statistics, use of statistical software or programming is required.

Program Length

Four quarters

Certificate Requirements

Quarter 1

Course	Title	Lecture	Lab
MN3911	Introduction to Data Analytics for Defense Management	3	0

Quarter 2

MN4912	Multivariate Data Analysis	3	0

Quarter 3

MN4913	Advanced Model Building for Causal Inference and Prediction	3	0

Quarter 4

MN4914	Applications of Data Analytics in Defense Management	3	0

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DoD Financial Management Certificate - Curriculum 195 (Resident)

Brief Overview

The Certificate in Financial Management is a graduate academic certificate program available to NPS resident and distance learning students. Designed for mid-to-senior level leaders interested in financial management and budget, the program prepares students for business, financial, and analysis positions within the DoD. This program supports continuous financial management reform initiatives mandated by Congress and senior leaders, and also supports initiatives to educate mid-to-senior level leaders in the areas of financial management and budget. The program educates and prepares financial managers assisting the DoD's decision-making processes at all levels by providing accurate, timely, and relevant information and analysis.

Convenes

Fall, Winter, Spring, Summer

Program Length

Five quarters

Five-Quarter Certificate (1 course per quarter)

The certificate requires the completion of 3 core courses and 2 elective courses (students choose a track for their electives). Students would take 1 course per quarter.

Core Courses

Course	Title	Lecture	Lab
MN3056	Financial and Managerial Accounting	4	0
GB4053	Defense Budget Policy and Financial Management Systems -or-	4	0
MN4053/GE4053	Defense Budget and Financial Management Policy -and-	4	0
MN4052	Managerial Finance	3	0

Elective Courses (Students will Choose a Track)

Track 1 - Audit Track: MN4520 and MN4530.

or

Track 2 - Data Analytics Track: two courses in data analytics offered by DDM.

Educational Skill Requirements (ESR)

Critical and Strategic Thinking - The graduate will be able to apply critical and strategic thinking to formulate and solve real-world problems, and will understand DoD senior-level decision-making processes under uncertainty. They will diagnose complex DoD problems, implement the corresponding decisions, and evaluate their results.

Decision Support - The graduate will be able to analyze data to solve complex and unstructured management problems faced by the DoD in accordance with an efficient procurement of resources and the effective accomplishment of the overall DoD objectives.

Accounting - The graduate will develop a thorough understanding of fundamental accounting concepts and methods, and accordingly be able to apply this knowledge to analyze federal and corporate accounting and costing information, including the use of metrics to evaluate and reward performance.

Budgeting - The graduate will understand the DoD's PPBE system and the overarching federal budget and regulatory

systems in which it operates. This includes the link from strategy to resources, budget formulation, presentation, justification, and execution.

Financial Management - The graduate will be able to use rigorous economic and financial techniques to solve long-term DoD financial problems that involve identifying, analyzing, and selecting among different alternatives. These techniques include cost estimation, capital budgeting, and asset pricing in risky environments.

Auditing and Internal Control Systems - In accordance with Generally Accepted Government Auditing Standards (GAGAS) and Generally Accepted Auditing Standards (GAAS), the graduate will understand the regulatory mandate and ethical challenges faced by the DoD in audit, will learn to apply audit techniques that enforce sound internal accounting and administrative controls, as well as be able to interpret audit reports and statements. Special attention will be given to stewardship and adequacy of systems and controls.

Data Analytics – The graduate will be able to apply analytical techniques and tools to evaluate data and models in order to predict outcomes, understand systems, prescribe policy changes, and measure the impact of resource management decisions.

DoD Financial Management Certificate - Curriculum 196 (DL)

Brief Overview

This program is not open for enrollment to individual students. A Sponsor is required to fund all students in order for the program to be offered.

The Certificate in Financial Management is a graduate academic certificate program available to NPS resident and distance learning students. Designed for mid-to-senior level leaders interested in financial management and budget, the program prepares students for business, financial, and analysis positions within the DoD. This program supports continuous financial management reform initiatives mandated by Congress and senior leaders, and also supports initiatives to educate mid-to-senior level leaders in the areas of financial management and budget. The program educates and prepares financial managers assisting the DoD's decision-making processes at all levels by providing accurate, timely, and relevant information and analysis. The students can choose between two tracks (i.e., audit or data analytics) by taking two elective courses in addition to the three core courses.

Convenes

Spring

Program Length

Five quarters

- Educate mid-career defense financial managers in accounting, budgeting, financial management, and audit or data analytics

- Support continuous financial management reform initiatives mandated by Congress and senior leaders
- Assist the DoD's decision-making processes at all levels by providing accurate, timely and relevant information and analysis

Five-Quarter Certificate (1 course per quarter)

The certificate requires the completion of 3 core courses and 2 elective courses (from 1 of the 2 tracks). Students would take 1 course per quarter.

Core Courses:

Course	Title	Lecture	Lab
MN3156	Financial and Managerial Accounting	4	0
GE4053	DoD Mission and Resource Determination	4	0
MN4510	Strategic Resource Management -or-	4	0
GE4052	Managerial Finance	3	0

Elective courses (Students will choose):

Audit Track:

MN4520	Internal Control & Audit -and-	3	0
MN4530	Management Control Systems	4	0

or Data Analytics Track:

MN3911	Introduction to Data Analytics for Defense Management	3	0
MN4912	Multivariate Data Analysis	3	0

Chief Information Officer Management Certificate - Curriculum 197 (Resident)

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Brief Overview

The DDM Chief Information Officer (CIO) Certificate will provide the critical education required by the Clinger-Cohen Act of 1996 to manage government information technology systems. This certificate will allow its graduates to effectively manage the resources, people,

processes, and technologies necessary to ensure our information technology systems optimize mission performance and information assurance. This certificate satisfies all of the Clinger-Cohen educational competency requirements.

Convenes

Summer

Program Length

Four quarters

The DDM Chief Information Officer (CIO) Certificate will provide the critical education required by the Clinger-Cohen Act of 1996 to manage government information technology systems. This certificate will allow its graduates to effectively manage the resources, people, processes, and technologies necessary to ensure our information technology systems optimize mission performance and information assurance. This certificate satisfies all of the Clinger-Cohen educational competency requirements.

Four-Quarter Certificate

Chief Information Officer Management Certificate - Curriculum 198 (DL)

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Brief Overview

The DDM Chief Information Officer (CIO) Cyber Management Certificate will provide the critical education required by the Clinger-Cohen Act of 1996 to manage government information technology systems. This certificate will allow its graduates to effectively manage the resources, people, processes, and technologies necessary to ensure our information technology systems optimize mission performance and information assurance. This certificate meets all of the Clinger-Cohen educational competency requirements.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

Four Quarter Certificate

Students are required to take four courses to complete the CIO Management Certificate (Curriculum 198):

MN4021 (4-0) Strategic Management of Information Technology **or** IS4182 (4-0) Enterprise Information and Systems Strategy and Policy

MN3331 (5-1) Principles of Acquisition and Program Management **or** MN3301 (4/0) Acquisition of Defense Systems **or** MN3221 and MN3222

MN3309 (3-2) Software Acquisition Management for Defense Systems

CY3201 (3-0) Foundations of Cyberspace Operations **or** CY3200 (4-2) Cyberspace Operations Fundamentals

Required Courses

Course	Title	Lecture	Lab
MN4021	Strategic Management of IT	4	0
	-or-		
IS4182	Enterprise Information Systems Strategy and Policy	4	0
	-and-		
MN3331	Principles of Acquisition and Program Management	5	1
	-or-		
MN3301	Acquisition of Defense Systems	4	0
	-or-		
MN3221	Principles of Acquisition and Program Management I	3	0
	-and-		
MN3222	Principles of Acquisition and Program Management II	3	0
	-or-		
MN3392	Systems and Project Management	4	0
	-and-		
MN3309	Software Acquisition Management for Defense Systems	3	2
	-or-		
CY3201	Foundations of Cyberspace Operations	3	0
	-and-		
CY3200	Cyberspace Operations Fundamentals	4	2

Principles of Analytical Management Certificate - Curriculum 201 (Resident)

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Brief Overview

The Operations and Logistics Management faculty designed this certificate to equip students with the fundamental tools for management based on rigorous analytical methods. It is designed for both civilian and military managers who are looking to upgrade and update their managerial and analytical skills.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

Upon completion of the certificate, students will be able to:

- Analyze data to inform and support managerial decisions;
- Design and analyze business processes; and
- Apply quantitative decision-making tools to develop solutions in defense business contexts.

Four-Quarter Certificate (1 course/quarter)

This certificate requires the completion of four courses (at least 12 credits) that were not counted for another certificate.

The following courses are required:
- MN3041 Managerial Statistics (MN3041 recently replaced GB3040)
- MN3442/GB3042 Process Analytics
- GB4043 Business Modeling and Analysis

The following courses are elective. Students should take at least one of them:
- GB3010/MN3010 Managing for Organizational Effectiveness
- MN3050 Financial Reporting and Analysis
- MN3156 Financial and Managerial Accounting
- GB3070 Economics for Defense Managers

- MN4460 Business Risk Management
- MN3301 Acquisition of Defense Systems

Principles of Analytical Management Certificate - Curriculum 202 (DL)

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Brief Overview

This program is closed to new admissions. DDM Operations and Logistics Management faculty designed this certificate to equip students with the fundamental tools for management based on rigorous analytical methods.

It is designed for both civilian and military managers who are looking to upgrade and update their managerial and analytical skills.

Upon completion of the certificate, students will be able to:
- analyze data to inform and support managerial decisions,
- design and analyze business processes, and
- apply quantitative decision-making tools to develop solutions in defense business contexts.

Four-Quarter Certificate (1 course/quarter)

This certificate requires the completion of four courses (at least 12 credits) that were not counted for another certificate.

The following courses are required:
- GE3040 Statistics for Executive Management
- GE3042/GB3042/MN3442 Process Analytics
- GE4043 Business Modeling and Analysis

The following courses are elective. Students should take at least one of them:

- GE3010 Organizations as Systems and Structures
- MN4474 Organizational Analysis
- GE3050 Financial Reporting and Analysis
- GE3070 Economics for Defense Managers
- MN4460 Business Risk Management
- MN3301 Acquisition of Defense Systems

Acquisition Logistics Certificate - Curriculum 203 (Resident)

Program Officer

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Brief Overview

The Operations and Logistics Management faculty designed this certificate to equip students with Acquisition Logistics skills based on rigorous applied analytical and managerial methods. It is designed for both civilian and military managers who are looking to upgrade and update their professional skills.

DOD and DON students may fulfill DAWIA Level I Certification in Life Cycle Logistics in a small number of courses.

This certificate requires prior completion of GB/GE3040, GB/GE3042, and GB/GE4043; or Program Director approval.

Convenes

Fall, Winter, Spring, Summer

Program Length

Five quarters

Upon completion of the certificate, students will be able to:

- Implement supply chain strategies to support major weapon systems; and
- Direct logistics activities to deliver cost effective readiness.

Five-Quarter Certificate (1 course/quarter)

This certificate requires the completion of five courses (at least 15 credits) that were not counted for another certificate.

The following courses are required:
- MN4450 Logistics Strategy

- MN4480 Supply Chain Management
- MN4485 Supply Chain Strategy

The following courses are elective. Students should take at least two of them:
- MN3221 Principles of Acquisition and Program Management I
- GE3221 Principles of Acquisition and Program Management I
- MN3222 Principles of Acquisition and Program Management II
- GE3222 Principles of Acquisition and Program Management II
- MN3331 Principles of Acquisition and Program Management (Replaces GE/MN3221/3222 and counts as two electives)
- MN3303 Principles of Acquisition and Contract Management
- MN3612 Fraud Examination

Acquisition Logistics Certificate - Curriculum 204 (DL)

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Program Manager

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Brief Overview

This curriculum is closed to new admissions. DDM Operations and Logistics Management faculty designed this certificate to equip students with Acquisition Logistics skills based on rigorous applied analytical and managerial methods.
It is designed for both civilian and military managers who are looking to upgrade and update their professional skills.

Upon completion of the certificate, students will be able to:
-- implement supply chain strategies to support major weapon systems, and
-- direct logistics activities to deliver cost effective readiness

DOD and DON students may fulfill DAWIA Level I Certification in Life Cycle Logistics in a small number of courses.

This certificate requires prior completion of GB/GE3040, GB/GE3042, and GB/GE4043; or Program Director approval.

Five-Quarter Certificate (1 course/quarter)

This certificate requires the completion of five courses (at least 15 credits) that were not counted for another certificate.

The following courses are required:
- MN4450 Logistics Strategy
- MN4480 Supply Chain Management
- MN4485 Supply Chain Strategy

The following courses are elective. Students should take at least two of them:
- MN3221 Principles of Acquisition and Program Management I
- GE3221 Principles of Acquisition and Program Management I
- MN3222 Principles of Acquisition and Program Management II
- GE3222 Principles of Acquisition and Program Management II
- MN3303 Principles of Acquisition and Contract Management
- MN3612 Fraud Examination

Strategic Leadership - Curriculum 205 (Resident)

Program Officer

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Brief Overview

Strategic thinking is central to military organizations, yet it can be very difficult. Completion of this certificate increases students' ability to think strategically; to understand and analyze trends in the strategic environment; and to be influential, strategic leaders. Students will examine historical examples and best practices in organizations, obtain a better appreciation of

senior leadership perspectives on organizational strategy, and improve their analytical and critical thinking about the strengths and weaknesses of competitors and their own organization. As a result of improved strategic thinking, organizational analysis skills, and strategic communication competencies, students will be better prepared to develop productive strategies and lead their organizations toward greater performance.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

Four-Quarter Certificate

The following courses are required:

Course	Title	Lecture	Lab
GB3010	Managing for Organizational Effectiveness	4	0
GB3012	Communication for Managers	3	0
GB4014	Strategic Management	4	0

The following courses are elective. Students should take at least one of them:

GE3109	Ethics and Moral Development	3	0
MN3400	Critical Thinking for Strategic Leadership	4	0
MN3811	Innovation Adoption & Implementation	3	0
MN4012	Maneuver Warfare for the Mind: The Art and Science of Interdisciplinary Learning for Innovation and Warfighting Leaders	4	0

Strategic Leadership - Curriculum 206 (DL)

Brief Overview

Strategic thinking is central to military organizations, yet it can be very difficult. Completion of this certificate increases students' ability to think strategically; to understand and analyze trends in the strategic environment; and to be influential, strategic leaders. Students will examine historical examples and best practices in organizations, obtain a better appreciation of senior leadership perspectives on organizational strategy, and improve their analytical and critical thinking about the strengths and weaknesses of competitors and their own organization. As a result of improved strategic thinking, organizational analysis skills, and strategic communication competencies, students will be better prepared to

develop productive strategies and lead their organizations toward greater performance.

Program Length

Four quarters

- Master the art and science of strategic thinking
- Analyze organizational processes and overcome inertia
- Learn high-impact communication skills
- Analyze trends in the organizational environment and address challenges in the defense and public sectors

Four-quarter certificate

This certificate requires the completion of four courses (at least 12 credits) that were not counted for another certificate.

Required Courses

The following courses are required:

- MN4105 Strategic Management **or** GE4016 Strategic Management **or** GB4014 Strategic Management **or** MN4014 Competitive Strategy and Innovation

- MN4474 Organizational Analysis **or** GE3010 Organizations as Systems and Structures **or** GB3010 Managing for Organizational Effectiveness **or** MN3010 Leading Innovative Organizations and People

Choose Two Elective Courses from the Following Options:

MN3012 Communications Strategies for Effective Leadership **or** GB3012 Communication for Managers

MN4510 (GB4510, GE4510) Strategic Resource Management

MN4017 High-performance Decision Practices

MN3118 Negotiation and Consensus Building

MN3400 (GB3400) Critical Thinking for Strategic Leadership

MN4012 (GB4012) Maneuver Warfare for the Mind: The Art and Science of Interdisciplinary Learning for Innovation and Warfighting Leaders

GE3109 Ethics and Moral Development

For Further Information

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Leadership for Public Administrators - Curriculum 207 (Resident)

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Brief Overview

The quality of leadership impacts an organization's effectiveness, its employees' satisfaction, and the ability of the organization to adapt to new challenges. Successful missions in the future will depend on military officers and civilian administrators who know how to lead with excellence in public organizations. Completion of this certificate builds knowledge, skills, and ethical standards that are necessary components of great leadership within public organizations. Students will develop advanced leadership skills, including ability to cultivate effective groups and teams, negotiate consensus among stakeholders, improve climate and productivity, and facilitate high-performance decision making processes while modeling ethical reasoning and behavior that will inspire the next generation.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

4-course sequence, one per quarter

This certificate requires the completion of four courses (at least 12 credits) that were not counted for another certificate.

The following courses are required:
- MN4011 Negotiation and Consensus Building
- MN3118 Negotiation and Consensus Building
- MN3015 Leading Teams or GE3011 Management of Teams

The following courses are elective. Students should take at least one of them:
- MN4017 High-performance Decision Practices
- MN4125 Managing Planned Change in Complex Organizations

- MN3111 Analysis of Human Resource Management
- GE3010 Organizations as Systems and Structures

Leadership for Public Administrators - Curriculum 208 (DL)

Program Officer

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Brief Overview

The quality of leadership impacts an organization's effectiveness, its employees' satisfaction, and the ability of the organization to adapt to new challenges. Successful missions in the future will depend on military officers and civilian administrators who know how to lead with excellence in public organizations. Completion of this certificate builds knowledge, skills, and ethical standards that are necessary components of great leadership within public organizations. Students will develop advanced leadership skills, including ability to cultivate effective groups and teams, negotiate consensus among stakeholders, improve climate and productivity, and facilitate high-performance decision making processes while modeling ethical reasoning and behavior that will inspire the next generation.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

Four-Quarter Certificate

This certificate requires the completion of four courses (at least 12 credits) that were not counted for another certificate.

The following courses are required:
- MN4011 Ethical Leadership in Public Organizations
- MN3118 Negotiation and Consensus Building
- MN3015 Leading Teams **or** GE3011 Management of Teams

The following courses are electives. Students must complete one:
- MN4017 High-performance Decision Practices
- MN4125 Managing Planned Change in Complex Organizations or MN4015 Management of Change
- MN3111 Analysis of Human Resource Management
- GE3010 Organizations as Systems and Structures **or** MN3010 Leading Innovative Organizations and People **or** MN4474 Organizational Analysis

Advanced Acquisition Program - Program Management Certificate - Curriculum 211 (DL)

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Program Manager

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Brief Overview

The Advanced Acquisition Program (AAP) is a 12-month, graduate certificate program designed for both the DoD acquisition workforce and professionals working with system acquisition and program management. Students develop an in-depth knowledge of the defense business and acquisition process.

This cohort-based program is offered part-time with flexible delivery mode options of online, resident and on-location. Completion of the AAP certificate satisfies DAWIA Level II and supports Level III in Program Management. Students also earn up to 19.5 graduate credit hours toward a NPS master's degree program. Additionally, AAP provides DoD students with up to 195 hours of Continuous Learning under the Continuous Learning program (CLP), 31.5 Continuing Education Units (CEU), 6.38 Business Credits toward the requirement of 24 for the GS-1102 series.

The AAP is a three-phased graduate certificate program of seven courses delivered over four NPS academic quarters. While the three phases must be completed in sequence, there is no requirement to complete them in the normal one-year time frame (four academic quarters).

Requirements for Entry

A baccalaureate degree with above-average grades is

desired.

Program Length

Four Quarters

Graduate Certificate Requirements

Requirements for the AAP are met by successful completion of all seven courses. Graduate credit is obtained by maintenance of a 3.0 grade point average on a 4.0 scale. Should a graduate of AAP matriculate into the Master of Science in Defense Program Management (816) curriculum, or the Master of Science in Program Management (836), graduate credit for AAP courses will be applied to the curricula as appropriate.

Past Sponsors

U.S. Army Tank Automotive Command, Warren, MI; U.S. Army Soldier Support Center, Natick, MA; U.S. Navy Undersea Warfare Center, Newport, RI; U.S. Navy Surface Warfare Center, Dahlgren, VA.

Program Phases

The program is administered with a phased approach:

- Phase I is a full-quarter distance-learning course taught via web-based technologies (6 hours in class per week) concentrating on Acquisition and Program Management breadth.
- Phase II is a series of five one-week courses (40 hours in class per week) taught on-location at the command, in-resident at NPS, or online via web-based technologies.
- Phase III is a full-quarter, distance-learning course taught via web-based technologies (4 hours of class per week) concentrating on Program Leadership through examination of case studies from actual Defense systems, IPT exercises, and application and written analysis of program management concepts.

Required Courses: Curriculum 211

Quarter 1

Course	Title	Lecture	Lab
MN3331	Principles of Acquisition and Program Management	5	1

Quarter 2 and 3

Course	Title	Lecture	Lab
MN3361	Software Acquisition Management	2	0
MN3362	Acquisition Design Verification and System Assessment	2	0
MN3363	Acquisition Manufacturing and Quality Management	2	0
MN3364	Business Financial and Contract Management	2	0
MN3365	Acquisition Logistics & Program Sustainment	2	0

Quarter 4

Course	Title	Lecture	Lab
MN4366	Defense Acquisition Case Studies	4	0

Acquisition Management Distance Learning Program (AMDLP) - Curriculum 212

Program Officer

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Brief Overview

This curriculum is closed to new admissions. The Naval Postgraduate School offers acquisition management distance education graduate acquisition courses that satisfy certain Defense Acquisition University (DAU) mandatory training requirements and Defense Acquisition Workforce Improvement Act (DAWIA) requirements for 24 semester-hours of business subjects. These courses can also be taken for continuing education that can lead to a master's degree program. These courses are offered primarily by distance learning methods.

Advanced Acquisition Studies - Curriculum 217 (Resident)

Program Officer

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Academic Associate

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Brief Overview

The Certificate in Advanced Acquisition Studies is graduate academic certificate program available to NPS resident students. Designed for students interested in Defense system acquisition and program management processes, the program operationalizes the business of Defense acquisition and creates Acquisition Warriors for the DoD. This program supports continuous acquisition reform initiatives mandated by Congress and senior leaders and also supports initiatives to educate operational warfighters in the acquisition sciences. The Navy and Army provide graduates with fulfillment credit

for Defense Acquisition Workforce Improvement Act (DAWIA) training requirements for the Program Management Practitioner certification level. Additionally, the program provides education supporting for Project Management Professional (PMP) certification. Requirements for Entry: a baccalaureate degree defined in section 4.2 of the Academic Council policy manual. Entry Dates: at the beginning of any quarter throughout an academic year (Jan, Apr, Jul, Oct). Program Length: the program length is flexible, and students can take the classes in any academic quarter. Graduate Certificate Requirements: requirements for the graduate Certificate in Advanced Acquisition Studies are met by successful completion of four of the available courses. Graduate credit is obtained by maintenance of a 3.0 grade point average on a 4.0 scale.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

- **Advanced Leadership and Management Concepts:** apply advanced leadership and management techniques to defense problems - policy formulation/execution, strategic planning, defense resource allocation, cost benefit and cost effectiveness analysis and decision support systems
- **Program Leadership and Management Principles:** apply the principles of project, program and portfolio management -risk management and tradeoff decision analysis using cost, schedule and performance; formulate and execute Defense acquisition policies, strategies, plans and procedures.
- **Systems Acquisition Process:** manage within the adaptive acquisition framework - requirements determination, research and development, funding and budgeting, procurement, systems engineering, test and evaluation, manufacturing and quality control, and integrated logistics support.
- **Analysis, Problem Solving and Critical Thinking:** conduct analysis and the ability to think creatively, manage change and complexity the Defense Acquisition Decision Support Systems.

Advanced Acquisition Studies

Required Courses

Students have three options for the one required course:

Course	Title	Lecture	Lab
MN3331	Principles of Acquisition and Program Management	5	1
	-or-		
MN3301	Acquisition of Defense Systems	4	0
	-or-		

Course	Title	Lecture	Lab
MN3221	Principles of Acquisition and Program Management I	3	0
MN3222	Principles of Acquisition and Program Management II	3	0

In addition to the required courses, any 3 of the following courses

Course	Title	Lecture	Lab
MN3302	Advanced Project Management	3	0
MN3309	Software Acquisition Management for Defense Systems	3	2
MN3384	Acquisition Production, Quality and Manufacturing Decision Science	3	2
MN4307	Defense Acquisition Program Management Case Studies	4	0
MN4470	Strategic Planning and Policy for the Acquisition Logistics Manager	4	0
MN4602	Acquisition Test and Evaluation Decision Science	3	2

*522 students only - SE4354 can be used as an authorized substitute for MN4602.

Advanced Acquisition Studies - Curriculum 218 (DL)

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Program Manager

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Brief Overview

The Certificate in Advanced Acquisition Studies is graduate academic certificate program available to NPS distance learning students. Designed for students interested in Defense system acquisition and program

management processes, the program operationalizes the business of Defense acquisition and creates Acquisition Warriors for the DoD. This program supports continuous acquisition reform initiatives mandated by Congress and senior leaders and also supports initiatives to educate operational warfighters in the acquisition sciences. Graduates earn fulfillment for Defense Acquisition Workforce Improvement Act (DAWIA) training requirements for the Program Management Practitioner certification level. Additionally, the program provides education supporting for Project Management Professional (PMP) certification. Requirements for Entry: a baccalaureate degree defined in section 4.2 of the Academic Council policy manual. Entry Dates: at the beginning of any quarter throughout an academic year (Jan, Apr, Jul, Oct). Program Length: the program length is flexible, and students can take the classes in any academic quarter. Graduate Certificate Requirements: requirements for the graduate Certificate in Advanced Acquisition Studies are met by successful completion of four of the available courses. Graduate credit is obtained by maintenance of a 3.0 grade point average on a 4.0 scale.

Program Length

Four quarters

- **Advanced Leadership and Management Concepts:** apply advanced leadership and management techniques to defense problems - policy formulation/execution, strategic planning, defense resource allocation, cost benefit and cost effectiveness analysis and decision support systems

- **Program Leadership and Management Principles:** apply the principles of project, program and portfolio management -risk management and tradeoff decision analysis using cost, schedule and performance; formulate and execute Defense acquisition policies, strategies, plans and procedures.

- **Systems Acquisition Process:** manage within the adaptive acquisition framework - requirements determination, research and development, funding and budgeting, procurement, systems engineering, test and evaluation, manufacturing and quality control, and integrated logistics support.

- **Analysis, Problem Solving and Critical Thinking:** conduct analysis and the ability to think creatively, manage change and complexity the Defense Acquisition Decision Support Systems.

Advanced Acquisition Studies

Required Courses

Students take one of the four options below for required courses:

Course	Title	Lecture	Lab
MN3331	Principles of Acquisition and Program Management	5	1

Course	Title	Lecture	Lab
	-or-		
MN3301	Acquisition of Defense Systems	4	0
	-or-		
MN3221	Principles of Acquisition and Program Management I	3	0
	-and-		
MN3222	Principles of Acquisition and Program Management II	3	0

The following courses are electives. Students must take at least three of them.

MN3309	Software Acquisition Management for Defense Systems	3	2
MN3384	Acquisition Production, Quality and Manufacturing Decision Science	3	2
MN4470	Strategic Planning and Policy for the Acquisition Logistics Manager	4	0
MN4602	Acquisition Test and Evaluation Decision Science	3	2
MN4307	Defense Acquisition Program Management Case Studies	4	0
MN3302	Advanced Project Management	3	0

Managerial Logistics Certificate - Curriculum 219 (Resident)

Program Officer

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Academic Associate

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Brief Overview

The Operations and Logistics Management faculty designed this certificate to equip students with the logistics leadership skills based on rigorous applied analytical and managerial methods. It is designed for both civilian and military managers who are looking to upgrade and update their professional skills.

This certificate requires prior completion of GB/GE3040,

GB/GE3042, and GB/GE4043.

Convenes

Fall, Winter, Spring, Summer

Program Length

Five quarters

Upon completion of the certificate, students will be able to:
- Lead Process Improvement Efforts in Logistics;
- Implement effective Supply Chain Strategies; and
- Manage innovation in inter-organizational relationships.

Certificate Requirements

This certificate requires the completion of five courses (at least 15 credits) that were not counted for another certificate.

The following courses are required:
- MN4450 Logistics Strategy
- MN4480 Supply Chain Management
- MN4485 Supply Chain Strategy

The following courses are elective. Students should take at least two of them:
- GB4014/MN4014 Strategic Management
- MN3118 Negotiation and Consensus Building
- MN3811 Innovation Adoption and Implementation
- GB3010/MN3010 Managing for Organizational Effectiveness

Managerial Logistics Certificate - Curriculum 220 (DL)

Program officer

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Brief Overview

This program is closed to new admissions. DDM Operations and Logistics Management faculty designed this certificate to equip students with the logistics leadership skills based on rigorous applied analytical and managerial methods.
It is designed for both civilian and military managers who are looking to upgrade and update their professional skills.

This certificate requires prior completion of GB/GE3040, GB/GE3042, and GB/GE4043.

Upon completion of the certificate, students will be able to:
- lead process improvement efforts in logistics,
- implement effective supply chain strategies, and
- manage innovation in inter-organizational relationships.

Five-Quarter Certificate (1 course/quarter)

This certificate requires the completion of five courses (at least 15 credits) that were not counted for another certificate.

The following courses are required:
- MN4450 Logistics Strategy
- MN4480 Supply Chain Management
- MN4485 Supply Chain Strategy

The following courses are elective. Students should take at least two of them:
- GE4016 Strategic Management OR
- MN4105 Strategic Management
- MN3118 Negotiation and Consensus Building
- MN3811 Innovation Adoption and Implementation
- MN4474 Organizational Analysis OR
- GE3010 Organizations as Systems and Structures

Implementing Technological Change - Curriculum 221

Brief Overview

Rapid technological advances, emerging capabilities, and innovations by adversaries have engaged the U.S. in an aggressive technological and cyberspace response that demands of its technological solution leaders the ability to shepherd initiatives from conception to realization. This certificate offers cyberspace and other technology professionals the opportunity to cultivate essential skillsets to spearhead policy development and drive organizational change. It will empower technological leaders with the cognitive ability to synchronize intellectual, communication, and policy skills with complex technological change.

Convenes

Summer

Program Length

Four quarters
- Understand policy for technology and cyberspace management.
- Translate complex technological concepts and challenges for non-technical stakeholders.

- Effectively advocate technological developments.
- Manage organizational change to enable technological innovations.
- Use high-impact writing and speaking strategies to effectively communicate and advocate technological change.

Certificate Requirements

To meet the certificate requirements, a student must complete two (2) required core courses (CS4926 and GB3012) and two (2) additional courses from among the selection below.

Required Core Courses

Course	Title	Lecture	Lab
CS4926	Advocating Emerging Technologies	4	1
GB3012	Communication for Managers	3	0

Additional Course Selections

The student will select two of the following courses (CY4410, CS4925, DA4104, and MN4125).

MN4015 may be taken in place of MN4125 (certificate credit for only one of MN4015 or MN4125 will be given).

CY4410	Cyber Policy and Strategy	3	0
CS4925	Innovation Leadership	3	2
DA4104	Militaries and Technological Change	4	0
MN4125	Managing Planned Change in Complex Organizations -or-	4	0
MN4015	Management of Change	4	0

This certificate is intended for in-resident students who are already admitted to another curriculum.

Cost-Benefit Analysis and Program Evaluation - Curriculum 229 (Resident)

Program Officer

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Brief Overview

The Cost-Benefit Analysis and Program Evaluation certificate teaches students the fundamental theories of economics and public policy that are necessary to understand consumer behavior and choice, the role of the public sector in the free-market economy, personnel economics, and cost-benefit analysis. Economic insights will be combined with the institutional expertise of DDM faculty to tailor the learning experience to defense-related areas. Students will gain subject mastery to critically evaluate cutting-edge research, allowing their organizations to make optimal use of the information contained in reports from academia, military focused policy organizations, and other government agencies. To earn the certificate, students must complete four courses (one per quarter) earning an average GPA of 3.3 or higher.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

Certificate Requirements

This certificate requires the completion of four courses (at least 12 credits) that were not counted for another certificate.

The following courses are required:
- MN3041 Managerial Data Analysis* OR
- MN3040 Data Management and Statistics for Manpower Analysis
- MN3070 Economics for Defense Managers
- MN4071 Advanced Economic and Defense Policy Analysis

*MN3041 recently replaced GB3040.

The following courses are elective. Students should take at least one of them:
- MN4760 Manpower Economics I
- MN4043 Business Modeling and Analysis

Cost-Benefit Analysis and Program Evaluation - Curriculum 230 (DL)

Program Officer

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Brief Overview

This program is closed to new admissions. The Cost-Benefit Analysis and Program Evaluation certificate teaches students the fundamental theories of economics and public policy that are necessary to understand consumer behavior and choice, the role of the public sector in the free-market economy, personnel economics, and cost-benefit analysis. Economic insights will be combined with the institutional expertise of DDM faculty to tailor the learning experience to defense-related areas. Students will gain subject mastery to critically evaluate cutting-edge research, allowing their organizations to make optimal use of the information contained in reports from academia, military focused policy organizations, and other government agencies. To earn the certificate, students must complete four courses (one per quarter) earning an average GPA of 3.3 or higher.

This certificate requires the completion of four courses (at least 12 credits) that were not counted for another certificate.

The following courses are required:
- GE3040 Statistics for Executive Management
- GE3070 Economics for Defense Managers
- MN4071 Advanced Economic and Defense Policy Analysis

The following courses are elective. Students should take at least one of them:
- MN4760 Manpower Economics I
- GE4043 Business Modeling and Analysis

Basic Contract Management Certificate - Curriculum 237 (Resident)

Program Officer

Matt Geiser, CDR, USN
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Academic Associate

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Brief Overview

The Basic Contract Management Certificate is a graduate academic certificate program available to NPS resident and distance learning students. Designed for students interested in basic concepts of Contract Management. This certificate supports continuous acquisition reform initiatives mandated by Congress and senior leaders and supports initiatives to educate operational warfighters in the business of contract management. The certificate contributes to Defense Acquisition Workforce Improvement Act (DAWIA) certification in the Contract Management career field. Additionally, the curriculum is aligned with the competencies established in the National Contract Management Association (NCMA) Contract Management Body of Knowledge (CMBOK) and the Contract Management Standard (CMS). The curriculum supports preparation for the NCMA professional certification examinations including the Certified Federal Contract Manager (CFCM) and the Certified Professional Contract Manager (CPCM).

Requirements for Entry

A baccalaureate degree defined in section 4.2 of the Academic Council policy manual.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

Graduate Certificate Requirements

Successful completion of the four courses and graduate credit is obtained by maintenance of 3.0 grade point average on a 4.0 scale.

Students will learn:
- Principles and concepts of contract management and the contracting life cycle phases and how they are applied in the federal government and the DoD.
- Application of contract pricing theory and strategies, to include costing methods, cost and price analysis, cost principles, and Cost Accounting Standards.
- Contract management functions and decision-making techniques in the pre-award, award, and post award contracting phases, to include both buyer and seller processes and job tasks.
- Application of the art and science of developing and conducting comprehensive government contract negotiations, with an emphasis on cost and price analytical techniques.

Basic Contract Management Certificate

Course	Title	Lecture	Lab
MN3303	Principles of Acquisition and Contract Management	4	0
MN3315	Acquisition Management and Contract Administration	4	0
MN3320	Contract Cost and Price Analysis	3	0
MN3321	Federal Contract Negotiations	3	0

Basic Contract Management Certificate - Curriculum 238 (DL)

Academic Associate

CDR Michael Schilling, Military Lecturer
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Program Manager/Program Officer

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Brief Overview

The Basic Contract Management Certificate is a graduate academic certificate program available to NPS resident and distance learning students. Designed for students interested in basic concepts of Contract Management. This certificate supports continuous acquisition reform initiatives mandated by Congress and senior leaders and also supports initiatives to educate operational warfighters in the business of contract management. The certificate contributes to Defense Acquisition Workforce Improvement Act (DAWIA) certification in the Contract Management career field. Additionally, the curriculum is aligned with the competencies established in the National Contract Management Association (NCMA) Contract Management Body of Knowledge (CMBOK) and the Contract Management Standard (CMS). The curriculum supports preparation for the NCMA professional certification examinations including the Certified Federal Contract Manager (CFCM) and the Certified Professional Contract Manager (CPCM).

Requirements for Entry

A baccalaureate degree defined in section 4.2 of the Academic Council policy manual.

Program Length

Four quarters

Graduate Certificate Requirements

Successful completion of the four courses and graduate credit is obtained by maintenance of 3.0 grade point average on a 4.0 scale.

Students will learn:
- Principles and concepts of contract management and the contracting life cycle phases and how they are applied in the federal government and the DoD.
- Application of contract pricing theory and strategies, to include costing methods, cost and price analysis, cost principles, and Cost Accounting Standards.
- Contract management functions and decision-making techniques in the pre-award, award, and post award

contracting phases, to include both buyer and seller processes and job tasks.
- Application of the art and science of developing and conducting comprehensive government contract negotiations, with an emphasis on cost and price analytical techniques.

Basic Contract Management Certificate

Course	Title	Lecture	Lab
MN3303	Principles of Acquisition and Contract Management	4	0
MN3315	Acquisition Management and Contract Administration	4	0
MN3320	Contract Cost and Price Analysis	3	0
MN3321	Federal Contract Negotiations	3	0

Advanced Contract Management Certificate - Curriculum 243 (Resident)

Program Officer

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Academic Associate

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Brief Overview

The Advanced Contract Management Certificate is a graduate academic certificate program available to NPS resident and distance learning students. Designed for students interested in advanced concepts of Contract Management. This certificate supports continuous acquisition reform initiatives mandated by Congress and senior leaders and supports initiatives to educate operational warfighters in the business of contract management. The certificate contributes to Defense Acquisition Workforce Improvement Act (DAWIA) certification in the Contract Management career field in conjunction with the Basic Contract Management Certificate. Additionally, the curriculum is aligned with the competencies established in the National Contract Management Association (NCMA) Contract Management Body of Knowledge (CMBOK) and the Contract Management Standard (CMS). The curriculum supports preparation for the NCMA professional certification

examinations including the Certified Federal Contract Manager (CFCM) and the Certified Professional Contract Manager (CPCM).

Requirements for Entry

A baccalaureate degree defined in section 4.2 of the Academic Council policy manual.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

Graduate Certificate Requirements

Successful completion of the four courses and graduate credit is obtained by maintenance of 3.0 grade point average on a 4.0 scale.

Students will learn:

- Fundamentals of major Congressional statutes, agency policies and regulations, and legal precedents which govern Federal contract management.
- DoD's major weapon systems contracting policies, processes, procedures, and practices with a primary focus on the contract management processes used to acquire defense weapon systems for the DoD.
- Federal Government and DoD acquisition and contracting policies with a primary focus on senior acquisition and contracting leader critical thinking and decision-making.
- DoD's major services contracting policies, processes, procedures, and practices to include performance-based services contracting (PBSC). Primary focus is on the contract management processes used to acquire complex services for the DoD.

Advanced Contract Management Certificate

Course	Title	Lecture	Lab
MN3312	Government Contracts Law	4	0
	-or-		
MN4304	Defense Systems Contracting	3	0
	-and-		
MN3318	Operational Contract Support & Contingency Contracting	3	0
MN4311	Contracting for Services	3	0
MN4371	Acquisition and Contracting Policy	4	0

Advanced Contract Management Certificate - Curriculum 244 (DL)

Academic Associate

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Program Manager/Program Officer

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Brief Overview

The Advanced Contract Management Certificate is a graduate academic certificate program available to NPS resident and distance learning students. Designed for students interested in advanced concepts of Contract Management. This certificate supports continuous acquisition reform initiatives mandated by Congress and senior leaders and supports initiatives to educate operational warfighters in the business of contract management. The certificate contributes to Defense Acquisition Workforce Improvement Act (DAWIA) certification in the Contract Management career field in conjunction with the Basic Contract Management Certificate. Additionally, the curriculum is aligned with the competencies established in the National Contract Management Association (NCMA) Contract Management Body of Knowledge (CMBOK) and the Contract Management Standard (CMS). The curriculum supports preparation for the NCMA professional certification examinations including the Certified Federal Contract Manager (CFCM) and the Certified Professional Contract Manager (CPCM).

Requirements for Entry

A baccalaureate degree defined in section 4.2 of the Academic Council policy manual.

Program Length

Four quarters

Graduate Certificate Requirements

Successful completion of the four courses and graduate credit is obtained by maintenance of 3.0 grade point average on a 4.0 scale.

Students will learn:

- Fundamentals of major Congressional statutes, agency policies and regulations, and legal precedents which govern Federal contract management.
- DoD's major weapon systems contracting policies, processes, procedures, and practices with a primary focus on the contract management processes used to acquire defense weapon systems for the DoD.
- Federal Government and DoD acquisition and contracting policies with a primary focus on senior acquisition and contracting leader critical thinking and decision-making.

- DoD's major services contracting policies, processes, procedures, and practices to include performance-based services contracting (PBSC). Primary focus is on the contract management processes used to acquire complex services for the DoD.

Advanced Contract Management Certificate

Course	Title	Lecture	Lab
MN3312	Government Contracts Law	4	0
MN3318	Operational Contract Support & Contingency Contracting -or-	3	0
MN3612	Fraud Examination	3	0
MN4311	Contracting for Services	3	0
MN4371	Acquisition and Contracting Policy	4	0

Department of Electrical and Computer Engineering

Chairman

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CDR Chad Bollmann, Assistant Professor (2021); Ph.D., Naval Postgraduate School, 2018.

Jon T. Butler, Distinguished Professor Emeritus (1987); Ph.D., Ohio State University, 1973.

Roberto Cristi, Professor (1985); Ph.D., University of Massachusetts, 1983.

Monique P. Fargues, Professor and Associate Chair for Student Programs (1989); Ph.D., Virginia Polytechnic Institute and State University, 1988.

Douglas J. Fouts, Professor and Chair of Electrical and Computer Engineering Department (1990); Ph.D., University of California at Santa Barbara, 1990.

David Garren, Professor (2012); Ph.D., College of William and Mary, 1991.

Tri T. Ha, Distinguished Professor Emeritus (1987); Ph.D., University of Maryland, 1977.

Robert (Gary) Hutchins, Associate Professor Emeritus (1993); Ph.D., University of California at San Diego, 1988.

David C. Jenn, Professor (1990); Ph.D., University of Southern California, 1989.

Jeffrey B. Knorr, Professor Emeritus (1970); Ph.D., Cornell University, 1970.

Frank Kragh, Associate Professor and Associate Chair for Instruction (2003); Ph.D., Naval Postgraduate School, 1997.

Herschel H. Loomis, Jr., Distinguished Professor Emeritus (1981); Ph.D., Massachusetts Institute of Technology, 1963.

John McEachen, Professor (1996); Ph.D., Yale University, 1995.

James Bret Michael, Professor (2004); Ph.D. George Mason University, 1993.

Sherif Michael, Professor (1983); Ph.D., University of West Virginia, 1983.

Donna Miller, Research Associate (2007); MSSE (Software Engineering), Naval Postgraduate School, 2000.

Jihane Mimih, Research Assistant Professor (2017); Ph.D., City University of New York, 2006.

Michael A. Morgan, Distinguished Professor Emeritus (1979); Ph.D., University of California at Berkeley, 1976.

Giovanna Oriti, Professor (2008); Ph.D. University of Catania, Italy, 1997.

Phillip E. Pace, Distinguished Professor Emeritus (1992); Ph.D., University of Cincinnati, 1990.

Matthew Porter, Research Associate (2012); M.S., Naval Postgraduate School, 2011.

John P. Powers, Distinguished Professor Emeritus (1970); Ph.D., University of California at Santa Barbara, 1970.

R. Clark Robertson, Professor (1989); Ph.D., University of Texas at Austin, 1983.

Darren J. Rogers, Research Associate (2021); Masters of Science in Information Warfare Systems, Naval Postgraduate School, 2012.

Ric Romero, Associate Professor (2010); Ph.D. University of Arizona, 2010.

John Roth, Assistant Professor (2017); Ph.D., Naval Postgraduate School, 2017.

James Scrofani, Associate Professor (2005); Ph.D., Naval Postgraduate School, 2011.

Weilian Su, Associate Professor (2004); Ph.D., Georgia Institute of Technology, 2004.

Charles W. Therrien, Professor Emeritus (1984); Ph.D., Massachusetts Institute of Technology, 1969.

Preetha Thulasiraman, Associate Professor (2012); Ph.D. University of Waterloo, Ontario, Canada, 2010.

Murali Tummala, Professor (1986); Ph.D., India Institute of Technology, 1984.

John J. Vitalich, Research Associate (2021); MSEE, Naval Postgraduate School, 2003.

Todd Weatherford, Professor (1995); Ph.D., North Carolina State University, 1993.

William Williamson, Research Associate Professor (2017); Ph.D., University of Toledo, 1996.

Yuntao Xu, Research Associate Professor (2021); Ph.D., Rensselaer Polytechnic Institute, 2001.

Xiaoping Yun, Distinguished Professor (1994); Sc.D., Washington University, 1987.

Di Zhang, Associate Professor (2021); Ph.D., Virginia Polytechnic Institute and State University, 2010.

Lawrence J. Ziomek, Professor Emeritus (1982); Ph.D., Pennsylvania State University, 1981.

*The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

Brief Overview

The Department of Electrical and Computer Engineering is the major contributor to programs for the education of officers in the Electronic Systems Engineering curriculum, the Combat Systems curriculum, the Space Systems Engineering curriculum, the Electronic Warfare curriculum, the Cyber Systems and Operations curriculum, and the Information Warfare curriculum. Additionally, the department offers courses in support of other curricula such as Information Technology Management; Command, Control, Communications, Computers and Intelligence (C4I); Space Systems Operations; Underwater Acoustics and Engineering Acoustics.

If needed, an MSEE student will usually spend six to twelve months learning or reviewing material at a junior or senior level before entering into graduate studies. The graduate study portion of a typical program is about one year in duration with a combination of course study and thesis work being performed. The thesis portion of the program is the equivalent of four courses (one quarter) with an acceptable written thesis being a requirement for graduation.

The curriculum is organized to provide the students with coursework spanning the breadth of Electrical and Computer Engineering. In addition, students concentrate in one major area of specialization within Electrical and Computer Engineering by taking a planned sequence of advanced courses. Currently there are formal concentrations in:

Communications Systems
Computer Systems
Cyber Systems
Guidance, Navigation and Control Systems
Power Systems and Microelectronics
Signal Processing Systems
Network Engineering

Sensor Systems Engineering

The department has about forty faculty members, including tenure track, non-tenure track, and military faculty, contributing to the instructional and research programs.

Degrees

The ECE department offers programs leading to the Master of Science degree in Electrical Engineering (MSEE), Master of Science in Computer Engineering (MSCE), the Master of Science in Engineering Science with a major in Electrical Engineering [MSES (EE)] or the Master of Science in Engineering Science with a major in Computer Engineering [MSES (CE)], the Master of Engineering with major in Electrical Engineering[MEng EE] or the Master of Engineering with a major in Computer Engineering [MEng CE], the degree of Electrical Engineer (EE) and Doctor of Philosophy (Ph.D.). A student is able to earn one of the academic degrees listed above while enrolled in Electronic Systems Engineering (Curriculum 590 resident or 592 non-resident distance learning), Space Systems Engineering (under Curriculum 566), Applied Physics of Combat Systems (Curriculum 533), and Undersea Warfare (Curriculum 525). The department typically graduates over forty graduate degree candidates per year in resident programs and additional candidates in distant learning programs.

MSEE Degree Program

The MSEE Degree Program is accredited by the Engineering Accreditation Commission (EAC) of ABET, http://www.abet.org. A Bachelor of Science in Electrical Engineering or its equivalent is required for the MSEE degree. Credits earned at the Naval Postgraduate School and credits from the validation of appropriate courses at other institutions are combined to achieve the degree equivalence.

This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The department chairman's approval is required for all programs leading to this degree.

Requirements:

1. A minimum of 52 credit hours of graduate level work.

2. There must be a minimum of 36 credits in the course sequence 3000-4999, of which at least 30 credits must be in Electrical and Computer Engineering. The remainder of these 36 credits must be in engineering, mathematics, physical science, and/or computer science.

3. Specific courses may be required by the department and at least four courses that total a minimum of 12 credits, must be in the course sequence 4000-4999.

4. An acceptable thesis for a minimum of 16 credits must be presented to, and approved by, the department.

MSEE Program Educational Objectives: The MSEE Degree program has the following objectives (i.e., skills and

abilities that graduates are expected to attain 3-5 more years after graduation):

- **Technical Leadership:** Graduates in the several years following graduation will be known and respected for their technical leadership along diverse career paths in government service and/or the private sector.
- **Technical Program Management:** Graduates in the several years following graduation will possess the ability to handle assignments related to research, design, development, procurement, maintenance, and life cycle management of electronic systems for Naval and other military platforms.
- **Operational Utilization:** Graduates in the several years following graduation will possess the ability to understand the capabilities and limitations of military electronic systems and to effectively employ electronic systems in military operations.

MSEE Student Outcomes: In order to achieve the above objectives, the Program curriculum is designed to produce the following outcomes (skills and abilities students will have at the time they complete the Program):

- **Independent Investigation:** Students will possess the ability to conduct and report the results of a technically challenging, defense-relevant independent investigation.
- **Depth and Breadth of Study:** Students will complete a course of study that includes appropriate depth and breadth for a masters-level student in an Electrical Engineering program by completing the graduate-level course requirements for one focus area and two specialty areas within the MSEE degree program at the Naval Postgraduate School.

MSCE Degree Program

The MSCE program provides both a broad-based education in traditional computer hardware and software related subjects while at the same time concentrating on military-relevant Computer Engineering topics such as Computer Security, High-Speed Networking, and Distributed and Parallel computing. A Bachelor of Science in Computer Engineering or its equivalent is required for the MSCE degree.

Requirements:

1. A minimum of 52 credit hours of graduate-level work.
2. There must be a minimum of 36 credits in the course sequence 3000-4999, of which at least 24 credits must be in Electrical and Computer Engineering, Computer Science, or Software Engineering.
3. Specific courses are required by the department, and at least four courses that total a minimum of 12 credits must be in the course sequence 4000-4999.
4. An acceptable thesis for a minimum of 16 credits must be presented to, and approved by, the department.

MSES (CE) Degree Program

Students who do not have BSCE degrees and are unable to achieve BSCE equivalency can pursue the MSES (CE) degree. Such students must, by virtue of their education and on-the-job experience, be capable of successfully completing the Computer Engineering Program Core and Specialization Tracks. Except for BSCE degree equivalency, the requirements for the MSES (CE) degree are the same as those for the MSCE degree.

Requirements:

1. A minimum of 52 credit hours of graduate-level work.
2. There must be a minimum of 36 credits in the course sequence 3000-4999, of which at least 24 credits must be in Electrical and Computer Engineering, Computer Science, or Software Engineering.
3. Specific courses are required by the department, and at least four courses that total a minimum of 12 credits must be in the course sequence 4000-4999.
4. An acceptable thesis for a minimum of 16 credits must be presented to, and approved by, the department.

MSES (EE) Degree Program

Students who do not have BSEE degrees and are unable to achieve BSEE equivalency can pursue the MSES(EE) degree. Such students must by virtue of their education and on-the-job experience be capable of successfully completing one of the MSEE Degree Program specialization tracks. Requirements:

1. A student needs a minimum of 52 credit hours of graduate level work.
2. There must be a minimum of 36 credits in the course sequence 3000-4999, of which at least 20 credits must be in graded EC graduate courses, and at a minimum, an additional 12 quarter credit hours in engineering, mathematics, physical science, and/or computer science.
3. At least 12 quarter credit hours must be in the sequence of advance courses 4000-4999.
4. An acceptable thesis for a minimum of 16 credits must be presented to, and approved by, the department.

MEng EE Program

The Master of Engineering in Electrical Engineering is a course-based degree program for non-resident students enrolled in distance learning programs.

Requirements:

1. Students must complete a minimum of 32 credit hours of graduate level course work which includes a minimum of three courses and 10 credit hours of 4000 level course work.
2. MEng (EE) degree programs must contain a minimum of 5 courses in electrical and computer engineering.
3. This degree program is quite flexible and can be designed with a focus tailored to meet distance learning customer requirements for work-force development.

MEng CE Program

The Master of Engineering in Computer Engineering is a course-based degree program for non-resident students enrolled in distance learning programs. Specific courses are required by the department.

Requirements:

1. Students must complete a minimum of 36 credit hours of graduate level course work which includes a minimum of four courses and 12 credit hours of 4000 level course work where at least three of the four 4000-level courses must be graded.

2. MEng (CE) degree programs must contain a minimum of eight courses in Electrical and Computer Engineering, Computer Science, or Software Engineering.

3. This degree program is quite flexible and can be designed with a focus tailored to meet distance learning customer requirements for work-force development.

EE Degree Program

Students with strong academic backgrounds may enter a program leading to the degree of Electrical Engineer. The EE degree program requires more course work and a more comprehensive thesis than a master's degree program but does not require the seminal research demanded in a Ph.D. program.

Requirements:

1. A minimum of 96 total graduate credits is required for the award of the engineer's degree, of which at least 24 must be in accepted thesis research, and at least 54 credits must be in Electrical and Computer Engineering courses.

2. At least 36 of the total hours are to be in courses in the sequence 4000-4999. Approval of all programs must be obtained from the Chairman, Department of Electrical and Computer Engineering.

TSSE Program

The Total Ship Systems Engineering Program is an interdisciplinary, systems engineering and design-oriented program available to students enrolled in Mechanical Engineering, Electrical and Computer Engineering, or Applied Physics of Combat Systems programs. The program objective is to provide a broad-based, design-oriented education focusing on the warship as a total engineering system. The eight-course sequence of electives introduces the student to the integration procedures and tools used to develop highly complex systems such as Navy ships. The program culminates in a team-performed design of a Navy ship, with students from all three curricula as team members. Students enrolled in programs leading to the Electrical Engineer Degree are also eligible for participation. Entry requirements are a baccalaureate degree in an engineering discipline with a demonstrated capability to perform satisfactorily at the graduate level. The appropriate degree thesis requirements must be met, but theses that address system design issues are welcome.

Ph.D. Degree Program

The Department of Electrical and Computer Engineering has an active program leading to the Doctor of Philosophy degree. Joint programs with other departments are possible. A noteworthy feature of these programs is that the student's research may be conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the federal government. The degree requirements are as outlined under the general school requirements for the doctor's degree.

ECE Department Laboratories

The laboratories of the department serve the dual role of supporting the instructional and research activities of the department. The department has well-developed laboratories in each specialty area.

Nano-electronics Lab

This laboratory supports design and analysis of semiconductor devices, design and development of VLSI integrated circuits, and design, implementation and testing of microprocessor and VLSI systems. Major equipment of the lab includes: Semiconductor Parameterization Equipment, Capacitance-Voltage measurement equipment, Semi-automatic Probing stations, High Speed Sampling Scopes, Logic Analyzers, Printed Circuit Assembly tools, Unix and PC workstations, Silvaco(TM) TCAD simulation tools, Tanner and Cadence Design tools and Semiconductor Parameterization Equipment (high power capability), Manual Probing stations (2+), Wire-bonding equipment, and PC workstations. The lab supports courses and thesis research projects in the MSEE degree Computer/Nanotechnology track and Power/Solid state track. This lab will be a major player in the nanoelectronics of the NPS Nano/MEMs initiative.

Digital Electronics/Microprocessor Lab

This laboratory is an instructional lab that supports courses in digital logic design and microprocessor-based system design. Students acquire practical knowledge through hard-wired and programmable logic design. Programmable design includes CPLDs (complex programmable logic devices) and FPGAs (field-programmable gate arrays). Students learn how to develop combinational and sequential circuits using hardware description languages, VHDL and/or Verilog. They learn the design, verification, and simulation process used in contemporary digital computer design using tools like ModelSim, Precision, and Synplify Pro. This lab supports instruction in microprocessor programming and interfacing, as well as system design involving high-speed pipeline processors and architectures. Specifically, ARM is used as a representative RISC (reduced instruction set computer) processor. Students gain an understanding of embedded computing through assignments that create systems which acquire inputs (data, keyboard entry, A/D

etc.) and produce outputs (processed data, displayed data, D/A, etc.). For example, students program an NXT robot that accepts human-supplied controller input and produces signals that drive actuator motors.

Circuits and Signals Lab

This laboratory provides support for instruction and research in the areas of basic analog design, discrete component testing, fundamental circuit design, and communication theory. The laboratory is equipped with CAD facilities capable of schematic capture, circuit simulation, and fault detection. The lab utilizes various test equipment to include, but not limited to, oscilloscopes, signal generators, spectrum analyzers, multi-meters, and high-speed data acquisition equipment.

Academic Computing Lab

This laboratory is the largest PC-equipped learning resource center in Spanagel Hall and the primary PC computational facility for the Department of Electrical and Computer Engineering. It is primarily a teaching laboratory for accomplishing computer assignments that are assigned as part of ECE courses. It is also used for research-related computing but only when such computing does not interfere with course work. The laboratory serves approximately 350 students annually and supports over 25 courses and over 12 curricula. It is also heavily used for student thesis preparation. The computers in this lab are, by necessity, high-end systems because the vast majority of software used in the lab are scientific and engineering applications that are extremely computationally intensive. The NPS Information Technology Assistance Center (ITAC) organization supplies labor for maintenance and upgrading of this facility.

Optical Electronics Lab

This laboratory provides educational and research support in the areas of fiber optics, lasers (including a fiber sigma laser), integrated optics and electro-optics. The laboratory has a variety of fiber optics instrumentation (including two OTDRs, a fusion splicer, optical spectrum analyzer, connector application equipment, a 1.5 Gb/s digital pattern generator and BER tester, an optical fiber amplifier, optical autocorrelator for pulsewidth measurement, various diode laser controllers), RF and microwave instrumentation (signal synthesizer, microwave spectrum analyzer), and general purpose test instrumentation. A variety of detectors, integrated optical modulators and imaging equipment are also available. The lab supports EC3210, EC3550, EO3911, EC4210, thesis students, and research in fiber optic communications and optical signal processing.

Electromagnetics Lab

This laboratory supports instruction and research in the area of microwave systems and technology. This is accomplished with a mix of hardware, instruments, test systems, and software. Included in the lab inventory are scalar and vector microwave network analyzers,

electromagnetic software for simulating antennas, ships and aircraft, and a software design system for simulation of microwave circuits and systems. There is also a fully automated anechoic chamber for antenna pattern measurements.

Radar and Electronic Warfare Systems Lab

The objective of the Radar and Electronic Warfare (EW) Systems Laboratory is to educate military officers and civilians in the technology and operational characteristics of electronic warfare. The Radar and Electronic Warfare Systems Laboratory supports both research and teaching. The hardware laboratory contains instrumented radar and electronic warfare equipment and has been in operation for over 35 years. Each radar system is well instrumented to operate as a teaching tool. The equipment allows the student to experience hands-on knowledge of performance characteristics, conduct experimental research, and reinforces concepts that are taught in the classroom.

Controls and Robotics Lab

This laboratory is mainly an instructional lab that supports experiments for all courses in Guidance, Navigation, Controls, and Robotics. Lab facilities include servo control stations and associated computers (equipped with A/D and D/A data acquisition cards, LabView, and Matlab/SIMULINK software) that are used to conduct simulations and physical experiments, modeling, analysis, and design of control systems. The lab is also equipped with advanced robots to support robotics laboratory assignments and thesis projects in robotics.

Power Systems Lab

The Power Systems Laboratory supports postgraduate education and thesis research related to the design, analysis, simulation and implementation of power converter and electric drive technology. Thesis research projects are closely coupled to current Department of Defense priorities including more-survivable power system architectures such as DC Zonal Electric Distribution, Integrated Power Systems, and electric propulsion. In coursework and projects, students employ modern device technologies, hardware-in-the-loop synthesis tools, simulation packages, measurement devices, and power converter and electric machine modules to assess component operation, develop feedback controls, and study evolving power system challenges. An emphasis is placed on prototyping and validating against detailed simulation models.

Digital Signal Processing Lab

This laboratory supports instruction and research in the area of Digital Signal Processing. Research and student thesis include work in the areas of detection and classification of signals, face recognition, acoustic communications, multirate signal processing and other areas. Lab facilities include several Windows based workstations and the capability of programming Field

Programmable Gate Arrays (FPGA) for real time applications.

Computer Communications and Networking Lab

This laboratory supports instruction and research in computer network design, engineering, and infrastructure development. The lab is currently divided between guided media (wire and fiber optic) networks and wireless networks. The lab also has facilities within the NPS High Performance Computing lab for network simulation and experimentation. Thesis work and research undertaken include modeling and simulation of high-speed and wireless networks and related protocols, video transmission and voice transmission over digital networks, traffic modeling, simulation and analysis, design and simulation of wide area networks, and related areas. Guided media lab facilities include routers, LAN switches, Voice-over-IP servers, Telcom fiber optic switches, ATM switches, video processing equipment, a channel simulator, protocol analyzers, network simulation packages, and computer workstations. The wireless lab facilities include WiFi, WiMax, VoIP, and sensor mote equipment, as well as a variety of signal generation and analysis equipment.

Secure Computing Lab

This lab contains computing facilities for classified projects (up to the SECRET level). It contains a variety of computing platforms from Windows-based PCs to a Linux cluster. The lab is also heavily used by students preparing classified documents including class presentations and theses.

Cryptologic Research Lab (CRL)

This laboratory is the NPS's center for research in communications engineering, focusing on physical layer design issues for wireless communications devices. Research areas emphasized are non-binary modulation, forward error correction coding, software defined radio, spread spectrum systems, cellular systems, wireless local and wide area networks, and interference mitigation. The CRL's facilities include many tools for modern communications engineering, such as eight software defined radio design stations; a state-of-the-art wireless fading channel simulator; arbitrary waveform generators; microprocessor-, digital signal processor (DSP)-, and field programmable gate array (FPGA)-based signal possessing development systems; and various signal generation, capture, and analysis tools.

Flash X-ray Lab

The NPS Flash X-ray Laboratory provides DoD support, testing and research capability to study weapons effects on electronics. It provides a Gamma radiation source to verify operation of electronic circuit and systems in a nuclear weapons environment. The machine can additionally be used to study Electro Magnetic Pulse for nuclear or microwave weapons. This is one of two Flash X-ray systems in the Navy (NRL).

Signal Enhancement Lab

The ECE department does a significant amount of research in wireless communications functions, both transmitting and receiving, in-the-clear and encrypted, solving interference, electromagnetic compatibility and radio spectrum utilization issues. Applications include Direction Finding, Improvised Explosive Device detection and jamming, and low-profile and Ultra-Wide-Band antenna development. This laboratory provides hardware and software support of these projects and is entirely research-supported.

Other support facilities within the department include the Calibration and Instrument Repair Laboratory. Classified instruction and research are supported by appropriately certified facilities.

Calibration and Repair Lab

The Calibration Lab and Electronics Repair Lab is a dual function facility that provides Electronics Calibration capabilities and Electronics General Repair functions.

The Electronics Test Equipment Repair Lab is a full-time, stand-alone repair facility. It provides a wide repair support for all NPS Electronics Test Equipment that are listed in the Property Book Inventories, maintained by each department. Repair parts, test equipment and library of repair and service manuals are also maintained on site.

The Calibration Lab is a Type 4 Electronics Field Repair Facility (FCA) assigned to region METCALPAC, Tech HQ, NAVSEASYSCOM. All test equipment that falls within the assigned Phase Packages (4 Phases) are all supported.

Electrical and Computer Engineering Course Descriptions

EC Courses (p. 362)

EO Courses (p. 379)

Guidance, Navigation & Control Systems - Curriculum 284

Program Officer

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Academic Associate

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Brief Overview

Provides students with the skills required for analysis, design and evaluation of guidance, navigation and control systems. The certificate provides a solid engineering

foundation which covers the fundamental concepts of optimal estimation methods for linear and nonlinear systems, optimal control laws for control systems, including minimum time control, minimum energy control, and linear quadratic regulator. Students will gain the skills required to analyze and design missile guidance and inertial navigation systems, ballistic missile targeting systems, and missile motion simulators.

The four-graduate-course sequence is extracted from the current set of graduate courses required to complete the Guidance, Navigation Control Systems specialization track for the MSEE Degree offered by the ECE Department.

The total number of NPS graduate credits obtained for the certificate is 16. This certificate program can also be applied toward a master's degree program.

Requirements for Entry

- Acceptance by the ECE Department: Entrance to the Electrical and Computer Engineering curriculum at the Naval Postgraduate School is through a three-part requirement consisting of a minimum grade point average at the undergraduate level, a sufficient mathematics background, and a sufficient background in technical undergraduate studies. Applicants with a B.S.E.E. degree usually will satisfy the last two requirements automatically.

- Command/Company endorsement.

Convenes

Winter, Summer

Subspecialty

5304L

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR to be awarded a certificate.

Required Courses: Curriculum 284

Course	Title	Lecture	Lab
EC3310	Optimal Estimation: Sensor and Data Association	3	2
EC3320	Optimal Control Systems	3	2
EC4330	Navigation, Missile, and Avionics Systems	3	2
EC4350	Nonlinear Control Systems	3	2
EC4310	Fundamentals of Robotics	3	2

The minor change consists of changing the requirements of taking: EC3310, EC3320, EC4330, EC4350 with taking EC3310, EC3320 AND SELECT TWO OUT OF THE THREE FOLLOWING COURSES: EC4310, EC4330, EC4350.

High-Performance Computer Architecture - Curriculum 286

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Brief Overview

The certificate provides a solid engineering foundation which covers both fundamental and advanced concepts of high-performance computers and computer systems. It provides students with the skills and abilities required to design, model, simulate, implement, analyze, and evaluate high-performance computers and computer systems by applying knowledge of digital logic design, computer architecture, embedded computing and cyber physical systems, implementation technologies (such as FPGAs and VLSI), and the use of CAD (Computer Aided Design) tools.

The three graduate-course sequence is extracted from the current set of graduate courses required to complete the Computer Systems specialization track for the MSEE Degree offered by the ECE Department.

The total number of NPS graduate credits obtained for the certificate is 12. This certificate program can also be applied toward a master's degree program.

Requirements for Entry

- Acceptance by the ECE Department: Entrance to the Electrical and Computer Engineering curriculum at NPS is through a three-part requirement consisting of a minimum grade point average at the undergraduate level, a sufficient mathematics background, and a sufficient background in technical undergraduate studies. Applicants with a B.S.E.E. degree usually will satisfy the last two requirements automatically.

- Command/Company endorsement.

Convenes

Winter

Program Length

Three quarters (9 months)

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Subspecialty

5309L

Required Courses

The certificate consists of the following three courses:

Course	Title	Lecture	Lab
EC3800	Microprocessor Based System Design	3	2
EC3840	Introduction to Computer Architecture	3	2

Choose one course below:

Course	Title	Lecture	Lab
EC4820	Advanced Computer Architecture	3	2
EC4830	Digital Computer Design	3	2

Digital Communications Certificate - Curriculum 287

Program Officer

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Brief Overview

Provides students the fundamental concepts of communication systems and networks, forward error control coding and its impacts when used in modern digital communications systems. In addition, provides students with an understanding of random processes sufficient for analysis of communication systems and networks corrupted by broadband noise and multipath fading.

The four-course sequence is extracted from the current set of graduate courses required to complete the Communication Systems specialization track offered by the ECE Department.

The total number of NPS graduate credits obtained for the certificate is 16.

Requirements for Entry

- Acceptance by the ECE Department: Entrance to the Electrical and Computer Engineering curriculum at the Naval Postgraduate School is through a three-part requirement consisting of a minimum grade point average at the undergraduate level, a sufficient mathematics background, and a sufficient background in technical undergraduate studies. Applicants with a B.S.E.E. degree usually will satisfy the last two requirements automatically.
- Command/Company endorsement.

Convenes

Fall

Program Length

Four quarters (12 months)

Subspecialty

5302L

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Required Courses: Curriculum 287

Course	Title	Lecture	Lab
EC3500	Analysis of Random Signals	4	0
EC3510	Communications Engineering	3	2
EC4550	Digital Communications	4	0
EC4580	Error Correction Coding	4	0

Cyber Warfare Certificate - Curriculum 288

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Brief Overview

The Cyber Warfare Certificate addresses the network threat environment, network infrastructure, network design and security for both wired and wireless environments as well as all facets of computer network operations, depending on the choice of certificate electives. The coursework equips students with an ability to apply techniques for network operations with both wired and wireless computer networks based on an ability to analyze, design and evaluate networks. Electives can be chosen to satisfy requirements for workforce education in both the DoD and Intelligence Community. Non-DoD sectors of government and the private sector which traditionally focus on network defense may also wish to consider this certificate to provide their employees with a more insightful understanding of computer and network defense challenges.

A minimum of 12 credit hours must be completed.

Requirements for Entry

- Acceptance by the ECE Department: Entrance to the Electrical and Computer Engineering curriculum at the Naval Postgraduate School is through a three-part requirement consisting of a minimum grade point average at the undergraduate level, a sufficient mathematics background, and a sufficient background in technical undergraduate studies. Applicants with a B.S.E.E. degree usually will normally satisfy the last two requirements automatically.
- Command/Company endorsement.
- TS/SCI clearance is required

Convenes

Any Quarter

Program Length

9 months

Subspecialty

5313L

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Required Courses: Curriculum 288

Course	Title	Lecture	Lab
EC3760	Information Operations Systems	3	2
EC4765	Cyber Warfare	3	2

Approved Elective(s):

DA3105	Conflict and Cyberspace	4	1
EC3730	Cyber Network and Physical Infrastructures	3	2
EC3750	Introduction to SIGINT Engineering	3	2
EC3970	Special Topics in Electrical & Computer Engineering	V	V
EC4730	Covert Communications	3	2
CS4558	Network Traffic Analysis	3	2
EC4755	Network Traffic, Activity Detection, and Tracking	3	2

Signal Processing Certificate - Curriculum 290

Academic Associate & Technical Point of Contact

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Brief Overview

Provides students an understanding of digital signal processing fundamentals, principles, and applications at the advanced level. The certificate provides a solid engineering foundation which covers the fundamental concepts needed to analyze and process digital information in many current applications including video, imaging, audio, communications, networking, underwater, and control applications. This program provides a mixture of instruction and computer-based laboratory exercises that offer students the opportunity to explore concepts and investigate applications in signal processing.

The four course sequence is extracted from the current set of graduate courses required to complete the Signal Processing Systems specialization track offered by the ECE Department.

The total number of NPS graduate credits obtained for the certificate varies between 15 and 16 depending on the elective choice. This certificate program can also be applied toward a master's degree program (Curriculum 592).

Requirements for Entry

- Acceptance by the ECE Department: Entrance to the Electrical and Computer Engineering curriculum at NPS is through a three-part requirement consisting of a minimum grade point average at the undergraduate level, a sufficient mathematics background, and a sufficient background in technical undergraduate studies. Applicants with a B.S.E.E. degree usually will satisfy the last two requirements automatically.
- Command/Company endorsement.

Convenes

At the beginning of Summer, Fall, or Winter quarters (July, September, or January).

Program Length

Four quarters

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Subspecialty

5306L

Required Courses

The certificate consists of the following three courses:

Course	Title	Lecture	Lab
EC3400	Digital Signal Processing	3	2
EC3410	Discrete-Time Random Signals	3	2
EC4440	Statistical Digital Signal Processing	3	2

and one of the following list of Signal Processing courses.

The current list, as of March 2014, includes:

Course	Title	Lecture	Lab
EC3460	Introduction to Machine Learning for Signal Analytics	3	2
EC3940	Special Topics in Electrical & Computer Engineering	V	V
EC4400	Advanced Topics in Signal Processing	3	0
EC4430	Multimedia Information and Communications	3	2
EC4450	Array Signal Processing	3	2
EC4480	Image Processing and Recognition	3	2
EC4910	Advanced Special Topics in Electrical Engineering	V	V

Electric Ships and Power Systems Certificate - Curriculum 291

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Brief Overview

The Electric Ship Power Systems graduate certificate program provides a solid engineering foundation which covers the fundamental concepts in electrical power conversion and electromechanical power conversion at the advanced level. This coherent program is obtained by taking a 4-graduate-course sequence which provides a mixture of instruction and computer-based laboratories offering students the opportunity to study the behavior and performance power systems in a virtual environment.

The 4-graduate-course sequence is extracted from the current set of graduate courses required to complete the Solid State Microelectronics and Power Systems specialization track to the MSEE Degree offered by the ECE department.

The total number of NPS graduate credits obtained for the certificate is 18.5.

Requirements for Entry

- Acceptance by the ECE Department: Entrance to the Electrical and Computer Engineering curriculum at the Naval Postgraduate School is through a three-part requirement consisting of a minimum grade point average at the undergraduate level, a sufficient mathematics background, and a sufficient background in technical undergraduate studies. Applicants with a B.S.E.E. degree usually will satisfy the last two requirements automatically.
- Command/Company endorsement.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

Subspecialty

5305L

Graduate Certificate Requirements

The academic certificate program must be completed within 3 years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Required Courses: Curriculum 291

Course	Title	Lecture	Lab
EC3130	Electrical Machinery Theory	3	3
EC4130	Advanced Electrical Machinery Systems	3	3
EC3150	Power Electronics	3	2
EC4150	Applied Power Electronics	3	2

Electronic Warfare Engineer Academic Certificate - Curriculum 292

Academic Associate & Technical Point of Contact

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Brief Overview

Provides students an understanding of the technical foundations found in electronic warfare at the system level and examines the impact of the physical environment. The certificate provides a solid engineering foundation which covers the fundamental concepts needed to understand how EW signals are affected by the environment and includes a survey of existing EW systems and analysis techniques. This program provides a mixture of instruction and computer-based laboratory exercises which offer students the opportunity to explore concepts and investigate applications in the electronic warfare

area.

The three-course sequence is extracted from the current set of graduate courses required to complete the Sensor Systems Engineering specialization track offered by the ECE Department.

The total number of NPS graduate credits obtained for the certificate is 12.0. This certificate program can also be applied toward a master's degree program (Curriculum 592).

Requirements for Entry

- Acceptance by the ECE Department: Entrance to the Electrical and Computer Engineering curriculum at Naval Postgraduate School is through a three-part requirement consisting of a minimum grade point average at the undergraduate level, a sufficient mathematics background, and a sufficient background in technical undergraduate studies. Applicants with a B.S.E.E. degree usually will satisfy the last two requirements automatically.
- Command/Company endorsement.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

Subspecialty

5310L

Upon completion of the certificate, student will have the skills and abilities required to:

1) analyze,

2) design, and

3) evaluate systems involving:

antennas, radiowave propagation, radar, communications, electronic warfare, and/or networked EW and apply these skills in a military systems environment.

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Course Requirements

A three-course sequence composed of:

1. EC3600,

2. EC3615 or EC3630,

3. EC3700 or EC4685.

Course	Title	Lecture	Lab
EC3600	Antennas and Propagation	3	2
EC3615	Radar Fundamentals	3	2
EC3630	Radiowave Propagation	3	2

Course	Title	Lecture	Lab
EC3700	Joint Network-Enabled Electronic Warfare I	3	2
EC4685	Principles of Electronic Warfare	3	2

Journeyman EW Engineer Academic Certificate Program - Curriculum 293

Academic Associate & Technical Point of Contact

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Brief Overview

Provides students an understanding of the microwave and optical aspects of sensor and electronic warfare systems. State-of-the-art material on microwave and optical devices and their use in systems are discussed during the courses. The certificate material also includes a description of the operation of devices and trade-offs involved in component selection. This program provides a mixture of instruction and computer-based laboratory exercises that offer students the opportunity to explore concepts and investigate applications in the electronic warfare area.

The three-course sequence is extracted from the current set of graduate courses required to complete the Sensor Systems Engineering specialization track offered by the ECE Department.

The total number of NPS graduate credits obtained for the certificate is 12.0. This certificate program can also be applied toward a master's degree program (Curriculum 592).

Requirements for Entry

- Acceptance by the ECE Department: Entrance to the Electrical and Computer Engineering curriculum at the Naval Postgraduate School is through a three-part requirement consisting of a minimum grade point average at the undergraduate level, a sufficient mathematics background, and a sufficient background in technical undergraduate studies. Applicants with a B.S.E.E. degree usually will satisfy the last two requirements automatically.
- Command/Company endorsement.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters.

Subspecialty

5310L

Upon completion of the certificate, student will have the

skills and abilities required to analyze, design, and evaluate systems involving: microwave components, RF systems, electro-optical systems and components, advanced radar concepts, and/or advanced topics in electronic warfare and apply these skills in a military systems environment.

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Students are required to take EC3210 and EC3610, and one of the following courses: EC4615, or EC4630, or EC4600.

Required Courses

Course	Title	Lecture	Lab
EC3210	Introduction to Electro-Optical Engineering	3	2
EC3610	Microwave Engineering -and-	3	2
EC4615	Advanced Radar -or-	3	2
EC4630	Radar Cross Section Prediction and Reduction -or-	3	2
EC4600	Advanced Topics in Electromagnetics	V	V

Senior EW Engineer Academic Certificate Program - Curriculum 294

Academic Associate & Technical Point of Contact

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Brief Overview

Provides students an understanding of advanced topics commonly found in EW. Among them are signature control (stealth) and low probability of intercept techniques for radar and electronic warfare. This program provides a mixture of instruction and computer-based laboratory exercises that offer students the opportunity to explore concepts and investigate applications in the electronic warfare area.

The three-course sequence is extracted from the current set of graduate courses required to complete the Sensor Systems Engineering specialization track offered by the ECE Department.

The total number of NPS graduate credits obtained for the certificate is 12.0. This certificate program can also be applied toward a master's degree program (Curriculum 592).

Requirements for Entry

- Acceptance by the ECE Department: Entrance to the Electrical and Computer Engineering curriculum at the Naval Postgraduate School is through a three-part requirement consisting of a minimum grade point average at the undergraduate level, a sufficient mathematics background, and a sufficient background in technical undergraduate studies. Applicants with a B.S.E.E. degree usually will satisfy the last two requirements automatically.
- Command/Company endorsement.

Convenes

Fall, Winter, Spring, and Summer

Program Length

Four quarters.

Subspecialty

5310L

Upon completion of the certificate, student will have the skills and abilities required to:

1) analyze,

2) design, and

3) evaluate systems involving:

advanced radar topics, radar cross-section concepts, radiowave propagation, communications, and/or electronic warfare and apply these skills in a military systems environment.

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Required Courses

A three-course sequence made up of:

1. EC3615 or EC3630

2. EC3700 or EC4685

3. EC4615 or EC4630

Course	Title	Lecture	Lab
EC3615	Radar Fundamentals -or-	3	2
EC3630	Radiowave Propagation	3	2
EC3700	Joint Network-Enabled Electronic Warfare I -or-	3	2
EC4685	Principles of Electronic Warfare	3	2
EC4615	Advanced Radar -or-	3	2
EC4630	Radar Cross Section Prediction and Reduction	3	2

Network Engineering Certificate - Curriculum 295

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Program Manager

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Brief Overview

The Network Engineering Certificate is comprised of three or four courses (EC3710, EC4745 and one or two elective courses). Upon completion of this certificate program, students will be awarded a certificate of completion from the Naval Postgraduate School. The Network Engineering Certificate addresses the design, implementation, traffic, signaling and performance analysis of modern enterprise and telecommunications network infrastructures integrating both wired and wireless media.

Requirements for Entry

For entry, the student must have a baccalaureate degree.

Convenes

Spring or Fall

Program Length

Four Quarters

Subspecialty

5312L

Introduce students to evolving cellular technology, including the foundations of 5G and 6G.

Certificate Requirements

Required Courses

Course	Title	Lecture	Lab
EC4745	Mobile Ad-hoc Wireless Networks	3	2
EC3710	Computer Communications Methods -or-	3	2

Course	Title	Lecture	Lab
CS3502	Computer Communications and Networks	3	2

And one or two of the following electives to total a minimum of 12 credit hours:

EC4725	Advanced Telecommunication Systems Engineering	3	2
EC4785	Internet Engineering	3	2
EC4710	High Speed Networking	3	2
EC4430	Multimedia Information and Communications	3	2
EC3795	Mobile Telecommunications Fundamentals	3	2

Cyber Systems Certificate - Curriculum 296

Academic Associate

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Brief Overview

This certificate is designed to provide students with a graduate level focus on cyber systems, system reverse engineering, and depending on elective choice, an ability to assess vulnerability and risk, architecture and engineering, or network traffic.

Requirements for Entry

Students who plan to enroll in the Cyber Systems Certificate Program should have a BSEE degree or a degree in another area of science or engineering with additional coursework and on-the-job experience, including a basic communications course, that will allow them to successfully complete the certificate courses.

Convenes

Fall

Program Length

Four quarters

Subspecialty

5313L

- The student will be able to describe the major components that connect the Internet, what protocols

they use, and who has administrative custody of them.

- The student will be able to identify the major components of an industrial control system.
- Given a schematic of an enterprise network, the student will be able to identify critical points of failure and potential vulnerabilities.
- Given a system of unknown behavior and design, the student will be able to systematically probe, evaluate and predict the functionality and response of the system under controlled conditions.
- Given the topology and components of a network of unspecified design, the student will be able to estimate the functionality, intent and limitations of the network.
- The student will be able to apply traffic analysis techniques to identify the nature and intent of communications observed on a packet switched network using standardized communications.

Certificate Requirements

Required Courses

Course	Title	Lecture	Lab
EC3730	Cyber Network and Physical Infrastructures	3	2
EC3740	Reverse Engineering in Electronic Systems	3	2

And one or two of the following electives to total a minimum of 12 credit hours:

Course	Title	Lecture	Lab
EC4715	Cyber System Vulnerabilities and Risk Assessment	3	2
EC4790	Cyber Architectures and Engineering	3	2
EC4755	Network Traffic, Activity Detection, and Tracking	3	2
EC4730	Covert Communications	3	2
EC4770	Wireless Communications Network Security	3	2
EC3795	Mobile Telecommunications Fundamentals	3	2

Wireless Network Security Certificate - Curriculum 297

Academic Associate

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Brief Overview

This certificate is designed to provide students with a graduate level focus on the security of wireless communications networks, and depending on elective choice, an ability to assess the security of wireless devices or telecommunications systems, to maintain situational awareness on wireless networks or assess the risk of covert malicious functionality in system hardware components.

Requirements for Entry

Students who plan to enroll in the Wireless Network Security Certificate Program should have a BSEE degree or a degree in another area of science or engineering with additional coursework and on-the-job experience, including a basic communications course, that will allow them to successfully complete the certificate courses.

Convenes

Fall

Program Length

Four quarters

Certificate Requirements

Required Courses

Course	Title	Lecture	Lab
EC4770	Wireless Communications Network Security	3	2
EC4745	Mobile Ad-hoc Wireless Networks	3	2

And one or two of the following electives to total a minimum of 12 credit hours:

Course	Title	Lecture	Lab
EC4730	Covert Communications	3	2
EC4735	Telecommunications Systems Security	3	2
EC4755	Network Traffic, Activity Detection, and Tracking	3	2
EC4795	Wireless Device Security	3	2

Electronic Systems Engineering - Curriculum 590

Website

http://www.nps.edu/web/ece

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Brief Overview

This curriculum is designed to educate officers in current electronics technology and its application to modern naval warfare. It establishes a broad background of basic engineering knowledge, leading to selected advanced studies in electronic systems, ship/weapon control systems, and communication/information processing applicability. It will enhance individual performance in all duties throughout a naval career, including operational billets, technical management assignments, and policy making positions, thereby preparing Naval officers for progressively increasing responsibility, including command, both ashore and afloat. U. S. Naval officer students are required to complete the requirements for the MSEE degree as well as certain additional requirements specified by the program sponsor for award of a Navy P-code. Other students are not required to satisfy these additional requirements.

Requirements for Entry

A baccalaureate degree in engineering or the physical sciences is desired. Differential and integral calculus, one year of calculus-based college physics and at least one semester of college chemistry are required. The Engineering Science Program within the ESE curriculum is available for candidates who do not meet all admission requirements. Refresher quarters are offered and is recommended for non-engineering undergraduates and those out of school greater than 5 years. The time required will vary with the candidate's background. Prior to undertaking the program, or as a part of the program, each officer will earn/have earned the equivalent of an accredited BSEE. An APC of 323 is required for direct entry.

Convenes

Electronic Systems Engineering is typically an eight-quarter course of study with entry dates in every quarter. A six-quarter program is available for officers with an ABET EAC accredited BSEE degree on a case-by-case basis. If further information is needed, contact the Academic Associate or the Program Officer.

Degree

Requirements for the Master of Science in Electrical Engineering degree are met en route to satisfying the educational skill requirements.

Subspecialty

Completion of this curriculum qualifies an officer as an Engineering Electronics Subspecialist with a subspecialty code 53XXP. A limited number of particularly well-qualified students may be able to further their education beyond the master's degree and obtain the Degree of Electrical Engineer and a 53XXN subspecialty code. The curriculum sponsor is the Naval Sea Systems Command.

U.S. Marine Corps officers completing this curriculum fulfill the requirements for MOS 8824.

Typical Subspecialty Jobs

Instructor: Naval Academy, Annapolis, MD
Project Manager: SPAWARSYSCOM; NAVSEASYSCOM; NIWA
Operations Test and Evaluation: COMOPTEVFOR
Electronics Research Manager: NSA/CSS, FT. Meade
C3 Staff Officer: DISA HQ, Washington, DC
Project Officer: Warfare Systems Architecture and Engineering, SPAWARHDQTRS
Electrical Engineer: USSTRATCOM

MSEE (590) - Computer Systems Option

MSEE Quarter 1

Course	Title	Lecture	Lab
EC2100	Circuit Analysis	3	2
EC2820	Digital Logic Circuits	3	3
MA1115	Multi Variable Calculus	4	0
NW3230	Strategy & War	4	2

MSEE Quarter 2

Course	Title	Lecture	Lab
EC2110	Circuit Analysis II	3	2
EC2200	Introduction to Electronics Engineering	3	3
EC2400	Discrete Systems	3	1
EC2840	Introduction to Microprocessors	3	2

MSEE Quarter 3

Course	Title	Lecture	Lab
EC2300	Introduction to Control Systems	3	2
EC2410	Analysis of Signals and Systems	4	1
EC3800	Microprocessor Based System Design	3	2
EC3000	Introduction to Graduate Research	1	0

MSEE Quarter 4

Course	Title	Lecture	Lab
ELECT	BSEE Elective I		
EC3830	Digital Computer Design Methodology	3	2
EC3500	Analysis of Random Signals	4	0
EC2320	Linear Systems	3	1

MSEE Quarter 5

Course	Title	Lecture	Lab
EC2220	Electrical Engineering Design	3	4
EC3820	Computer Systems	3	2
ELECT	BSEE Elective II		
ELECT	BSEE Elective III		

MSEE Quarter 6

EC3830	Digital Computer Design Methodology	3	2
EC4010	Principles of Systems Engineering	3	2
EC4830	Digital Computer Design	3	2
EC0810	Thesis Research	0	8

MSEE Quarter 7

ELECT	MSEE Elective I		
EC0810	Thesis Research	0	8
EC0810	Thesis Research	0	8

MSEE Quarter 8

EC4800	Advanced Topics in Computer Engineering	3	0
EC4870	VLSI Systems Design	3	2
ELECT	MSEE Elective II		
EC0810	Thesis Research	0	8

Cyber Warfare Engineering and Science (CWES) Track

The CWES track consists of 3 mandatory core focus areas including computer networks, reverse engineering, and wireless communications, complemented by 2 or more student-selected specialization areas. The CWES Track leads to an MSES(EE) degree with specializations including AI/ML, cryptography, cyber operations, adversarial techniques, systems acquisition and modeling, policy and analysis, electronic warfare, etc.

The CWES track is open to Navy 1840s, other Services, and civilian students based on their educational background. It is assumed that gaining students have a strong familiarity with software development and are capable programmers. A computer science or electrical engineering undergraduate degree is typical but not required.

Non-Navy students are not required to complete JPME courses.

Quarter 1 - CWES Track

Course	Title	Lecture	Lab
CS3600	Introduction to Cybersecurity	4	1
MA3025	Logic and Discrete Mathematics II	4	1
OS3180	Probability and Statistics for Systems Engineering	4	1
CS3502	Computer Communications and Networks	3	2

MA2025 is an accepted alternative to MA3025 depending on gaining quarter and student background.

OS3105 is an acceptable alternative to OS3180; OS3180 is preferred.

CS3502 or EC3710 will satisfy the networking requirement.

The provided CWES progression is typical and must be tuned for each student based on their educational background and earned certifications. The program is designed to support either Summer or Fall Quarter gains.

A full or partial refresher quarter is available based on student background and is supported by the approved progression.

It may be possible that Winter and Spring accessions are supported, though these alternatives have not been fully investigated.

Quarter 2 - CWES Track

EC2700	Introduction to Cyber Systems	3	3
SS3610	Space Communications Systems: Fundamentals and Analysis	4	2
MA3560	Applied Modern Algebra and Number Theory	4	0
MN3331	Principles of Acquisition and Program Management	5	1

Quarter 3 - CWES Track

CS4558	Network Traffic Analysis	3	2
EC3730	Cyber Network and Physical Infrastructures	3	2
EC4745	Mobile Ad-hoc Wireless Networks	3	2
NW3230	Strategy & War	4	2
EC3000	Introduction to Graduate Research	1	0

Quarter 4 - CWES Track

EC3740	Reverse Engineering in Electronic Systems	3	2
EC0810	Thesis Research	0	8
NW3275	Joint Maritime Operations - part 1	4	0
ELECT	Specialization Elective		

Quarter 5 - CWES Track

EC4730	Covert Communications	3	2
EC0810	Thesis Research	0	8
NW3276	Joint Maritime Operations - part 2	2	2
ELECT	Specialization Elective		

Quarter 6 - CWES Track

EC4770	Wireless Communications Network Security	3	2
CS4677	Computer Forensics	3	2
EC0810	Thesis Research	0	8
NW3285	Theater Security Decision Making	4	0

Quarter 7 - CWES Track

ELECT	Specialization Elective		
ELECT	Specialization Elective		
EC0810	Thesis Research	0	8

EC0810	Thesis Research	0	8

Quarter 8 - CWES Track

EC0810	Thesis Research	0	8
ELECT	Specialization Elective		
ELECT	Specialization Elective		
ELECT	Specialization Elective		

CWES Specialization Option - AI/ML/Data Science

OA3802	Computational Methods for Data Analytics	4	0
CS3315	Introduction to Machine Learning and Big Data	3	1
AE4824/ME4824	Applications of Deep Learning for Military Systems	3	2
OA4118	Statistical and Machine Learning	4	0

CWES Specialization Option - Cryptography

MA2025	Bridge to Advanced Mathematics	4	1
MA3560	Applied Modern Algebra and Number Theory	4	0
MA4570	Cryptography - Foundations and Practice	4	1
CS4615	Cryptographic Protocol Design and Attacks	3	1

MA2025 (or MA3025) and MA3560 are also required as part of the CWES core.

CWES Specialization Option - Exploit and Collection

EC3760	Information Operations Systems	3	2
EC4765	Cyber Warfare	3	2

CWES Specialization Option - Cyber Adversarial Techniques

CS3690	Network Security	4	1
CS4678	Advanced Cyber Vulnerability Assessment	4	1
CS4648	Software Reverse Engineering and Malware Analysis	3	2
CS4679	Advances in Cyber Security Operations	4	1

CWES Specialization Option - Systems Acquisition and Modeling

MN3309	Software Acquisition Management for Defense Systems	3	2
SE3250	Capability Engineering	3	2
SE4420	Modeling and Simulation in Acquisition	3	2
MN3331	Principles of Acquisition and Program Management	5	1

MN3331 is also required as part of the CWES core.

CWES Specialization Option - Cyber Policy and Analysis

DA3105	Conflict and Cyberspace	4	1
CY4410	Cyber Policy and Strategy	3	0
DA3180	Warfare in the Electromagnetic Spectrum: Principles and Applications	4	0

CWES Specialization Option - Applied Cyber Operations

CS3690	Network Security	4	1
CY4700	Defensive Cyberspace Operations	3	3
CY4710	Adversarial Cyberspace Operations	3	2

CWES Specialization Option - Random Signals and Analysis

EC2410	Analysis of Signals and Systems	4	1
EO2512	Introduction to Communications & Countermeasures	4	2
EO3512	Telecommunications Engineering	4	1
EC3460	Introduction to Machine Learning for Signal Analytics	3	2

CWES Specialization Option - Embedded Systems Engineering

EC2820	Digital Logic Circuits	3	3
EC3800	Microprocessor Based System Design	3	2
EC4830	Digital Computer Design	3	2

Either EC3800 or EC3840 are acceptable. Either EC4830 or EC4820 are acceptable.

CWES Specialization Option - Electronic Warfare

EC3460	Introduction to Machine Learning for Signal Analytics	3	2
EC3600	Antennas and Propagation	3	2
EC3615	Radar Fundamentals	3	2

Educational Skills Requirements (ESR)

Electronic Systems Engineering - Curriculum 590

Subspecialty Codes: 5300P-5311P

1. **Mathematics:** The officer will have a thorough knowledge of mathematical tools, which are intrinsic to electrical and computer systems engineering, including but not limited to differential equations, vector analysis, linear algebra, probability, and Fourier and Laplace methods.

2. **Engineering Science and Design:** To acquire the requisite background needed to meet the other military education requirements, the officer will acquire proficiency in modern physics, electromagnetic, electronic devices and circuits, system theory, modern

electronic system design, and integrated electrical power systems and their controls. In addition, proficiency will be gained in other appropriate fields, such as underwater acoustics, dynamics, fluid mechanics or thermo-dynamics, that provide the requisite breadth to a military engineering education.

3. **Electronic and Electrical Engineering:** In order to provide officers skilled in the application of electronic systems to military needs, the officer will have competence in the broad area of electrical engineering including circuits, electronics, computer and communications networks, and systems engineering. To achieve depth and breadth of understanding, the officer shall specialize in a minimum of two from the following areas: (a) Electronics - Including semiconductor nanotechnology for defense-related electronic technologies; reliability and radiation hardening for electronic military systems; solar cell photovoltaic components; engineering techniques for analog IC design, modeling and simulation (b) Communication Systems - including radio communications, modulation, forward error correction coding, electronic countermeasures, software defined radio, and other military issues (c) Guidance, Control & Navigation Systems - including robotics, unmanned systems, avionics systems, target tracking, sensors as applied to guidance and control, and data association (d) Power Systems - including shipboard electric machinery, converters for advanced shipboard electric power and the simulation and analysis of power electronic drives (e) Signal Processing Systems – including signal analytics for efficient extraction, representation, and identification of information as applied to surveillance, signals intelligence, RF and underwater data acquisition and processing, imaging and other defense-related issues (f) Cyber Systems - including a rigorous treatment of the cyber infrastructure, reverse engineering of cyber systems, cyber systems vulnerabilities and risk assessment, cyber warfare systems, telecommunications systems engineering, and Internet engineering (g) Computer Systems - including logic design, FPGA and ASIC design, computer architecture and the hardware/software interface, parallel and distributed computing, embedded and real-time computing, high-reliability and reconfigurable computing, computer systems modeling, simulation, and analysis (h) Sensor Systems Engineering – including radar, sonar, RF and micro-wave devices, infrared and electro-optical imaging and tracking, antennas and propagation, network-enabled electronic warfare, and spectrum management (I) Network Engineering - including wireless networks, sensor networks, high speed data networking, the Internet and telecommunication systems.

4. **Conducting and Reporting Independent Investigation:** The officer will demonstrate the ability to conduct independent investigation of a Navy and/or DoD relevant electronic systems problem, to resolve the problem, and to present the results of the analysis in both written and oral form.

5. **Engineering Duty Officer Cyber Education:** The officer will have a sound understanding of cyber infrastructure systems and technologies of interest to the military. Knowledge will include but not be limited to the underlying principles of cyber infrastructure and systems, inherent vulnerabilities and threats, and defensive security procedures. Specific focus areas should include computer systems, computer networks – including Ethernet, Internet protocol, Address Resolution and routing protocols, wired and wireless communication systems, cyber security and defense, and Industrial Control Systems.

Cyber Warfare Engineering and Science (CWES) Track ESRs

Subspecialty Code: TBD

In addition to ESRs 6-9, CWES-track students are required to complete ESR 4: Conducting and Reporting Independent Investigation.

1. **CWES Mathematics:** The officer will have a thorough knowledge of mathematical tools which are intrinsic to electrical and computer systems engineering, including but not limited to discrete math, logic, linear algebra, probability, and statistics.

2. **CWES Computer Network Communications**: The officer will have thorough knowledge and proficiency in the theory, design, and operation of wired and wireless computer communications and networks as well as communications security practices.

3. **CWES Cyber Systems Engineering and Security:** The officer will have knowledge and proficiency in the design and implementation of computers and hardware security, including the reverse engineering of cyber systems.

4. **CWES Specializations:** In order to provide officers skilled in the application of electronic systems to cyber warfare needs, the officer will have additional competence in specialized topics supporting the broad area of cyber security. To achieve depth and breadth of understanding, the officer shall take at least six of the following courses to specialize in a minimum of two specialties from the following list: artificial intelligence (AI)/machine learning (ML)/data science, cryptography, embedded systems, cyber adversarial techniques, cyber system acquisition and modeling, cyber policy and analysis, applied cyber operations, random signals analysis, and electronic warfare.

   (a)   AI/ML/Data Science – including computational methods and statistical foundations for AI and ML, algorithms, and military applications

   (b)   Cryptography - including mathematical foundations of cryptography and design and attack of

cryptographic algorithms

(c)   Cyber Adversarial Techniques - including advanced computer and network security, vulnerability assessment, friendly and adversarial cyber security operations, and malware analysis and design

(d)   Embedded Systems Engineering – principles of embedded system elements of military systems including digital logic, embedded systems and real time programming, modeling and simulation with hardware description languages, CPU operations and interaction with software and hardware, embedded systems design, and hardware optimization for specialized computing.

(e)   Cyber Systems Acquisition and Modeling - including principles of acquisition and program management, capabilities engineering and analysis, modeling and simulation for acquisition, and software cybersecurity and acquisition.

(f)   Electronic Warfare - including fundamentals of the electromagnetic spectrum, antennas and propagation, and AI and ML methods supporting signal analysis and electromagnetic spectrum operations

(g)   Applied Cyber Operations - including advanced network security, applied defensive cyber operations, and adversarial cyber operations

(h)   Cyber Policy and Analysis - including cyber policy design and analysis, information operations using the electromagnetic spectrum, and conflict analysis relative to cyber warfare

(i)   Exploitation of Cyber Systems and Intelligence Collection - including information operations systems and collection systems design and engineering

(j)   Analysis of Random Communications Signals – including communications signal analysis, communications engineering, countermeasures, and ML methods for signal analysis.

Electronic Systems Engineering (DL) - Curriculum 592

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Brief Overview

Electrical and Computer Engineering Department Distance

learning programs are tailored to customer requirements and may lead to one of several master's degrees. Options include the Master of Science in Electrical Engineering (MSEE), the Master of Science in Engineering Science with a major in electrical engineering (MSES(EE)) and the Master of Engineering (MEng). Courses are delivered on a schedule determined in consultation with the customer, with one course per quarter being typical (four courses per year). A typical program can be completed in two to three years. MS degree programs are research-based and require submission and approval of a written thesis. The MEng degree is course-based and may require a capstone project. A 3.0 GQPR in course work is required for award of a master's degree. Non-resident students enrolled in ECE Department certificate programs may, upon completion of the certificate program(s), transfer from the certificate curriculum to the 592 curriculum and apply certificate program courses toward requirements for a master's degree.

Research or Capstone Project

Course work is followed by research and submission of a written thesis in MSEE and MSES(EE) degree programs. The MSEE Degree Program is accredited by the Engineering Accreditation Commission of ABET and requires that students have a baccalaureate degree from an ABET EAC accredited engineering program or establish equivalency. The ECE Department can provide transition education for the purpose of establishing equivalency, but additional course work is required. The MSES(EE) Degree Program is also research-based but is not accredited by the Engineering Accreditation Commission of ABET. It is intended for students who have not satisfied ABET EAC undergraduate program criteria but by their academic preparation and on-the-job experience can successfully complete graduate courses in a chosen area of electrical engineering. Theses must be submitted and approved within a three year period following the completion of course work in research-based degree programs.

The MEng degree program is course-based, and the degree may be awarded solely on the basis of course work. MEng programs may include a capstone project if a customer wants one. The total time required to complete a degree program ranges from four to seven years, depending on the courses selected.

DL Program Delivery Mode

To maintain quality, it is ECE Department policy to enroll non-resident students in courses offered synchronously to resident students. Courses are delivered to the remote site via video tele-education (VTE) using two-way audio and video. Lectures are recorded and streaming video is made available to accommodate those DL students whose attendance at the remote site is interrupted by job-related travel. Course materials are provided online using SAKAI (http://www.nps.edu/Technology/CLE/). Student mentoring sessions will be scheduled by each instructor and conducted via e-mail or phone. Courses can also be

delivered synchronously using Blackboard Collaborate (www.blackboard.com).

Requirements for Entry

- An APC score of 323.
- Acceptance by the ECE Department: Entrance to the Electrical and Computer Engineering curriculum at Naval Postgraduate School is through a three-part requirement consisting of a minimum grade point average at the undergraduate level, a sufficient mathematics background, and a sufficient background in technical undergraduate studies. Applicants with a B.S.E.E. degree usually will satisfy the last two requirements automatically.
- Command/Company endorsement.

Convenes

At the beginning of any quarter in the academic year.

Degree

MSEE, MSES(EE) or MEng.

Subspecialty

This program does not lead to a subspecialty code.

Typical course of study (MEng with specialization in EW):

Employment years 1-2

Course	Title	Lecture	Lab
EC3600	Antennas and Propagation	3	2
EC3630	Radiowave Propagation	3	2
EC3700	Joint Network-Enabled Electronic Warfare I	3	2

Employment years 3-4

EC3210	Introduction to Electro-Optical Engineering	3	2
EC3610	Microwave Engineering	3	2
EC4610	Radar Systems	3	2

Employment years 5-6

EC4630	Radar Cross Section Prediction and Reduction	3	2
EC4640	Airborne Radar Systems	3	2
EC4680	Joint Network-Enabled Electronic Warfare II	3	2

Employment year 7

EC0820	Integrated Project	0	12
EC4900	Topics for Individual Study in Electrical Engineering	V	V

Electronic Systems Engineering PhD - Curriculum 594

Website

http://www.nps.edu/web/ece/

Program Officer

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Academic Associate

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Brief Overview

The Department of Electrical and Computer Engineering has an active program leading to the Doctor of Philosophy degree. Joint programs with other departments are possible. A noteworthy feature of these programs is that the student's research may be conducted away from the Naval Postgraduate School in a cooperating laboratory or other installation of the federal government. The degree requirements are as outlined under the general school requirements for the doctor's degree.

Total Ship Systems Engineering (Under Department of Electrical and Computer Engineering)

Program Director

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Brief Overview

The objective of this program is to provide a broad-based, design-oriented education focusing on the warship as a total engineering system including hull, mechanical, electrical and combat systems. The program is for selected Naval Mechanical Engineering, Electrical Engineering, and Applied Physics of Combat Systems students and is structured to lead to the MSME, MSEE, or MS in Physics. Entry to the Total Ship Systems Engineering program is through the standard 533/570/590/591 curricula.

Convenes

Total Ship Systems Engineering will generally fit as part of an eight or nine-quarter program, with TSSE elective commencing in October. The ease of accommodating TSSE in a student's program is influenced by the student's NPS entry quarter and undergraduate background and

performance. Individuals interested in the program should explore the necessary course sequencing with the program officer or academic associate as early as possible.

Subspecialty

Completion of this program will contribute toward the graduate's subspecialty code within his/her designated curriculum. The student will also receive 5602P subspecialty code for completion of the TSSE Program.

Typical Subspecialty Jobs

Upon award of the subspecialty code, the officer would be eligible for assignments typical of the P-Code. The expectation is that the combination of education and experience would lead to individuals qualified for assignment later in their career to more responsible positions in systems design and acquisition in NAVSEA, SPAWAR and OPNAV, and as Program Managers.

Department of Information Sciences

Chairman

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Associate Chairman, Research

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Associate Chairman, Operations

Seth Gibson
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Associate Chairman, Instruction

Steven J. Iatrou
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* The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

Richard Bergin, Lecturer (2002); M.S., University of Southern California, 1998.

Alexander Bordetsky, Professor (2000); Ph.D., Chelyabinsk State Technical University of Russia, 1982.

Eugene Bourakov, Faculty Associate - Research (2002); MSEE, Chelyabinsk State Technical University of Russia, 1974.

Donald Brutzman, Associate Professor (1994); Ph.D., Naval Postgraduate School, 1994.

Mustafa A. Canan, Assistant Professor (2018); Ph.D., Old Dominion University, 2011, 2017.

Duane Davis, Senior Lecturer (2012); Ph.D., Naval Postgraduate School, 2006.

Shelley P. Gallup, Research Associate Professor (1999); Ph.D., Old Dominion University, 1998.

Victor R. Garza, Faculty Associate - Research (2003); M.S., Golden Gate University, 2000.

Thomas J. Housel, Professor (2001); Ph.D., University of Utah, 1980.

Steven J. Iatrou, Senior Lecturer (2000); M.S., Naval Postgraduate School, 1992.

Cynthia Irvine, Distinguished Professor (1994); Ph.D., Case Western University, 1975.

Magdi N. Kamel, Associate Professor (1988); Ph.D., University of Pennsylvania, 1988.

Anthony Kendall, Lecturer (1999); M.S., Naval Postgraduate School, 1980.

Douglas MacKinnon, Research Associate Professor (2005); Ph.D., Stanford University, 2005.

Randall Maule, Research Associate Professor (2003); Ph.D., University of Florida, 1987.

Mollie McGuire, Assistant Professor (2017); Ph.D., Claremont Graduate University, 2016.

Scot Miller, Faculty Associate - Research (2007); M.B.A., University of West Florida, 1986; M.S., Naval Postgraduate School, 1994; M.A., Naval West College, 2001.

Johnathan C. Mun, Research Professor (2005); Ph.D., Lehigh University, 1998.

Carl Oros, Assistant Professor (2010); Ph.D., Naval Postgraduate School, 2019.

Alan Shaffer, Senior Lecturer (2008); Ph.D., Naval Postgraduate School, 2008.

Ying Zhao, Research Professor; Ph.D., Massachusetts Institute of Technology , 1991.

Emeritus Professors

Dan C. Boger, Professor Emeritus, Department of Information Sciences and Professor (1979); Ph.D., University of California at Berkeley, 1979

Daniel R. Dolk, Professor Emeritus (1982); Ph.D., University of Arizona, 1982.

Mark Nissen, Professor (1996); Ph.D., University of Southern California, 1996.

Michael G. Sovereign, Professor Emeritus (1970); Ph.D., Purdue University, 1965.

Brief Overview

The Department of Information Sciences provides in-residence graduate education, as well as a continuum of career-long learning opportunities, in support of defense requirements in the areas of information sciences, systems, and operations. The Department maintains an internationally respected research program in selected areas of information sciences, systems, and operations,

and has the capability of developing research programs in additional areas of information sciences that are required to support graduate education.

Degrees

The Department provides the following degree programs:

Master of Science in Information Technology Management

The degree of Master of Science in Information Technology Management will be awarded at the completion of the appropriate interdisciplinary program in Curriculum 370 that meets the degree requirements outlined in this catalog's Degree-Specific Requirements section. The Master of Science in Information Technology Management requires:

Master of Science in Information Warfare Systems Engineering

The degree of Master of Science in Information Warfare Systems Engineering will be awarded at the completion of a multidisciplinary program in Curricula 595 that meets the degree requirements outlined in this catalog's Degree-Specific Requirements section. The Master of Science in Information Warfare Systems Engineering program has not been reviewed by the Engineering Accreditation Commission of ABET.

Master of Science in Network Operations and Technology

The degree Master of Science in Network Operations and Technology will be awarded at the completion of the multidisciplinary program in Curriculum 386 that meets the requirements outlined in this catalog's Degree Specific Requirements section.

Master of Science in Cyber Systems and Operations

The Master of Science in Cyber Systems and Operations is awarded after the satisfactory completion of a program that meets the requirements outlined in this catalog's Degree Specific Requirements section.

Master of Science in Applied Cyber Operations

The Master of Science in Applied Cyber Operations is awarded after satisfactory completion of a program that meets the requirements outlined in this catalog's Degree Specific Requirements section.

Doctor of Philosophy in Information Sciences

The Department offers the Ph.D. degree in Information Sciences. The program begins with advanced course work guided by the Departmental Ph.D. Committee, which leads to qualifying examinations. The primary emphasis then shifts to the student's research program, culminating in the Ph.D. dissertation. Three areas of primary concentration within the field of information sciences are available: information systems, command and control, and information operations/warfare. Interested potential students may obtain further details by contacting the Information Sciences Ph.D. Program Director, Code IS, 589 Dyer Road, Room 200A, Naval Postgraduate School, Monterey, CA 93943-5100. An applicant to the Ph.D.

program will need to apply to the School Admissions Office formally (see www.nps.edu/Admissions/PhD/index.html), and will need to submit: an application letter describing general background, interests and experience in research, and career goals; official or certified copies of all academic transcripts; results of a GRE general examination taken within the past five years; and three letters of references relating to your suitability to pursue a doctoral degree. Send these materials to the Director of Admissions, 1 University Circle, He-022, Naval Postgraduate School, Monterey, CA 93943. Detailed admission procedures may vary depending on the individual's location and position. However, in all cases, the student must fulfill the general school requirements for the doctoral degree. Residency for this program is one year at the minimum, and the program generally requires three years beyond completion of a master's degree to complete.

Network Operations and Technology-Operations (NWOT-OPS) - Academic Certificate in Network Operations and Technology-Operations - Curriculum 271

This curriculum is closed to new admissions. Previous catalog descriptions of this curriculum are found in the Past Edition Archives at this link: http://www.nps.edu/Academics/Admissions/Registrar/AcademicCatalog

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Network Operations and Technology-Technology (NWOT-TECH) - Academic Certificate in Network Operations and Technology-Technology - Curriculum 272

This curriculum is closed to new admissions. Previous catalog descriptions of this curriculum are found in the Past Edition Archives at this link: http://www.nps.edu/Academics/Admissions/Registrar/AcademicCatalog

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Knowledge Superiority (KS) Academic Certificate in Information Systems and Operations - Curriculum 277

This curriculum is closed to new admissions. Previous catalog descriptions of this curriculum are found in the Past Edition Archives at this link: http://www.nps.edu/Academics/Admissions/Registrar/AcademicCatalog

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Certificate in Applied Cyber Operations - Curriculum 226 (Res)

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Brief Overview

The Applied Cyber Operations certificate is a graduate-level, non-degree program designed to enable DoD and U.S. Government personnel to effectively employ cyber capabilities in an operational context and to prepare students to maintain a high state of readiness for cyber operations in the face of hostile action.

Students will be able to utilize their understanding of cyber capabilities and their employment to achieve or support both cyber and overall mission objectives while accounting for adversary activity and environmental constraints.

The program consists of three courses to be taken over a minimum of a three-quarter period. The total number of NPS graduate credits obtained for the certificate is 13 or 13.5, depending upon the choice of courses. This certificate program may be applicable toward a master's degree program in Curriculum 326.

Requirements for Entry

- A baccalaureate degree is required.
- Recent completion, viz. within the past five years, of courses in computer and network security, computer and communications networks. Students lacking these prerequisites may be acceptable to the program through their undergraduate records and other indicators of success.

Convenes

Fall, Spring

Program Length

Three quarters

Subspecialty

6208L

Required Courses

One of the following electives.

Course	Title	Lecture	Lab
CY3520	Practical Network Operations	3	3
CY3602	Network Operations II	3	2
CS3690	Network Security	4	1
DA3104	Computer Network Attack and Defense	4	1

And both of the following.

CY4700	Defensive Cyberspace Operations	3	3
CY4710	Adversarial Cyberspace Operations	3	2

Cyber Operations Infrastructure - Curriculum 228 (Res)

Program Officer

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Brief Overview

The Cyber Operations Infrastructure certificate is a graduate-level, non-degree program designed to enable

DoD and U.S. Government personnel to differentiate the various components of the infrastructure underpinning cyber operations for its effective use in all aspects of cyber operations.

The objective of the program is to prepare students to deploy cyber-specific assets appropriately within the DoD cyber infrastructure. Students will be able to assess how differing elements of the underlying cyber infrastructures impact cyber operations. Students will learn about the communications systems that support cyber operations and will be able to choose communications modes most suitable for a given cyber mission. They will be able to develop information usage strategies across distributed platforms and will be able to adapt their choices based upon the capabilities of these data-centric systems. They will be able to evaluate the benefits and weaknesses of infrastructure-dependent choices and will be able to integrate these choices in cyber mission planning. Students will be able to develop strategies for cyber operations in contested situations based upon their understanding of the infrastructure.

The program consists of four courses to be taken over a minimum of a four-quarter period in the case of distance learning students. Resident students may be able to complete the certificate in three academic quarters. The total number of NPS graduate credits obtained for the certificate is 15, depending upon the choice of courses. This certificate program may be applicable toward a master's degree program in Curriculum 326.

Requirements for Entry

- A baccalaureate degree is required.
- Recent completion, viz. within the past five years, of courses in computer and network security, computer and communications networks. Students lacking these prerequisites may be acceptable to the program through their undergraduate records and other indicators of success.
- Command or company endorsement
- A TS/SCI clearance is required

Convenes

At the beginning of the Winter or Summer quarters. (January or July)

Program Length

Three quarters (9 months)

Subspecialty

6208L

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR in the certificate program to be awarded a certificate.

Required Core Course

Course	Title	Lecture	Lab
CY4400	Cyber Mission Planning	3	0

And any three of the following:

Course	Title	Lecture	Lab
CY4600	Network Operations in a Contested Environment	3	2
CY3300	Cyber Communications Architectures	4	0
EC3730	Cyber Network and Physical Infrastructures	3	2
CY3650	Foundations in Data Science	3	1
CS3670	Secure Management of Systems	3	2
EC3760	Information Operations Systems	3	2

Cyber Systems and Operations - Curriculum 326

Cyber Systems and Operations (CSO)

Program Officer

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Brief Overview

The CSO program uniquely prepares Officers with the educational background, problem solving, and critical thinking skills to serve in challenging Cyberspace Operations and Cyber Warfare key leadership, operational planning, systems management, and Cyber capability employment positions within the military. The program couples the factors of decision-making, operational warfare context, and technical specialization based in the disciplines of computer science, electrical engineering, and emerging Cyber academic programs. The CSO program includes emphasis on means to support the Information Dominance pillars of Assured Command and Control, Battlespace Awareness, and Integrated Fires. The program directly supports Navy, USMC, and DOD goals of operating the network as a warfighting platform, delivering warfighting effects through cyberspace, creating shared situational awareness, and aiding in maturing of Cyber Mission Forces.

The CSO program requires students to choose one of four available tracks following completion of the first instructional quarter. The systems and operations,

computational, engineering science, and electrical engineering tracks augment a common CSO core that is administered by the Cyber Academic Group and the Computer Science, Information Sciences, and Electrical and Computer Engineering Departments. Each track is managed independently to meet all sponsor-approved educational skill requirements and culminates in the award of a degree appropriate to the track.

Requirements for Entry

This program is open to officers of the U.S. Armed Forces and civilian employees of the U.S. Federal Government. A baccalaureate degree, or the equivalent, with grades resulting in an APC of at least 334, basic computer programming capability, and a general understanding of computer architectures and operating systems is required. A TOP SECRET clearance is required with eligibility for SCI access.

Convenes

January and July.

Program Length

Cyber Systems and Operations is an eight-quarter resident course of study with JPME. If further information is needed, contact the Academic Associate or Program Officer for this program.

Degree

Students completing the CSO core matrix and track shall be eligible for one of the following track-specific degrees:

Systems and Operations Track (administered by the Information Sciences Department)

Master of Science in Cyber Systems and Operations

Computational Track (administered by the Computer Science Department)

Master of Science in Computer Science

Engineering Science Track (administered by the Electrical and Computer Engineering Department)

Master of Science in Electrical Engineering Science (with emphasis in Electrical Engineering)

Electrical Engineering Track (administered by the Electrical and Computer Engineering Department)

Master of Science in Electrical Engineering

Degree Requirements

Degree requirements are available under their host departments' degree descriptions.

Subspecialty

6208P

Typical Course of Study -- Summer Entry

Quarter 1

Course	Title	Lecture	Lab
CS2020	Introduction to Programming	3	2
EC2700	Introduction to Cyber Systems	3	3
MA2025	Bridge to Advanced Mathematics	4	1
MA1113	Single Variable Calculus I	4	0

Quarter 2

CS3600	Introduction to Cybersecurity	4	1
EC3730	Cyber Network and Physical Infrastructures	3	2
CS3040	Low Level Programming	3	2
CY3000	Introduction to Cyber Systems and Operations	3	0
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 3

EC3760	Information Operations Systems	3	2
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
CY4900	Research Topics in Cyber Systems and Operations	1	0

Quarter 4

CS3690	Network Security	4	1
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
CS4903	Research Methods in Computer Science	2	0

Quarter 5

ELECT	CSO Track Requirement		
CS3250	Introduction to Cyber Physical Systems	3	2
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
NW3230	Strategy & War	4	2
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 6

NW3285	Theater Security Decision Making	4	0
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
CY0810	Thesis Research	0	8

CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 7

EC3740	Reverse Engineering in Electronic Systems	3	2
NW3275	Joint Maritime Operations - part 1	4	0
ELECT	CSO Track Requirement		
CY0810	Thesis Research	0	8
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 8

CY4400	Cyber Mission Planning	3	0
NW3276	Joint Maritime Operations - part 2	2	2
ELECT	CSO Track Requirement		
CY0810	Thesis Research	0	8
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Program Major Area Sponsor

DCNO for information Dominance (N2/N6).

Educational Skill Requirements

1. **Cyberspace Operations (CO) Foundations.** Graduates of the CSO program will: have acquired knowledge of Cyber Warfare and Cyberspace Operations concepts and methodologies; demonstrate a proficient application of the technical dimensions of Cyberspace Operations; and be able to analyze, synthesize, and evaluate management, engineering, and operational approaches to solve complex problems within cyber warfare. This foundation must provide graduates who possess the educational skills to:

   - Develop and execute well-formed strategies and plans to effectively operate and maintain ready information and control networks supporting military operations.
   - Develop and execute best practices and methodologies for effective Defensive Cyberspace Operations (DCO) to include assessment of threat vectors and vulnerability assessment, means to mitigate cyber-attacks and exploitation through active defense, and network maneuver methodologies.
   - Build and assess disparate behaviors and indicators within cyberspace to ascertain Cyber Intelligence supporting military operations.
   - Define, identify, and assess Cyber Key Terrain from with supporting System of Systems and associated functional processes.

   - Be able to generate operational risk factors in support of mission assurance and cyber operations.

2. **Technical Foundations.** Graduates will be able to apply critical thinking, fundamental mathematical, computer science, and engineering concepts underpinning Cyberspace Operations in an operational context. In particular, graduates will be able to employ Cyberspace Operations concepts to solve operationally relevant problems. This education will be founded in the following technical areas: computer architecture; operating systems; virtualization; networking, mobile, and wireless technologies; cyber physical systems and industrial control systems; computer and network security; computer programming; reverse engineering and digital forensics; data analytics; probability; statistics; and signals operations.

3. **Military Application.** Officers will be able to analyze cyber requirements within military operations and synthesize and evaluate courses of action that include the use of Cyber capabilities within the full range of military capabilities (kinetic to non-kinetic). These skills will be reinforced through the use of the Joint Operational Planning Process, Joint Targeting Cycle, Joint Doctrine on Cyberspace Operations, and related operational concepts. The officer is to build skills for the effective application of cyber capabilities, effects, and be able to integrate Cyberspace Operations within operational planning and execution processes. In particular, the Officer will be able to develop, compare, and evaluate courses of action incorporating Cyberspace Operations and identify targets and processes against which cyber capabilities can be employed to achieve operational effects in support of operational objectives.

4. **Organizational Construct and Policy Context.** The officer will be able to describe the administrative and operational structures and command relationships of the organizations and commands that operate within the cyberspace domain. The officer must have foundational understanding of the application of DOD / DON policies, related strategies, authorities, and the Law of Armed Conflict in the execution of Cyberspace Operations, Cyber Warfare, and associated capabilities. The officer will be able to illustrate the employment of these organizational relationships and policy, strategy, authorities, and legal context in an operational environment (i.e., Cyberspace Operations implications from U.S. law, National Security Strategy, DOD Cyber strategies, DOD and related policies, Rules of Engagement, etc.)

5. **Comprehension of the Cyberspace Environment.** The officer will understand the characteristics of friendly, neutral, and adversary Cyber environments and likely methodologies for adversary employment of cyber capabilities (e.g., infrastructure, prevalent technologies, policy limitations or deterrence, etc.). The officer will understand the parameters of Cyberspace Situational

Awareness methodologies for attribution, collateral damage effects, and operational risk of Cyberspace Operations. Further, the officer will understand architecture and design principles that underpin cyberspace as well as demonstrate the ability to analyze specific cyber system implementations to identify vulnerabilities and potential attack vectors. The officer must also understand operational implications when the environment shifts from a permissive to a contested environment.

6. **Relationship to other Warfare Areas.** The officer will understand and illustrate the relationships, overlaps, and interdependencies between cyberspace and traditional warfare areas to include air, surface, undersea, amphibious, strike, and expeditionary warfare. Further, the officer will also demonstrate understanding of the relationships and interdependencies between cyberspace and space and Electromagnetic Maneuver Warfare. In particular, the officer will be able to describe alternative approaches to conducting Cyberspace Operations within an Anti-Access/Area Denial scenario.

7. **Independent Research.** The officer will demonstrate the ability to conduct independent research and investigation through the completion of a thesis or capstone project which meets the requirements of the conferred degree. Thesis or capstone work will be conducted in a framework that exercises the practice of innovation, critical thinking, problem solving, and real-world applicability. Where possible, the topic of the thesis or capstone project will support operational focus areas defined by the mission area sponsor. Further, the officer will be able to present research goals and results in both written and oral form.

8. **Joint Professional Military Education (JPME).** Per community requirements, the officer will have an understanding of warfighting within the context of operational art to include strategy and war, theater security decision making, and joint maritime operations. Completing the Naval War College four-course series leading to Intermediate Level Professional Military Education and JPME phase I certification fulfills this requirement.

Program Sponsor and ESR Approval Authority

DCNO for Information Dominance (N2/N6).

Applied Cyber Operations (MACO)

Program Officer

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Brief Overview

The Applied Cyber Operations (ACO) program addresses a range of operational and technical topics in defensive and offensive cyberspace operations. This includes computer network attack, active and passive defense, exploitation, cyber analysis via automated and manual toolsets, operations, policy, and engineering. Complementing the Cyber Systems and Operations program, Applied Cyber Operations covers a focused set of cyber topics suited for the technical enlisted workforce by providing graduates with a rigorous foundation in cyber security necessary for defensive and offensive cyber operations, as well as maintenance operations for the Global Information Grid (GIG). The degree covers the range of cyber topics needed by technicians serving military missions.

Designed to serve Navy enlisted personnel with Cryptologic Technician Networks (CTN) and Information Systems Technician (IT) ratings, as well as the respective enlisted personnel in other military services, the Applied Cyber Operations program is intended to provide a deep understanding of the implementation of national and military application of integrated lines of operation, including operation of the DoD Information Network Operations (DoDINOps), Defensive Cyberspace Operations (DCO), and Offensive Cyberspace Operations (OCO), cyber security fundamentals and the required technical operations underpinning these. Students will learn to seize and sustain an information advantage through all stages of operations, from compliance and early warning through detection, planning, targeting, cyber fires, assessing effects and resetting for follow-on plans and operations.

Site visits, laboratory exercises, seminars, guest speakers, and practical workshops complement traditional instruction. A cyber exercise is integrated into the program. A capstone project allows students to apply concepts introduced, demonstrated and practiced earlier in the program by working and reporting on topics of interest to stakeholders under the supervision of faculty experts. Tight integration with front-line war fighters ensures that capstone research is on target and rapidly integrated.

Requirements for Entry

A baccalaureate degree, or the equivalent, with grades resulting in an APC of at least 344 is required for direct entry. Applicants must possess a Bachelor of Science degree in a technical field, such as Computer Science, Electrical Engineering, Information or Engineering Technology, or a Bachelor's degree accompanied by completion of the following training: A and C Schools for the CTN and IT respectively, namely, Joint Cyber Analysis Course (JCAC) or IT A School and IT System Administrator

C School or equivalent enlisted service schools for USA, USAF, and USMC. A TOP SECRET clearance is required with eligibility for SCI access.

Convenes

Fall and Spring

Program Length

Five Quarters. No JPME. If further information is needed, contact the Academic Associate or Program Officer for this program.

Degree

The Applied Cyber Operations degree is comprised of courses that, in combination, provide a coherent, logical approach to learning applied cyber systems and operations in a complex and rapidly evolving military domain. Of these courses, a subset comprises a specialization track. In addition to course work, each student must complete a capstone project.

The Master of Science in Applied Cyber Operations is awarded after satisfactory completion of a program that meets, as a minimum, the following degree requirements:

1. All required courses must be satisfied through the course of study or through validation prior to graduation.
2. Completion of a minimum of 40 quarter-hours of graduate-level courses.
3. At least 12 quarter-hours of courses must be at the 4000 level.
   a. To ensure a sufficient breadth in operational understanding of the cyber domain, the following course topics must be satisfied as part of the course of study or through validation prior to graduation:
   b. Introduction to Cyber Systems and Operations (CY3000), or Command and Control (CC3000)
   c. Introduction to Computer Security (CS3600),
   d. One of Cyber Network & Physical Infrastructures (EC3730), Reverser Engineering (EC3740), or Information Operations Systems (EC3760),
   e. Applied Defensive Cyber Operations (CY4700) or Adversarial Cyber Operations (CY4710).
4. Completion of a specialization track.
5. Submission of an acceptable capstone project on a subject previously approved by the Information Science Department Chair.

Specialization Tracks

Each student in the Applied Cyber Operations program will choose a specialization track no later than the start of the second quarter of study. The current specializations offered by the Cyber Academic Group are as follows:

Network Operations (NetOps) Specialization

Course	Title	Lecture	Lab
CS3670	Secure Management of Systems	3	2

Course	Title	Lecture	Lab
CS3690	Network Security	4	1

Defense Specialization

Course	Title	Lecture	Lab
CS4677	Computer Forensics	3	2
CS4684	Cyber Security Incident Response and Recovery	3	2

Adversarial Techniques Specialization

Course	Title	Lecture	Lab
CS4648	Software Reverse Engineering and Malware Analysis	3	2
CS4678	Advanced Cyber Vulnerability Assessment	4	1

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
CS3600	Introduction to Cybersecurity	4	1
CS3690	Network Security	4	1
EC2700	Introduction to Cyber Systems	3	3
CS2020	Introduction to Programming	3	2
CS4903	Research Methods in Computer Science	2	0

Quarter 2

Course	Title	Lecture	Lab
CS3040	Low Level Programming	3	2
CY3000	Introduction to Cyber Systems and Operations	3	0
CY4710	Adversarial Cyberspace Operations	3	2
CY4900	Research Topics in Cyber Systems and Operations	1	0
CS4684	Cyber Security Incident Response and Recovery	3	2

Quarter 3

Course	Title	Lecture	Lab
CY4700	Defensive Cyberspace Operations	3	3
CY4410	Cyber Policy and Strategy	3	0
EC3760	Information Operations Systems	3	2
CS4677	Computer Forensics	3	2
CS4679	Advances in Cyber Security Operations	4	1
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 4

Course	Title	Lecture	Lab
CS3140	Low-level Programming II	3	2
EC4765	Cyber Warfare	3	2
CY4410	Cyber Policy and Strategy	3	0
CY0809	Capstone Project	0	8

CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0
Quarter 5			
EC3740	Reverse Engineering in Electronic Systems	3	2
CS4684	Cyber Security Incident Response and Recovery	3	2
IO4300	Planning and Execution of Military Operations in the Information Environment	3	2
CY0809	Capstone Project	0	8
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Information Systems and Technology - Curriculum 370

Information Systems and Technology

Program Officer

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Brief Overview

The Information Systems Technology program is part of the larger Information Sciences, Systems, and Operations (ISSO) discipline. The ISSO curricula consist of the Professional Practice Core and seven degree tracks: Computer Sciences; Joint C4I Systems; Information Systems and Technology; Information Warfare; Intelligence Information Management; Modeling, Virtual Environments, and Simulation; and Space Systems Operations. The Professional Practice Core consists of material in Information Sciences and Technology; Command and Control; C4ISR Systems; Acquisition; C4ISR System Evaluation; Information Operations/Warfare; and Enterprise Policy, Strategy, and Change.

This program provides officers with knowledge of information systems technology to include computer and telecommunications systems, software engineering, networked and distributed applications, database management systems, and decision support systems in the military services. Students will also gain proficiency in information systems, economics, and management

necessary for the critical management decisions needed in the development and utilization of complex and evolving computer-based military systems.

Information Systems Technology is an interdisciplinary, graduate-level, master's program integrating mathematics, accounting, economics, statistics, computer science, information systems, communications engineering, networks, and management disciplines. This program is sponsored by the Headquarters USMC, Director of Command, Control, Communications, and Computers (C4).

Requirements for Entry

A baccalaureate degree, or the equivalent, with above-average grades in mathematics (including differential and integral calculus) resulting in an academic profile code (APC) of at least 325 is required for direct entry. Students lacking these quantitative prerequisites may be acceptable for the program, through a twelve-week refresher, providing their undergraduate records and/or other indicators of success, such as the Graduate Record Examination (GRE) or Graduate Management Admission Test (GMAT), indicate a capability for graduate-level work. While previous computer, communications, or information systems experience is certainly helpful, it is not essential. International students should refer to the Admissions section for current TOEFL and entrance requirements.

Convenes

Summer

Program Length

Information Systems Technology is an eight-quarter course of study. If further information is needed, contact the Academic Associate or Program Officer for this program.

Degree

Requirements for the Master of Science in Information Technology Management degree are met as a milestone en route to satisfying the Educational Skill Requirements established by the curricular program's sponsor.

Master of Science in Information Technology Management

The Master of Science in Information Technology Management degree will be awarded at the completion of the appropriate interdisciplinary program. The Master of Science in Information Technology Management requires:

- Completion or validation of core courses in each of the following disciplines:
  - Information Systems
  - Computer Science
  - Electrical and Computer Engineering
  - Systems Management
- Completion of a minimum of 52 hours of graduate-level courses, at least 20 hours of which are at the 4000

level.
- Completion of an acceptable thesis.
- Approval of the candidate's program by the Chairman, Information Sciences Department.

Subspecialty

Navy none.

U.S. Marine Corps officers completing this program fulfill the requirements for MOS 8848.

Required Courses

The following notional courses are required.

Course	Title	Lecture	Lab
CC3000	Command and Control	4	0
CC4250	Enterprise Architecture	4	0
CS3600	Introduction to Cybersecurity	4	1
EO3502	Telecommunications Systems Technology	4	0
IS3001	Information Sciences for Defense	3	0
IS3200	Enterprise Systems Analysis and Design	3	2
IS3201	Enterprise Database Management Systems	4	2
IS3202	Thin-Client Database Systems Development	4	2
IS3301	Computer-Based Tools for Decision Support	3	2
IS3330	Research Methods for Information Sciences	3	0
IS3333	Thesis Research for Information Sciences	2	0
IS3460	Networked Autonomous and Unmanned Systems	4	0
IS3502	Network Operations I	4	2
IS4031	Economic Evaluation for Enterprise Technology Investments	4	0
IS4182	Enterprise Information Systems Strategy and Policy	4	0
IS4220	Technology Enabled Process Improvement	3	2
IS4300	Project Management for Enterprise Systems	3	2
IS4520	Systems Thinking and Modeling for a complex World	4	0
IW3101	Military Operations in the Information Environment	4	0
MA1010	Algebra and Trigonometry	V	0
MN3154	Financial Management in the Armed Forces	3	0
MN3331	Principles of Acquisition and Program Management	5	1

Course	Title	Lecture	Lab
MN4125	Managing Planned Change in Complex Organizations	4	0
MO1901	Mathematics for ISSO	4	0
NW3230	Strategy & War	4	2
OS3105	Statistics for Technical Management	4	1
SS3011	Space Technology and Applications	3	0
SS3613	Military Satellite Communications	3	0

Each student in the Information Systems and Technology program will choose a specialization track no later than the start of the third quarter of study. Current track specializations offered by the Information Sciences Department are:

Network Management Track

Prerequisites

Course	Title	Lecture	Lab
IS3502	Network Operations I	4	2

Network Track Courses (Choose 3)

Course	Title	Lecture	Lab
CS3690	Network Security	4	1
IS4926	Network Operating Centers	3	2
IS4505	Wireless Networking	3	2

CS3690: w/su

IS4926: w

IS4505: sp

Computer and Information Security Track

Course	Title	Lecture	Lab
CC4250	Enterprise Architecture	4	0

Track Courses (Choose 3)

Course	Title	Lecture	Lab
CS3670	Secure Management of Systems	3	2
CS3695	Network Vulnerability Assessment and Risk Mitigation	3	2
CS3690	Network Security	4	1
CS4677	Computer Forensics	3	2

CS3670, CS4677: f/sp

CS3695: f/sp/su

CS3690: w/s

Information Operations/Information Warfare Track

(Classified: U.S. Only)

Prerequisite

Course	Title	Lecture	Lab
IW3101	Military Operations in the Information Environment	4	0

Track Courses (Choose 3)

Course	Title	Lecture	Lab
IO4300	Planning and Execution of Military Operations in the Information Environment	3	2
IW3921	Non-Kinetic Warfare	3	0
IW4500	Information Warfare Systems Engineering	3	2

IO4300: su

IW3921: sp

IW4500: w

USN Space Cadre

Prerequisite (Already in Matrix)

Course	Title	Lecture	Lab
SS3011	Space Technology and Applications	3	0
SS3613	Military Satellite Communications	3	0

SS3011, SS3613: su/f

Track Courses

Course	Title	Lecture	Lab
PH2514	Introduction to the Space Environment	4	0
PH3052	Physics of Space and Airborne Sensor Systems	4	0

PH2514: f/w

PH3052: f/sp

Acquisition Track

Prerequisite (Already in Matrix)

Course	Title	Lecture	Lab
MN3331	Principles of Acquisition and Program Management	5	1

Track Courses (Choose 3)

Course	Title	Lecture	Lab
MN3307	Enterprise Innovation Design	4	0
MN3309	Software Acquisition Management for Defense Systems	3	2
MN3318	Operational Contract Support & Contingency Contracting	3	0
SE4011	Systems Engineering for Acquisition Managers	3	2

MN3309: w/s

MN3318: f/sp

SE4011: sp

Cyber Systems Track

(Classified: U.S. Only)

Prerequisite (Already in Matrix)

Course	Title	Lecture	Lab
CS3600	Introduction to Cybersecurity	4	1

Course	Title	Lecture	Lab
IS3502	Network Operations I	4	2

Track Courses

Course	Title	Lecture	Lab
CY3110	Internet Protocols	3	1
CY3520	Practical Network Operations	3	3
CY4700	Defensive Cyberspace Operations	3	3
CY4710	Adversarial Cyberspace Operations	3	2

CY3110, CY4700, CY4710: f/sp

CY3520: w/su

There may be other available courses based upon clearance (TS/SCI) and experience.

Students with a strong educational or experience background in information systems or computer science may be eligible to validate certain requirements. Students who have validated certain courses will be required to substitute additional courses into their educational plan. These courses may include additional courses of study within their specialization track or other courses offered within the Information Sciences Department or other related fields of study. The Academic Associate and the Program Officer must approve all changes to the matrix.

Educational Skill Requirements (ESR)
Information Systems Technology Program

Engineering, Management and Problem Solving: The Information Systems and Technology graduate shall have the knowledge, skills, and competencies to engineer information systems afloat and ashore; manage information systems, centers, and commands afloat and ashore; and solve information systems engineering and management problems individually and in teams. These general Educational Skill Requirements are supported by the following topical Educational Skill Requirements.

1. **Space, Information Warfare and Command and Control Professional Practices:** The officer shall possess skills in the ISSO core subject areas of Science and Technology (Information Technology, Communications, Space, and Sensors), Analysis and Evaluation (Statistics, Operations Analysis, and System Evaluation), Operations Information Management and Systems (C2, C4ISR, Information Operations, and Acquisition Management).

2. **Software Development:** The officer must have a thorough knowledge of modern software development to include: an understanding of the software development process; the ability to plan and implement a major programming project and develop the appropriate documentation; the ability to utilize object-oriented techniques in system design; and the ability to use modern software development tools in the construction of modeling, virtual environment, and simulation systems.

3. **Information Systems Technology:** The officer must have a thorough knowledge of information systems

technology to include: computer system components, computer networks, computer and network security, communication systems and networks, software engineering, database management systems, decision support and expert systems.

4. **Information Systems Analysis and Management:** The officer must master the following concepts to effectively manage information system assets: managerial concepts, evaluation of information systems, systems analysis and design, management of information systems, adapting to technological, organizational, and economic changes.

5. **Military Applications:** The officer must be able to combine analytical methods and technical expertise with operational experience for effective military applications to include: DoD decision-making process on information systems, information technology acquisition management, DoD computer and telecommunications, C4ISR, C2W, and military use of commercial telecommunications systems.

6. **Independent Research:** The graduate will demonstrate the ability to conduct independent research analysis, and proficiency in communicating the results in writing and orally by means of a thesis and a command-oriented briefing. The research in information technology and its management will include problem formulation, decision criteria specification, decision modeling, data collection and experimentation, analysis, and evaluation.

Program Sponsor and ESR Approval Authority

HQMC C4. May 2016.

Network Operations and Technology

Program Officer

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Brief Overview

The Network Operations and Technology (NWOT) is an interdisciplinary, graduate-level, master's program integrating the study of military operations, decision making, information networks and systems, and information sciences.

The NWOT program is designed to provide the broad base of knowledge needed to assist in fighting and winning America's wars in today's networked environment. The program consists of a professional practice core of courses and specialization tracks of study in Information Domain Operations and Information Systems Management. The academic core consists of web services, network operations, enterprise strategies and policy, and managing process change. The specialization tracks are designed to provide students and opportunity to explore specific areas of interest to the Navy.

Requirements for Entry

A baccalaureate degree or the equivalent resulting in an academic profile code (APC) of at least 334 is required for direct acceptance into the program. Students not meeting the minimum APC may be considered for admission following review of their past academic performance.

Convenes

Fall (Optional refresher quarter begins in July.)

Program Length

Network Operations and Technology is a seven-quarter (21-month) course of study.

Degree

The Master of Science in Network Operations and Technology degree will be awarded after successful completion of an approved matrix of courses and research under the following guidelines:

- Completion of a minimum of 36 quarter-hours of core graduate course work, of which 12 quarter hours must be at the 4000 level.
- In addition to these 36 hours of core work, students must complete an approved specialization sequence of courses in one of the following areas:
  - Decision Superiority
  - Network Operations
  - Information Systems Management
- Complete an acceptable thesis or research project approved by the Chairman, Information Sciences Department.

Subspecialty

Completion of this program qualifies a Navy officer for the 6209P (proposed) subspecialty.

Core Course of Study

The following courses are core to the NWOT degree and are required for all tracks (JPME Optional):

Course	Title	Lecture	Lab
CS3690	Network Security	4	1
SS3613	Military Satellite Communications	3	0
CC4250	Enterprise Architecture	4	0
IS3001	Information Sciences for Defense	3	0
IS3201	Enterprise Database Management Systems	4	2

Course	Title	Lecture	Lab
IS3301	Computer-Based Tools for Decision Support	3	2
IS3330	Research Methods for Information Sciences	3	0
IS3502	Network Operations I	4	2
IS4182	Enterprise Information Systems Strategy and Policy	4	0
IS4220	Technology Enabled Process Improvement	3	2
IS4505	Wireless Networking	3	2
IS4926	Network Operating Centers	3	2
NW3230	Strategy & War	4	2
NW3275	Joint Maritime Operations - part 1	4	0
NW3276	Joint Maritime Operations - part 2	2	2
NW3285	Theater Security Decision Making	4	0
IS0810	Thesis Research	0	8

IS0810: taken three times

In addition to the core courses students must complete one of two approved curriculum tracks consisting of the following courses (or their equivalent) as appropriate for each track:

Information Domain Ops (IDO):

CS3695	Network Vulnerability Assessment and Risk Mitigation	3	2
CS4684	Cyber Security Incident Response and Recovery	3	2
SS3011	Space Technology and Applications	3	0
IS3210	Information and Knowledge Management Issues in Defense	4	0
IS3450	RF and EW Concepts in Networked Systems	4	0
IS3460	Networked Autonomous and Unmanned Systems	4	0
IS4926	Network Operating Centers	3	2
ISXXXX	NWOT Capstone		
ISCS01	Elective Course Required	V	0

Information Systems Management (ISM):

CC4250	Enterprise Architecture	4	0
CS3030	Fundamentals of Computer Architecture and Operating Systems	4	0
IS3200	Enterprise Systems Analysis and Design	3	2
IS3202	Thin-Client Database Systems Development	4	2

IS4031	Economic Evaluation for Enterprise Technology Investments	4	0
IS4300	Project Management for Enterprise Systems	3	2
MN3331	Principles of Acquisition and Program Management	5	1
MN3154	Financial Management in the Armed Forces	3	0
MN3309	Software Acquisition Management for Defense Systems	3	2
SE3100	Fundamentals of Systems Engineering	3	2
ISCS01	Elective Course Required	V	0

Educational Skill Requirements (ESR)
Network Operations and Technology Program
Subspecialty Code: 6209P - (Proposed)

1. Graduates will be able to identify and describe theories and concepts associated with data, information, information systems and networks (human and technological). They will demonstrate the ability to apply theories and technology associated with the physical information and cognitive domains to enhance and improve military operations and decision-making processes. Graduates will possess domain specific knowledge in Network Operations and the theories and technologies that enable networked military operations.

2. The following common core knowledge areas will be common to all officers earning the 6209 subspecialty code:
   • Computing and networking theory and applications to include cloud computing concepts, "Big Data" management and applications, RF-based and mobile telecommunications;
   • Cybersecurity and Information Assurance (IA) theory, applications, and emerging capabilities;
   • Network, enterprise, systems, and software architecture, policy, security, and life-cycle management theory and applications;
   • Information theory and data-centric implications in the military environment to include a survey of Information Management, and Data Science concepts and approaches;
   • Analytical Decision Making and Process Change Management.

3. Graduates will possess the skills to be able to
   • Compare and evaluate existing, emerging and innovative technological and theoretical approaches to military operations in terms of how information is acquired, processed, stored, transmitted, managed, protected, organized, displayed, and ultimately used. This includes understanding the application of these areas as they apply to concepts

of observation, orientation, decisions and ultimately actions in the battlespace.

- Evaluate and critique existing information policies, procedures and doctrine affecting military operations, and propose alternatives to seize and maintain information advantage. This includes security policies and those impacting the authenticity, availability, confidentiality, integrity, and non-repudiation of information.
- Optimize information warfare system configurations to align with changes in the operational environment and understand the critical nature of information in military planning and operations. This includes concepts associated with cloud computing, big data, emerging media, and various transmission capabilities.
- Develop and manage the implementation of Information Assurance and computer security policies appropriate for the operational environment and current regulations.
- Conduct independent research. Students will demonstrate their ability to incorporate concepts learned in the Common Core and their Specialized Track by completing either a group research project or individual thesis. The group research project (i.e., practicum) or individual thesis research will be conducted in an area relevant to current Navy priorities and strategy. In addition to completing a written project report or individual thesis, each student will demonstrate knowledge and skills through an oral presentation of their research.

4. Specialized Tracks: Each graduate will complete courses related to one of two specialized areas of interest to Network Operations and Technology: Information Dominance Operations and Information Systems Management.

Track 1: Information Domain Operations (IDO): This track focuses on developing skills needed to assure effective maritime command and control, battlespace awareness and integrated fires across the full spectrum of maritime warfare. Emphasis will be on the mastery of data, information, knowledge and insights into creating an information environment conducive to generating high quality decisions. This will include knowledge of RF spectrum utilization in all military environments and phases of operation; unmanned, autonomous and unattended sensors and platforms; and industrial control systems. This track includes a capstone course designed to integrate concepts of information warfare. Graduates of the IDO track will be able to relate existing concepts of operational art, information theories and information systems technologies to current and emerging military problem sets. To this end, graduates will demonstrate the ability to:

1. Identify elements of Assured C2 and identify means to achieving Assured C2 throughout the Navy. This includes an understanding of the constituent components (e.g., resources, requirements, capabilities, governance, tactics, techniques and procedures) that must be marshaled and aligned with doctrine, organizational structure, training, material, logistics, personnel and facilities to achieve optimal effect.

2. Optimize information/C2 systems configurations to align with emergent and anticipated changes in the operational environment to support decision maker needs including satellite and space communications systems, Positioning, Navigation and Timing (PNT), and space-based sensing capabilities and applications.

3. Identify resilient C2 configuration plans to cope with natural and human-induced changes in communication channel capacity and the information environment in general. These changes include but are not limited to anti-access/area denial situations, emission control and Electromagnetic Maneuver Warfare (EMW) requirements, satellite loss and/or degradation, intruded, degraded or compromised networks (to include – Denied Disconnected, Intermittent and Limited (D-DIL) bandwidth environments), varied terrestrial, celestial and meteorological environments.

4. Evaluate ship, shore, airborne, expeditionary, National information warfare capabilities (to include DoD Information Networks (DODIN)), Radio Frequency (RF) theory, and electromagnetic spectrum usage and protection.

5. Assess emerging Information Technology capabilities to include a survey of advanced sensing, computer vision, robotics, autonomous systems, industrial and control systems networks, and machine learning.

Track 2: Information Systems Management (ISM): This track focuses on the systems engineering, acquisition and program management of Information Technology (IT) in support of sustainment to global and collaborative military operations while accounting for concepts and technologies used to achieve confidentiality, integrity, and authenticity for information processed across networks. Students will examine modern industry trends, human factors, methods/policies, enterprise investment strategies, information security and risk management considerations, system analysis, analytics, and design as they apply to information systems. Graduates will understand how to develop appropriate technical and acquisition plans and policies, perform financial, cost-benefit and trade-off analyses, and execute required lifecycle planning, programming, and budgeting actions for an IT enterprise that supports National Security Strategy. To this end, graduates will demonstrate the ability to:

1. Plan and manage an information technology project/program including required planning, programming and budgeting actions. Understand how to exploit technology advantages in a network-centric

environment to achieve operational objectives.

2. Effectively manage information system assets through a thorough understanding of systems engineering, managerial concepts, evaluation techniques, systems analysis and design, which involves adapting to technological, organizational, and economic changes.

Program Sponsor and ESR Approval Authority

Deputy Chief of Naval Operations for Information Dominance/Director of Naval Intelligence OPNAV (N2/N6). May 2017.

Information Sciences PhD - Curriculum 473/474 (DL and Res)

Program Manager

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Brief Overview

The Department of Information Sciences at the Naval Postgraduate School will award the Doctor of Philosophy in Information Sciences degree as a result of meritorious and scholarly achievement in a particular field of information sciences (IS). This program includes course work, scholarly socialization, written and oral examinations, research, and a written dissertation. A candidate must exhibit scholarly application to the entire course of study, achieve a high level of scientific advancement, and establish ability for original investigation leading to the advancement of fundamental knowledge.

IS broadly encompasses the design, implementation, use, promotion and evaluation of organizations, processes and systems associated with knowledge, information, data and communication. It includes areas of concentration in information systems, information technology, information warfare, information operations, and command and control.

The study of IS is multidisciplinary, and no single theory or perspective dominates the field. In general, the field can be divided into technical and behavioral approaches. The technical approach to IS emphasizes mathematically based, normative models to study capabilities of systems and processes, in addition to emphasis on the technological artifacts that enable and support organizations, processes and systems associated with knowledge, information, data and communication. The behavioral approach to IS emphasizes behavioral problems associated with design, implementation, use, promotion and evaluation of organizations, processes and systems associated with knowledge, information, data and communication. A great part of IS research involves integrating these two, complementary approaches.

The Ph.D. in Information Sciences prepares scholars to conduct original research that contributes new knowledge in the domain of information systems, information technology, information warfare, information operations, or command and control. With such ability to conduct original research and contribute new knowledge, the IS Ph.D. helps to prepare scholars also to teach effectively.

Requirements for Entry

U.S. military officers, foreign military officers, U.S. Government civilians, and employees of foreign governments may apply. Applications should begin with the Office of Admissions (see www.nps.edu/admissions/index.html). In addition to a completed application form, the complete application should include: an application letter describing your general background, your interests and experience in research, and your career goals; Official or Certified copies of all academic transcripts; results of a GRE general examination taken within the past five years; and letters from three references relating to your suitability to pursue a doctoral degree. These materials should be sent directly to the Admissions Office. Foreign students who are not native speakers of English must provide scores from the Test of English as a Foreign Language (TOEFL) examination.

An applicant should have a master's degree in any Information Sciences Department program or in a closely related field from another NPS school or civilian institution. Generally, an acceptable Ph.D. applicant must have above-average grades (GPA > 3.5) in a typical master's degree program. The Ph.D. Committee will also take other evidence of research or academic ability into account in making a recommendation as to whether to admit an applicant. Final acceptance will be based on the professional discretion of the Chairman, Ph.D. Committee.

Convenes

The Ph.D. Program Committee will evaluate each applicant to gauge the minimum amount of time the applicant will need to complete the program (normal time is three years of full-time study). The Information Sciences Department may impose the condition that the applicant obtain authorization for at least four years to complete the Ph.D. Admitted Ph.D. students may begin in any quarter.

Program of Study

Each student's Doctoral Committee will guide the student in designing a program suitable for his/her special interests and background, alert them to opportunities both within the Department of Information Sciences and other departments at NPS, and monitor the student's progress.

The doctoral program is based on a core of courses designed to provide the student with the broad knowledge, analytic skills, and proficiency in research methods necessary for advanced course work and dissertation research. Additional course work in application areas may be required and is based on the discretion of the student's primary advisor.

Core Courses

Course	Title	Lecture	Lab
IS4700	Introduction to the Philosophy of Science	3	2
IS4710	Qualitative Methods for Research	3	2
IS4720	Quantitative Methods for Research	3	2
IS4730	Design of Experiments for Research	3	2
IS4790	Research Seminar for Ph.D. Students	0	3

Students who have taken the equivalent of these courses may waive one or more of these core requirements by the Departmental Ph.D. Committee.

Sample Ph.D. Program in Information Sciences

First Year: Complete the core program course and residency requirements for the Ph.D. program. Complete additional course work in accordance with the student's specific program requirements. Have a faculty advisor for course work appointed.

A diagnostic review will be conducted following the first year of study. The review will consider indicators of scholastic achievement, including performance in master's- and Ph.D.-level courses, as well as other indicators deemed appropriate by the examining faculty. The review culminates in a formal report to the Chairman of the Departmental Ph.D. Committee; includes a recommendation as to whether or not the student should continue in the program; and, if so, makes recommendations regarding how the student can improve his or her performance. A professor from the student's chosen academic unit then discusses the report with the individual, making a careful assessment of demonstrated strengths and weaknesses in order to help the student to progress more effectively.

Second Year: Finish course requirements, and prepare for the Written and Oral Qualifying Examinations. Take Qualifying Examinations, in residence, near the middle of the second year. Upon successful completion of both examinations, the student will establish a Dissertation Committee, defend a dissertation proposal, and then advance to candidacy. Students who fail either of the qualifying examinations can petition the Departmental Ph.D. Committee Chair for one additional attempt at passing it.

Third Year: Concentrate primarily on dissertation research, with perhaps a course or two related to the dissertation.

The dissertation culminates the student's academic endeavors. Working closely with faculty members from his or her committee during all phases of research, the student is expected to complete a dissertation of substantial magnitude, and to make a significant contribution to the advancement of knowledge in the Information Sciences field. It should be of sufficient originality and quality to merit publication, either in whole or in part, in a scholarly journal.

The dissertation is defended, in residence, at a final oral examination. It must be completed and accepted within five years of advancement to candidacy. The dissertation defense is held before an examination committee, and is open to the public. The defense will normally consist of a one-hour public segment and a one-hour private segment, but should, in no case, exceed two hours in length.

The pursuit of the Ph.D. is both challenging and rewarding. A Ph.D. is not a more in-depth version of the Master's Degree. It requires high-level, integrative, critical thinking; extended, independent research; self-motivated effort; and a commitment to expand one's perspective of the world. It is difficult to assess one's likelihood of success based on previous academic or professional performance. Applicants should be aware that admission to the program does not guarantee completion. It is anticipated that a number of candidates will not be allowed to continue after the diagnostic review (approximately one year), and that a number of candidates will self-select out of the program throughout its various stages. Applicants should seriously consider the effort that will be required for successful completion prior to applying.

Information Warfare - Curriculum 595

Program Officer

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Brief Overview

Graduates of this curriculum are thoroughly knowledgeable in Information Operations (IO) and Information Warfare (IW). They receive a Master of Science in Information Warfare Systems Engineering (MSIWSE) degree that provides the services with officers who are well versed in the technical, theoretical, and operational aspects of interdisciplinary IO/IW as they relate to joint mission objectives in modern warfare. This curriculum is sponsored by the Headquarters USMC, Director of Strategy and Plans.

Requirements for Entry

A baccalaureate degree with above-average grades with courses in science and mathematics (through integral calculus) is required for entry. Additionally, applicants must have a minimum academic profile code (APC) of 324. Eligibility for TOP SECRET security clearance with access to SPECIAL COMPARTMENTED INFORMATION (SCI) is required for U.S. students. Applicants not meeting the mathematics requirements may be considered for entry via a refresher quarter.

Convenes

Spring

Program Length

The Information Warfare curriculum is an eight-quarter course of study. For further information, contact the Program Officer or Academic Associate for this curriculum.

Degree

Requirements for the MSIWSE degree are met en route to satisfying the Educational Skill Requirements of the curricular program.

Master of Science in Information Warfare Systems Engineering

The MSIWSE degree will be awarded at the completion of a multidisciplinary program in Curricula 595. The MSIWSE degree program has not been reviewed by the Engineering Accreditation Commission, ABET. The MSIWSE requires:

• Completion of a minimum of 45 quarter-hours of graduate-level work, of which at least 15 hours must represent courses at the 4000 level, and in two (or more) discrete disciplines.

• Graduate courses in at least four discrete academic specialization sequences, minimum, and in two disciplines, a course at the 4000 level must be included.

• One Systems Engineering class.

• In addition to the 45 graduate hours of course work, an acceptable thesis must be completed.

• The candidate's program must be approved by the Chairman, Information Sciences Department.

Subspecialty

Navy none.

U.S. Marine Corps officers completing this curriculum fulfill the requirements for MOS 8834, Technical IO.

Courses

ISWE is an interdisciplinary program drawing from nine NPS departments to ensure graduates receive a broad and deep education in all aspects of information's impact on the operational environment.

Information Sciences

Course	Title	Lecture	Lab
IW3101	Military Operations in the Information Environment	4	0
IW3921	Non-Kinetic Warfare	3	0
IW4500	Information Warfare Systems Engineering	3	2
IW4960	Advanced Information Warfare Systems	3	2
IO4300	Planning and Execution of Military Operations in the Information Environment	3	2
CY3000	Introduction to Cyber Systems and Operations	3	0
CY4400	Cyber Mission Planning	3	0
CY4710	Adversarial Cyberspace Operations	3	2

Computer Science

Course	Title	Lecture	Lab
CS2020	Introduction to Programming	3	2
CS3030	Fundamentals of Computer Architecture and Operating Systems	4	0
CS3600	Introduction to Cybersecurity	4	1
CS3690	Network Security	4	1

Applied Mathematics

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0

Space Systems

Course	Title	Lecture	Lab
SS3001	Military Applications of National Space Systems	4	1
SS3011	Space Technology and Applications	3	0
SS3400	Orbital Mechanics, Launch and Space Operations	4	2
SS3613	Military Satellite Communications	3	0

Defense Analysis

DA3102	Psychological Warfare and Deception	4	0
DA4302	Coping with Wicked Problems	4	0

Electrical and Computer Engineering

EO3602	Electromagnetic Waves, Transmission Lines, and Antennas	4	2
EO4612	Microwave Devices, Propagation, and Radar Systems	4	2

Mechanical and Aerospace Engineering

AE4860	Space Control	2	2

Operations Research

OS3105	Statistics for Technical Management	4	1

Educational Skill Requirements (ESR)
Information Warfare - Curriculum 595
Sciences, Technology, and Business Processes (Knowledge, Comprehension, and Application):

1. Identify, describe, and apply concepts, theories, and practices in mathematics; physics; statistics; engineering; systems engineering; systems analysis, design and testing; and operations research that apply to information operations systems and processes.

2. Describe, explain and apply DoD acquisition regulations and processes as they apply to information operations related systems.

Information Operations (Knowledge, Comprehension and Application):

1. Identify, describe, explain and apply concepts, theories and practices associated with the employment of information operations assets and methods across the range of military operations.

Information Operations (Analysis, Synthesis and Evaluation)

1. Compare existing strategies, objectives and technologies with emerging concepts in these areas. They will be able to identify and compare the advantages, disadvantages and risks associated with each area. The graduate will be able to defend their assessment in terms of operational advantage, financial risk and technological feasibility. This skill area shall provide for subject-area track options in:
   a. Public Policy
   b. SIGINT/EW
   c. CNO/Cyberspace Operations and
   d. Operations and Planning.

Planning and Execution (Application and Analysis):

1. Relate existing information operations technologies and theories to current and emerging military problem sets across the range of military operations (ROMO).

These theories and technologies include, but are not limited to, those associated with electronic warfare, computer network operations, networks and cyberspace operations, decision making/command and control (C2), psychological operations/military information support operations, deception and influence operations.

Strategy and Policy (Synthesize and Evaluate):

1. Evaluate and critique existing policies, procedures and doctrine affecting information operations and propose alternatives to overcome identified shortcomings.

2. Graduates will support these proposals by identifying their impact across the range of military operations (ROMO).

Problem Solving and Real World Applicability (Application, Analysis, Synthesis and Evaluation):

1. Incorporate concepts learned in each of the aforementioned skill requirements by designing, developing and executing a research project resulting in the writing of a comprehensive master's thesis.

Department of Mechanical and Aerospace Engineering

www.nps.edu/MAE

Chair

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Christopher A. Adams, Senior Lecturer (2008); M.S., Naval Postgraduate School, 1996.

Brij N. Agrawal, Distinguished Professor (1989); Ph.D., Syracuse University, 1970.

Caleb MacDonald, CDR, USN Program Officer (2022), M.S., Naval Postgraduate School, 2014.

Erick Alley, Research Associate Professor (2018).

Troy Ansell, Research Assistant Professor (2019); Ph.D., Oregon State, 2015.

Christopher M. Brophy, Associate Professor (1998); Ph.D., University of Alabama-Huntsville, 1997.

Jarema M. Didoszak, Assistant Professor (2004); Ph.D., Naval Postgraduate School, 2019.

Vladimir N. Dobrokhodov, Research Associate Professor (2001); Ph.D., Zhukovskiy Air Force Engineering Academy, Russia, 1999.

Anthony J. Gannon, Research Assistant Professor (2006); Ph.D., University of Stellenbosch, 2002.

Ibrahim (Emre) Gunduz, Associate Professor (2018); Ph.D., Northeastern University, 2006.

Joshua H. Gordis, Associate Professor (1992); Ph.D., Rensselaer Polytechnic Institute, 1990.

Garth V. Hobson, Professor (1990); Ph.D., Pennsylvania State University, 1990.

Douglas P. Horner, Research Associate Professor (2005); Ph.D., Naval Postgraduate School, 2013.

Jennifer Hudson, Research Associate Professor (2020); Ph.D., University of Michigan, 2010.

Kevin D. Jones, Research Associate Professor (1997); Ph.D., University of Colorado, 1993.

Isaac I. Kaminer, Professor (1992); Ph.D., University of Michigan, 1992.

Mark Karpenko, Research Assistant Professor (2012); Ph.D., University of Manitoba, Canada, 2009.

Jae Jun Kim, Research Assistant Professor (2007); Seoul National University, 2004.

Young W. Kwon, Distinguished Professor (1990); Ph.D., Rice University, 1985.

Marcello Romano, Professor (2004); Ph.D., Politecnico di Milano, Italy, 2001.

I. Michael Ross, Distinguished Professor (1990); Ph.D., Pennsylvania State University, 1990.

Douglas L. Seivwright, Research Associate (2005), M.S. Naval Postgraduate School, 1996.

Walter Smith, Research Associate Professor (2019), Ph.D., Rensselaer Polytechnic Institute, 2016.

Oleg A. Yakimenko, Professor (1989); Ph.D., Russian Academy of Sciences, 1991.

Professors Emeriti:

Robert E. Ball, Distinguished Professor Emeritus (1967); Ph.D., Northwestern University, 1962.

Oscar Biblarz, Professor Emeritus (1968); Ph.D., Stanford University, 1968.

Charles N. Calvano, Professor Emeritus (1991); ED, Massachusetts Institute of Technology, 1970.

Muguru S. Chandrasekhara, Research Professor (1987); Ph.D., University if Iowa, 1983.

Morris R. Driels, Professor (1989); Ph.D., City University of London, 1973.

Allen E. Fuhs, Distinguished Professor Emeritus (1966); Ph.D., California Institute of Technology, 1958.

Anthony J. Healey, Distinguished Professor Emeritus (1986); Ph.D., Sheffield University, United Kingdom, 1966.

Matthew D. Kelleher, Professor Emeritus(1967); Ph.D., University of Notre Dame, 1966.

Claudia C. Luhrs, Associate Professor and Associate Chair for Operations (2011); Ph.D., Autonomous University of Barcelona (UAB-ICMAB), 1997

Paul J. Marto, Distinguished Professor Emeritus (1965); Sc.D., Massachusetts Institute of Technology, 1965.

Terry R. McNelley, Distinguished Professor Emeritus (1976); Ph.D., Stanford University, 1973.

Knox T. Millsaps, Professor Emeritus (1992); Ph.D., Massachusetts Institute of Technology, 1991.

David W. Netzer, Distinguished Professor Emeritus (1968); Ph.D., Purdue University, 1968.

Maximilian F. Platzer, Distinguished Professor Emeritus (1970); Dr. Tech. Science; Technical University of Vienna, Austria, 1964.

Young S. Shin, Distinguished Professor Emeritus (1981); Ph.D., Case Western Reserve University, 1971.

* The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

Brief Overview

The Department of Mechanical and Aerospace Engineering (MAE) provides a strong academic program which spans the engineering disciplines of thermal-fluid sciences, structural and computational mechanics, dynamic systems, guidance and control, autonomous systems, materials science and engineering, propulsion, and systems engineering, including total ship systems engineering, spacecraft, and missile design. These disciplines are blended together with a strong emphasis on Naval engineering applications required by surface vessels, submarines, aircraft, rotorcraft and spacecraft. Furthermore, the Department provides advanced education in classified topics in Astronautical Engineering. Programs leading to the degrees of Master of Science in Mechanical Engineering and Master of Science in Astronautical Engineering are accredited by the Engineering Accreditation Commission of ABET. A specific curriculum must be consistent with the general minimum requirements for the degree as determined by the Academic Council. Any program leading to a degree must be approved by the Department Chair at least two quarters before completion. In general, approved programs will require more than the stated minimum degree requirements in order to conform to the needs and objectives of the United States Navy, and satisfy the applicable subspecialty-code requirements.

Program Educational Objectives

Mechanical Engineering

The overall Program Educational Objective of the Mechanical Engineering Program is to support the NPS Mission by producing graduates who have knowledge and technical competence at the advanced level in Mechanical

Engineering in support of national security. In order to achieve this goal, the specific objectives are to produce graduates who are expected to achieve the following within a few years of graduation:

1. Have become technical experts who are able to formulate and solve important engineering problems associated with national security in Mechanical Engineering and related disciplines using the techniques, skills and tools of modern practice, including experiments, and modeling and simulation. These problems may include issues of research, design, development, procurement, operation, maintenance or disposal of engineering components and systems for military applications.

2. Have assumed positions of leadership in the specification of military requirements in the organization and performance of research, design, testing, procurement and operation of technically advanced, militarily effective systems. The graduate must be able to interact with personnel from other services, industry, laboratories and academic institutions, and be able to understand the role that engineering and technology have in military operations, and in the broader national and global environment.

3. Can communicate advanced technical information effectively in both oral and written form.

Astronautical Engineering

The overall Program Educational Objective of the NPS Astronautical Engineering Program is to support the NPS Mission by producing graduates who have knowledge and technical competence in astronautical engineering at the advanced level and who can apply that knowledge and competence to fill technical leadership roles in support of national security. In order to achieve this goal, the specific objectives are to produce graduates who achieve the following within a few years of graduation:

1. Are established as a valued source of technical expertise in research, design, development, acquisition, integration and testing of national security space (NSS) systems including formulation of operational requirements, plans, policies, architectures, and operational concepts for the development of space systems.

2. Have assumed positions of leadership involving program management, systems engineering, and/or operational employment of space systems within the national security space (NSS) enterprise.

3. Have effectively managed the operation, tasking, and employment of national security space (NSS) systems to increase the combat effectiveness of the Naval Services, other Armed Forces of the U.S. and our partners, to enhance national security.

Degrees

The following degrees are available. Consistent with NPS Academic Policy, with the exception of the Engineer's or

Doctoral degrees, all degree requirements must be satisfied independently. A student is able to earn an academic degree listed below while enrolled in Naval Mechanical Engineering (Curriculum 570), Reactors/Mechanical Engineering DL (Curriculum 571), Nuclear Power School/Mechanical Engineering DL (Curriculum 572), Space Systems Engineering (Curriculum 566), Aerospace Engineering DL (Curriculum 608), Aerospace Engineering (Curriculum 609), U.S. Naval Test Pilot School/Mechanical and Aerospace Engineering Program (Curriculum 613).

Master of Science in Mechanical Engineering

A candidate shall have completed academic work equivalent to the requirements of this department for the Bachelor of Science degree in Mechanical Engineering or closely related field. Candidates who have not majored in engineering, or who have experienced significant lapses in continuity with previous academic work, will initially take undergraduate courses in mechanical engineering and mathematics to fulfill these requirements in preparation for their graduate program.

The Master of Science degree in Mechanical Engineering requires:

1. A minimum of 48 quarter-hours of graduate level work.

2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:

   a. There must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a mini-mum of 12 quarter-hours at the 4000 level.

   b. Of the 32 quarter-hours at least 24 quarter-hours must be in courses offered by the MAE Department.

3. The candidate must demonstrate competence at the advanced level in at least one of the available disciplines of Mechanical Engineering. These disciplines are the thermal-fluid sciences; solid mechanics, shock and vibration; dynamic systems and control; system design; and materials science. This is accomplished by completing at least eight quarter-hours of the 4000 level credits by courses within one discipline, and a thesis in the same discipline.

4. An acceptable, individually-authored thesis for a minimum of 16 credits is also required for the Master of Science degree in Mechanical Engineering. An acceptable thesis for the degree of Mechanical Engineer may also meet the thesis requirement of the Master of Science in Mechanical Engineering degree.

5. The student's thesis advisor, the Academic Associate, the Program Officer and the Department Chairman must approve the study program and the thesis topic.

Under special circumstances as approved by the Academic Associate, the Program Officer, and the Department Chair, students may take four additional courses in lieu of a thesis. Those four additional courses should be at least 3000 and 4000 level courses. The technical courses should

be related to mechanical engineering. At least two courses should be at the 4000 level.

Master of Science in Astronautical Engineering

The Master of Science degree in Astronautical Engineering requires:

1. A minimum of 48 quarter-hours of graduate level work.
2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:
   a. There must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.
   b. Of the 32 quarter-hours, at least 24 quarter-hours must be in courses offered by the MAE Department.
3. A student must demonstrate knowledge of orbital mechanics, attitude determination, guidance and control, telecommunications, space structures, spacecraft rocket propulsion, space power, spacecraft thermal control, and spacecraft design and testing.
4. The student must also demonstrate competence at the advanced level in one of the above disciplines of Astronautical Engineering. This may be accomplished by completing at least eight quarter-hours of the 4000 level credits by courses in this Department in a particular area and a thesis in the same discipline area. The typical specialization track is in Structures, Dynamics, and Control, and requires two (2) non-design AE48XX courses.
5. An acceptable, individually-authored thesis for a minimum of 16 credits is also required. The student's thesis advisor, the Academic Associate, the Program Officer, and the Department Chairman must approve the study program and the Thesis Proposal.

Under special circumstances as approved by the Academic Associate, the Program Officer, and the Department Chair, students may take four additional courses in lieu of a thesis. Those four additional courses should be at least 3000 and 4000 level courses. The technical courses should be related to astronautical engineering. At least two courses should be at the 4000 level.

Master of Science in Engineering Science (Mechanical Engineering)

Candidates with acceptable academic background may enter a program leading to the degree of Master of Science in Engineering Science (Mechanical Engineering). Candidates who have not majored in engineering or closely related subject areas, or who have experienced significant lapses in continuity with previous academic work, will initially take undergraduate courses in mechanical engineering and mathematics to prepare for their graduate program.

The Master of Science in Engineering Science (Mechanical Engineering) degree requires:

1. A minimum of 48 quarter-hours of graduate level work.

2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:
   a. There must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.
   b. Of the 32 quarter-hours, at least 24 quarter-hours must be in courses offered by the MAE Department.
3. The candidate must demonstrate competence at the advanced level in at least one of the available disciplines of Mechanical Engineering. These disciplines are the thermal-fluid sciences; solid mechanics, shock and vibration; dynamic systems and control; system design; and materials science. This is accomplished by completing at least eight quarter-hours of the 4000 level credits by courses within one discipline, and a thesis in this same discipline.
4. An acceptable, individually-authored thesis for a minimum of 16 credits is also required for the Master of Science in Engineering Science (Mechanical Engineering) degree.
5. The student's thesis advisor, the Academic Associate, the Program Officer, and the Department Chairman must approve the study program and the thesis topic.

Under special circumstances as approved by the Academic Associate, the Program Officer, and the Department Chair, students may take four additional courses in lieu of a thesis. Those four additional courses should be at least 3000 and 4000 level courses. The technical courses should be related to mechanical engineering. At least two courses should be at the 4000 level.

Entrance into the 571 Reactors/Mechanical Engineering Curriculum Program, leading to the degree Master of Science in Engineering Science (Mechanical Engineering), is restricted to individuals who have successfully completed the Bettis Reactor Engineering School (BRES) and who have an academic profile code (APC) of 121 or better. All entrants must be nominated for the program by the designated program coordinator and primary consultant for Naval Reactors (SEA-08). See Curriculum 571 for details.

Entrance into the 572 Nuclear Power School/Mechanical Engineering Curriculum Program is restricted to graduates of the Officers Course of Naval Nuclear Power School and having an APC of (323), and undergraduate engineering degree or equivalent, and being nominated by their command. See Curriculum 572 for details.

Master of Science in Engineering Science (Astronautical Engineering)

Candidates with acceptable academic background may enter a program leading to the degree of Master of Science in Engineering Science (Astronautical Engineering). Candidates who have not majored in astronautical engineering or closely related subject areas, or who have experienced significant lapses in continuity

with previous academic work, will initially take undergraduate courses in astronautical engineering and mathematics to prepare for their graduate program.

The Master of Science in Engineering Science (Astronautical Engineering) degree requires:

1. A minimum of 48 quarter-hours of graduate level work.
2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:
   a. there must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.
   b. Of the 32 quarter-hours, at least 24 quarter-hours must be in courses offered by the MAE Department.
3. A student must demonstrate knowledge of orbital mechanics, attitude determination, guidance and control, telecommunications, space structures, spacecraft/rocket propulsion, space power, spacecraft thermal control, and spacecraft design and testing.
4. The student must also demonstrate competence at the advanced level in one of the above disciplines of Astronautical Engineering. This may be accomplished by completing at least eight quarter-hours of the 4000 level credits by courses in this department and a thesis in the same discipline area. The typical specialization track is in Structures, Dynamics, and Control, and requires two (2) non-design AE48XX courses.
5. An acceptable, individually-authored thesis for a minimum of 16 credits is also required. The student's thesis advisor, the Academic Associate, the Program Officer, and the Department Chairman must approve the study program and the Thesis Proposal.

Under special circumstances as approved by the Academic Associate, the Program Officer, and the Department Chair, students may take four additional courses in lieu of a thesis. Those four additional courses should be at least 3000 and 4000 level courses. The technical courses should be related to astronautical engineering.   At least two courses should be at the 4000 level.

Master of Science in Aerospace Engineering

A candidate shall have completed academic work equivalent to the requirements of this department for the Bachelor of Science degree in Aerospace Engineering or a closely related field. Candidates who have not majored in engineering, or who have experienced significant lapses in continuity with previous academic work, will initially take undergraduate courses in mechanical engineering and mathematics to fulfill these requirements in preparation for their graduate program.

The Master of Science in Aerospace Engineering requires:

1. A minimum of 48 quarter-hours of graduate level work.
2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:

a. There must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.
   b. Of the 32 quarter-hours, at least 24 quarter-hours must be in courses offered by the MAE Department.
3. A student must demonstrate knowledge of aerodynamics, aircraft stability and control, avionics, aircraft structures, aircraft and missile propulsion.
4. The student must also demonstrate competence at the advanced level in one of the above disciplines of Aeronautical Engineering. This may be accomplished by completing at least eight quarter-hours of the 4000 level credits by courses in this department and a thesis in the same discipline area. The typical specialization track is in Aircraft Structures, Aerodynamics, Stability and Control, Avionics or Propulsion.
5. An acceptable, individually-authored thesis for a minimum of 16 credits is also required. The student's thesis advisor, the Academic Associate, the Program Officer, and the Department Chairman must approve the study program and the Thesis Proposal.

Under special circumstances as approved by the Academic Associate, the Program Officer, and the Department Chair, students may take four additional courses in lieu of a thesis. Those four additional courses should be at least 3000 and 4000 level courses. The technical courses should be related to aerospace engineering.   At least two courses should be at the 4000 level.

Master of Science in Engineering Science (Aerospace Engineering)

Candidates with acceptable academic background may enter a program leading to the degree of Master of Science in Engineering Science (Aerospace Engineering). Candidates who have not majored in aeronautical/aerospace engineering or closely related subject areas, or who have experienced significant lapses in continuity with previous academic work, will initially take undergraduate courses in aeronautical engineering and mathematics to prepare for their graduate program.

The Master of Science in Engineering Science (Aerospace Engineering) degree requires:

1. A minimum of 48 quarter-hours of graduate level work.
2. The candidate must take all courses in an approved study program, which must satisfy the following requirements:
   a. there must be a minimum of 32 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.
   b. Of the 32 quarter-hours, at least 24 quarter-hours must be in courses offered by the MAE Department.
3. A student must demonstrate knowledge of aerodynamics, aircraft stability and control, avionics, aircraft structures, aircraft and missile propulsion.
4. The student must also demonstrate competence at the advanced level in one of the above disciplines of

Aeronautical Engineering. This may be accomplished by completing at least eight quarter-hours of the 4000 level credits by courses in this department and a thesis in the same discipline area. The typical specialization track is in Aircraft Structures, Aerodynamics, Stability and Control, Avionics or Propulsion.

5. An acceptable, individually-authored thesis for a minimum of 16 credits is also required. The student's thesis advisor, the Academic Associate, the Program Officer, and the Department Chairman must approve the study program and the Thesis Proposal.

Under special circumstances as approved by the Academic Associate, the Program Officer, and the Department Chair, students may take four additional courses in lieu of a thesis. Those four additional courses should be at least 3000 and 4000 level courses. The technical courses should be related to aerospace engineering. At least two courses should be at the 4000 level.

Master of Engineering in Mechanical Engineering, Master of Engineering in Astronautical Engineering, Master of Engineering in Aerospace Engineering

The MEng programs focus exclusively on coursework and offer the option to include significant engineering design capstone experience as a culminating project.

The MEng {ME, Astro or Aero} degree requires the following:

- A minimum of 44 quarter-hours of graduate level engineering coursework.
  - Technical Depth: A minimum of 16 quarter-hours of advanced-level technical depth coursework in a single focus area, with at least 8 quarter-hours at the 4000-level.
- Before commencing the program, candidates must create their plan-of-study to satisfy the degree requirements and obtain approval from the relevant Academic Associate, Program Officer, and Department Chair. Any subsequent modifications to the plan-of-study must also receive approval from the Academic Associate.
- Optional Capstone: The plan-of-study may contain a culminating major engineering design experience. This option should be included in as appropriate capstone coursework and must satisfy the ABET EAC baccalaureate criteria for the experience that 1) incorporates appropriate engineering standards and multiple constraints, and 2) is based on the knowledge and skills acquired in earlier course work.
- Due to the accelerated nature of the program, candidates are required to have completed post-secondary educational and professional experiences that align with the ABET Criteria for Accrediting Engineering Programs, General Criteria for Stand-Alone Master's Level Programs, Criterion MS1. If the student has graduated from an EAC of ABET accredited baccalaureate program, then the presumption is that

these prerequisites/ corequisites have been satisfied.

A graduate student with a superior academic record (as may be demonstrated by a graduate QPR of 3.70 or better) may apply to enter a program leading to the Mechanical Engineer Degree. A candidate must prepare his or her application and route it through the Program Officer to the Department Chairman for a decision. Typically, the selection process occurs after completion of the candidate's first year of residence.

A candidate must take all courses in a curriculum approved by the Chairman of the MAE Department. At a minimum, the approved curriculum must satisfy the requirements stated in the following list.

Mechanical Engineer

The Mechanical Engineer Degree requires:

1. At least 64 quarter-hours of graduate level credits in Mechanical Engineering and Materials Science, at least 32 of which must be at the 4000 level.
   a. At least 12 quarter-hours of graduate level credits must be earned outside of the MAE Department.
   b. At least one advanced mathematics course should be included in these 12 quarter-hours.
2. An acceptable, individually-authored thesis of 28 credit hours is required for the Mechanical Engineer Degree. Approval of the thesis advisor and program must be obtained from the Chairman of the MAE Department.

Astronautical Engineer

A graduate student with a superior academic record (as may be demonstrated by a graduate QPR of 3.70 or better) may apply to enter a program leading to the Astronautical Engineer Degree. A candidate must prepare his or her application and route it through the Program Officer to the Department Chairman for a decision. Typically, the selection process occurs after completion of the candidate's first year of residence.

A candidate must take all courses in a curriculum approved by the Chairman of the MAE Department. At a minimum, the approved curriculum must satisfy the requirements stated in the following list.

The Astronautical Engineer Degree requires:

1. At least 64 quarter-hours of graduate level credits in Astronautical Engineering or Mechanical Engineering and Materials Science, at least 32 of which must be at the 4000 level.
   a. At least 12 quarter-hours of graduate level credits must be earned outside of the MAE Department.
   b. At least one advanced mathematics course should normally be included in these 12 quarter-hours.
2. An acceptable, individually-authored thesis of 28 credit hours is required for the Astronautical Engineer Degree. Approval of the thesis advisor and program must be obtained from the Chairman of the MAE Department.

Doctor of Philosophy

The Department offers Doctor of Philosophy (Ph.D.) degrees in Mechanical Engineering, Astronautical Engineering, and Aeronautical Engineering. Students having a superior academic record may request entrance into the doctoral program. All applicants will be screened by the departmental doctoral committee for admission. The department also accepts officer students selected in the Navy-wide doctoral program, qualified international officers, and DoD civilian students.

An applicant to the doctoral program who is not already at NPS should submit transcripts of previous academic and professional work. Also, all applicants are required to submit a current Graduate Record Examination (GRE) general test to the Director of Admissions, Naval Postgraduate School, 1 University Circle, He-022, Monterey, California 93943.

Every applicant who is accepted for the doctoral program will initially be enrolled in one of the following programs: Mechanical Engineer, Astronautical Engineer, or Aeronautical Engineer Program; under a special option which satisfies the broad departmental requirements for the Engineer's degree, which includes research work. As soon as feasible, the student must identify a faculty advisor to supervise research and to help formulate a plan for advanced study. As early as practicable thereafter, a doctoral committee shall be appointed to oversee that student's individual doctoral program as provided in the school-wide requirements for the doctor's degree. Joint programs with other departments are possible.

Special Programs

Along with degree programs, the department offers special programs that are sequences of courses along with capstone design projects that focus on the design of important military systems, such as platforms and weapons.

Total Ship Systems Engineering Program

The Total Ship Systems Engineering Program is an interdisciplinary, systems engineering and design-oriented program available to students enrolled in Mechanical or Astronautical or Aeronautical Engineering, Electrical and Computer Engineering or Combat Systems programs. The program objective is to provide a broad-based, design-oriented education focusing on the warship as a total engineering system. The sequence of electives introduces the student to the integration procedures and tools used to develop highly complex systems such as Navy ships. The program culminates in a team-performed design of a Navy ship, with students from all three curricula as team members. Students enrolled in programs leading to the Engineer's degree are also eligible for participation. Entry requirements are a baccalaureate degree in an engineering discipline with a demonstrated capability to perform satisfactorily at the graduate level. The appropriate degree thesis requirements must be met, but theses that address system design issues are welcome.

Missile Systems Engineering Program

The Missile Systems Engineering Track is an option that can be perused within the framework of the Master of Science in Mechanical Engineering (MSME) or Master of Science in Engineering Science Degree programs. This program is a regular part of the TEMASEK program, but is also open to DoD contractors, as well and all U.S. Military and DoD Civilian Students. The program provides a solid engineering foundation in analysis and design techniques involved in developing offensive and defensive missile systems.

This option consists of a four-course sequence of special missile courses embedded in the normal MSME or MSES(ME) degree program of courses and a thesis.

The courses for this program are:

1. ME3205 Missile Aerodynamics
2. AE4452 Advanced Missile Propulsion
3. ME4703 Missile Flight Dynamics and Control
4. ME4704 Missile Design

NPS works with industry, primarily with Raytheon Missile Systems Division in Tucson, AZ, to create this unique blend of high-quality academic courses and "real word" systems engineering focus in missile design and manufacturing, leading to a program of unique military relevance.

Laboratories

MAE Laboratories are designed to support the educational and research mission of the Department. In addition to extensive facilities for the support of student and faculty research, a variety of general use equipment is available. This includes equipment and facilities for the investigation of problems in engineering mechanics; a completely equipped materials science laboratory, an oscillating water tunnel, an underwater towing tank and a low turbulence water channel; a vibration and structural dynamics laboratory; a fluid power controls laboratory; a robotics and real-time control laboratory; facilities for experimentation with low velocity air flows.

NPS Center for Autonomous Vehicle Research: The primary goal of the NPS Center for Autonomous Vehicle Research (CAVR) is to educate students in the development and use of technologies needed for unmanned vehicles through coursework, thesis and dissertation research. The secondary goal of the CAVR is to advance Naval autonomous vehicle operations by providing support to the fleet, Navy labs and Program offices, testing and experimentation of advanced technologies, independent verification and validation of a variety of novel autonomous vehicles concepts, and by innovative concept development. Currently the CARV houses two autonomous submarines (Aries and REMUS), Sea Fox surface vehicle and a wide variety of Tier I and Tier II class unmanned aerial vehicles (UAV) staring from Scan Eagle UAV and all way down to miniature flapping-wing vehicles.

CAD/CAE Computer Laboratory: This lab consists of

Windows PCs and is used heavily by students for both class and thesis related work. This lab has a wide range of special mechanical engineering software for analysis and design. This facility includes a 128 processor cluster for large scale computations.

Additional Laboratories

Nano/MEMS Laboratory: This laboratory provides a facility for teaching the emerging technologies of Nano/MEMS.

Fluid Mechanics and Hydrodynamics Laboratories: The fluid mechanics laboratory supports instruction in basic courses in fluid mechanics. It is equipped with a small wind tunnel for specific instructional purposes. The hydrodynamics laboratory includes a unique U-shaped oscillating water tunnel for the study of a wide range of phenomena, such as flow about stationary and oscillating bodies, vortex-induced vibrations, stability of submarines and boundary layers, and vortex-free-surface interactions. The hydrodynamics laboratory also houses a recirculating water tunnel for numerous flow-separation and vibration phenomena and a vortex-breakdown facility for the investigation of the stability of swirling flows. These facilities are supported by a 3-beam Laser-Doppler-Velocimeter, numerous other lasers, high-speed motion analyzers, data-acquisition systems, and dedicated computers for numerical simulations.

Materials Laboratory: Laboratory supports teaching and research in processing, characterization, and testing of advanced structural, functional, and nanotechnology materials for defense applications.

- **Auger Surface Analysis Laboratory:** It consists of an ultrahigh vacuum system and an electron beam source to probe the surface and interface structure of composites and microelectronic devices.

- **Transmission Electron Microscopy Lab:** Contains a TOPCON 002B TEM used for materials science and engineering teaching and research.

- **Scanning Electron Microscopy Lab:** Contains a TOPCON 540 SEM used for materials science and engineering teaching and research.

- **X-Ray Diffraction Laboratory:** Two Philips X-ray Systems are used for materials science and engineering teaching and research.

- **Optical Microscopes Laboratory:** This lab includes several optical microscopes as well as electronic imaging and image analysis systems that are used for materials science and engineering teaching and research.

- **Metallurgical Sectioning/Polishing Laboratory:** This supports all teaching and research by provision of facilities to prepare samples for examination.

- **Transmission Electron Microscopy II Lab:** This laboratory is equipped with a JEOL-100CX microscope and is used primarily for instruction of students in the techniques of electron microscopy.

- **Scanning Electron Microscopy Laboratory:** This laboratory is equipped with an older model Cambridge Instruments SEM.

- **Physical Testing (Dilatometer) Laboratory:** This laboratory is dedicated to dilatometry and is primarily used for research applications.

- **Heat Treatment Laboratory:** This laboratory supports courses and research mainly in the materials area and includes a selection of conventional furnaces.

- **Corrosion Laboratory:** This laboratory supports the instructional program in the area of corrosion science and engineering.

- **Metallurgical Etching Laboratory:** This laboratory supports all teaching and research in materials by provision of facilities for the chemical treatment of samples for metallo-graphic examination.

- **Welding Laboratory:** Welding is the primary method of fabrication for Naval vessels, and instruction and research on welding/joining of both conventional and advanced alloys is carried out in this facility.

- **Materials Processing Laboratory:** This supports both teaching and research involving deformation and thermal processing of materials. It is equipped with presses, a rolling mill, and various heat treatment furnaces.

- **Creep Test Laboratory:** This laboratory supports research in high-temperature structural metals and composites.

- **Mechanical Test Laboratory:** This lab supports mechanical testing with impact, creep, and fatigue instrument and electromechanical properties.

- **Ceramics Laboratory:** This laboratory is devoted primarily to research on high temperature materials based on various ceramic compositions.

- **Composites Laboratory:** This laboratory supports research in composite materials, especially metal matrix composites.

Marine Propulsion Laboratory

This laboratory has gas turbine (Allison C-250) and diesel (Detroit 3-53) engines connected to water brake dynamometers, located in separate, isolated engine test cells. These engines are instrumented to obtain steady-state performance and high-frequency, time-resolved measurements. Aerothermodynamic, acoustic, and vibration phenomena in turbomachinery and reciprocating engines are being investigated, particularly relating to non-uniform flow and condition-based maintenance (CBM) in naval machinery. These engines are used for both instructional and applied research programs in the area of marine power and propulsion. In addition, this lab has bench-top rotordynamics experiments for demonstrating high-speed machinery balancing and investigating rotordynamic instabilities. The lab has sub-scale flow facilities for developing and testing low observable (stealth) technologies for engine inlets and

exhausts.

Rocket Propulsion Laboratory

This lab conducts research on advanced concepts in solid, liquid, and combined mode propellants. Experimental and computational research is conducted in the areas of propellant mixing, combustion, pulse detonation, thrust control, and plume mixing. A full range of mechanical and optical diagnostic techniques are used on small and subscale experiments.

Structural Dynamics Laboratory

This lab is devoted to structural dynamics and is especially designed to facilitate both teaching and research into vibration and shock effects associated with underwater explosions, as well as related shipboard vibration problems. The ability to validate simulation models with lab-scale tests is critical for student education. The lab includes a state of the art multi-channel data acquisition system, and a large variety of transducers and instrumentation.

Thermal Engineering Laboratories

These labs are used mainly for instruction in heat transfer to investigate convection phenomena of single and multi-phase flows and include facilities for measurement of temperature change and fluid motion in a range of systems. The lab also includes equipment/instrumentation for measurements in microelectronics and micro-heat exchanger systems.

- **Convection Heat Transfer Laboratory:** Used mainly for instruction in heat transfer by convection phenomena and includes facilities for measurement of temperature change and fluid motion in a range of systems.

- **Electronic Cooling Laboratory:** The operation of microelectronic devices results in intense, but very localized, heating of electronic devices.

- **Two-Phase Heat Transfer Laboratory:** This is an instructional and research laboratory for the study of heat transfer involving more than one phase, e.g., heat transfer involving liquid and vapor phases during boiling or condensation.

Ship Systems Engineering (TSSE) Laboratory

This is an integrated design center in which student teams perform a capstone design project of a Navy ship. Ship design encompasses hull, mechanical, and electrical systems as well as combat systems, and is done in cooperation with the Meyer Institute.

Astronautical Engineering Laboratories

- **Spacecraft Design Laboratory:** This laboratory houses computer-aided design tools for spacecraft design and a spacecraft design library. It is used heavily by students for three spacecraft design courses, AE3870, AE4870, and AE4871. Students can do collaborative spacecraft design using the unique design tools not available in other educational institutions.

- **Smart Structure and Attitude Control Laboratory:** This lab consists of five major ongoing experiments to facilitate the instruction and research by students in the area of both smart structures, sensors, and actuators for active vibration control, vibration isolation, and shape control in space applications and attitude control of flexible spacecraft and space robotic manipulators. In addition to students' thesis research, it also supports courses AE4816, AE3811, and AE3818.

- **Optical Relay Spacecraft Laboratory:** This joint laboratory of NPS and AFRL is used for both instruction and research on acquisition, tracking, and pointing of flexible military spacecraft. The main facilities include a bifocal relay mirror spacecraft attitude simulator, actuated by variable speed control moment gyros; a single focal spacecraft attitude simulator, actuated by reaction wheels; and an optical beam and jitter control test bed. This laboratory is used for courses AE3811, AE3818, and AE4818.

- **Spacecraft Robotics Laboratory:** The Spacecraft Robotics Laboratory, funded by NPS and AFRL, hosts the Autonomous Docking and Spacecraft Servicing Simulator (AUDASS). This test bed, consisting of two independent robotic vehicles (a chaser and a target), aims to carry out on-the-ground testing of satellite servicing and proximity formation flight technologies. The vehicles float, via air pads, on a smooth epoxy floor, providing a frictionless support for the simulation in 2-D of the zero-g dynamics. This is used for course AE3811.

- **FLTSATCOM Laboratory:** This laboratory consists of a qualification model of the Navy communications satellite, FLTSATCOM and the associated ground support equipment for testing the satellite. This is an instructional laboratory and is used by students in laboratory course AE3811. Students get operational experience including spin-up of a reaction wheel, rotation of a solar array drive, firing sequence of thrusters, and receiving telemetry on the satellite operational parameters.

- **Segmented Mirror Telescope (SMT):** The SMT is a unique platform for research into advanced Adaptive Optics (AO) techniques employing a prototype satellite imaging system with approximately 1,000 degrees of freedom.

Research Centers

The following Research Centers are organized in the MAE Department:

- **Aerodynamic Decelerator Systems Center and Laboratory:** Payload delivery has always played a vital role in a variety of combat and humanitarian operations. In the recent years the touchdown accuracy improved drastically allowing delivering not only traditional bundle supplies, but also smaller, time-critical items like munitions, medical resupplies, sensors, autonomous ground robots. Moreover, the delivery of these articles is possible using smaller

autonomous aerial vehicles as opposed to conventional military aircraft. The center focuses on a variety of novel research topics that support technologies vital to the Army's and Navy's future force, combating terrorism and new emerging threats. It includes the development of guidance, navigation and control algorithms for a family of various-weight precision guided airdrop systems to be deployed from fixed- and rotary-wing unmanned platforms, along with research on different sensors to support airdrop missions. The center is constantly working on different challenging projects, providing a wide variety of thesis opportunities in different areas: conceptual design, CFD analysis, computer modeling, image processing, control design, sensor integration; supports coursework in Control and Autonomous Systems.

- **Center for Materials Sciences and Engineering:** The Center for Materials Sciences and Engineering provides a focus for research and education in Materials Science and Engineering at NPS.
- **Center for Autonomous Underwater Vehicle Research:** The primary goal of the NPS Center for AUV Research is to educate Navy and USMC officer students in the development and use of technologies needed for unmanned underwater vehicles through coursework, thesis, and dissertation research. The secondary goal of the Center is to advance Naval UUV operations by providing: Support to the Fleet, Navy Labs and Program Offices.
- **Turbopropulsion Laboratory:** The Turbo Propulsion Laboratory houses a unique collection of experimental facilities for research and development related to compressors, turbines, and advanced air-breathing propulsion engine concepts. In a complex of specially designed concrete structures, one building, powered by a 750 HP compressor, contains 10 by 60 inch rectilinear and 4 to 8-foot diameter radial cascade wind tunnels, and a large 3-stage axial research compressor for low speed studies. A two-component, automated traverse, LDV system is available for CFD code verification experiments. A second building, powered by a 1250 HP compressed air plant, contains fully instrumented transonic turbine and compressor rigs in explosion-proof test cells. A spin-pit for structural testing of rotors to 50,000 RPM and 1,800 degrees Fahrenheit is provided. Data acquisition from 400 channels of steady state and 32 channels of non-steady measurements, at up to 200 kHz, is controlled by the laboratory's Pentium workstations. A third building houses a 600 HP radial and 150 HP boost compressor capable of delivering 2000 scfm of air at 10 and 20 atmospheres respectively. These charge four tanks for blow-down to a supersonic wind tunnel (4 x 4 inches), a transonic cascade wind tunnel (2 x 3 inches), and two free jets (one 6-inch and one 1-inch in diameter). The large free jet is equipped with an instrumented thrust stand for the testing of small gas turbine engines. The building also houses a 3-

inch diameter shock tube.
- **Spacecraft Research and Design Center:** The Spacecraft Research and Design Center at the Naval Postgraduate School consists of six state-of-the-art laboratories: Fltsatcom Laboratory, Spacecraft Attitude Dynamics and Control Laboratory, Smart Structures Laboratory, Spacecraft Design Center, NPS-AFRL Optical Relay Mirror Spacecraft Laboratory, and Satellite Servicing Laboratory. These laboratories are used for instruction and research in the Space System Engineering and Space Systems Operations curricula. The emphasis has been on providing students with hands-on experience in the design, analysis, and testing of space systems, and to provide students with facilities for experimental research. The emphasis in the research is on acquisition, tracking, and pointing of flexible spacecraft with optical payloads; active vibration control, isolation, and suppression using smart structures; space robotics, satellite servicing, space system design, and computer aided design tools. These laboratories have been used in joint projects with Naval Satellite Operational Center, NRL, AFRL, Columbia University, and Boeing. See www.nps.edu/SRDC.
- **Center for Survivability and Lethality:** The Center provides research and education in a broad range of technologies and methodologies to make platforms more survivable to attack and more lethal to hostile platforms and systems. Work in submarines, surface ships, fixed wing and rotorcraft, and space systems are supported. The Center also conducts research in improving the survivability of civilian infrastructure and transportation systems. Twenty NPS faculty members from MAE, Physics, and Electrical Engineering participate in the Center. See www.nps.edu/csl.

Mechanical and Aerospace Engineering Course Descriptions

AE Courses (p. 328)

ME Courses (p. 403)

MS Courses (p. 439)

MX Courses (p. 447)

TS Courses (p. 516)

Aerospace Engineering Certificate - Curriculum 118 (DL)

Program Officer

CDR Caleb MacDonald
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Brief Overview

The Aerospace Engineering Certificate is designed for a practicing engineers with a STEM undergraduate degree

to provide foundational knowledge to begin working on topics in aerospace & missile systems.

Uniquely relevant defense examples and applications include missile design and aircraft systems integration

The objective of this program is to provide graduate education in the field of Aerospace Engineering in order to produce graduates that have a working knowledge and technical competence for the operation, design, and acquisition of modern military aerospace systems.

Convenes

Fall, Winter, Spring, Summer

Program Length

Four quarters

The Aerospace Engineering program is designed to meet the specific needs of the U.S. Military and its international partners with a broad-based graduate education in the areas of aerodynamics, flight mechanics, propulsion, flight structures, and systems integration with a focus on missile design, autonomous systems, fixed-wing and rotary aircraft. Additionally, officers receive graduate level instruction in aircraft/missile design.

Apply U.S. military standards and industry practices to solve engineering problems and analyze structural components of aerospace systems.

Be able to analyze and design aircraft and missile guidance and control systems, including feedback stabilization schemes using classical and modern control techniques.

Understand the principles and operating characteristics of fixed wing, rotary wing, and missile propulsion engines and be able to analyze the performance of rocket motors through knowledge of the behavior and design characteristics of their individual components.

Integrate all of the disciplines of aerospace engineering into a design of a missile or autonomous system rotorcraft in response to a realistic set of military requirements, specifications, constraints and cost limitations. The design must include considerations for safety, reliability, maintainability and survivability.

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR to be awarded a certificate.

Required Courses

4-course technical graduate courses, nominally over one year, focusing on relevant topics in Aerospace Engineering. Students must take 4 of 6 course listed below, depending on start quarter.

Course	Title	Lecture	Lab
ME3611	Mechanics of Solids II	4	0
ME3205	Missile Aerodynamics	4	1
ME4751	Combat Survivability, Reliability and Systems Safety Engineering	4	1
AE4452	Advanced Missile Propulsion	4	1
ME4703	Missile Flight and Control	4	1
ME4704	Missile Design	3	2

Mechanical Engineering (Structures) Certificate - Curriculum 122 (DL)

Program Officer

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Brief Overview

The Mechanical Engineering program is designed to provide graduate education, with an emphasis in the field of Naval Mechanical Engineering, to produce graduates with the technical competence to operate and maintain modern warships and military combat systems. It establishes a broad background of basic engineering knowledge leading to advanced studies in heat transfer, fluid mechanics, control systems, solid mechanics and vibrations and material science, by applying U.S. military standards and industry practices to solve engineering problems and analyze structural components of mechanical systems.

The Mechanical Engineering certificates provide students with scientific and technical knowledge of mechanical engineering. Students will gain an understanding of the role that engineering, and technology have in military operations environment. Emphasis is on naval engineering and its applications to surface vessels, submarines, and spacecraft. These Mechanical Engineering certificates bring the core of the on-campus courses together with proven DL technology and faculty expertise to deliver a unique curriculum focused on mechanical engineering.

Skills/knowledge gained: The ability to identify, formulate, and solve technical and engineering problems in mechanical engineering and other engineering disciplines—examples: thermal-fluid sciences, structural mechanics, ship systems engineering, spacecraft designs, and others.

The Structures and Thermo/Fluids Certificate DL Programs are targeted toward DoD employees and Active-Duty personnel working at Warfare Centers and SYSCOMS. These commands have many practicing engineers who require advanced knowledge of structural mechanics or thermos fluids to perform their duties and will benefit from the option of stackable certificates to earn a Master of Science in Mechanical Engineering (MSME) (Curriculum 569).

The Master of Science in Mechanical Engineering is part of a proud heritage. On June 9, 1909, Secretary of the Navy George von L. Meyer established a school of marine

engineering at Annapolis. This small program, consisting of 10 0fficer students and two Navy instructors, was the first Naval / Mechanical Engineering Program and would later become today's Naval Postgraduate School.

Convenes

Fall

Program Length

Four quarters

The objective of the program is to provide personnel with the conceptual knowledge and practical applications of structural mechanics, including quasi-static and dynamic structural responses to multiple load types, strengthening mechanisms to support material selection, and finite element theory and software implementation.

The Mechanical Engineering certificates provide students with scientific and technical knowledge of mechanical engineering. Students will gain an understanding of the role that engineering, and technology have in military operations environment. Emphasis is on naval engineering and its applications to surface vessels, submarines, and spacecraft.

Skills/knowledge gained: The ability to identify, formulate, and solve technical and engineering problems in mechanical engineering and other engineering disciplines—examples: thermal-fluid sciences, structural mechanics, ship systems engineering, spacecraft designs, and others.

Required Courses

Fall Quarter

Course	Title	Lecture	Lab
ME3521	Mechanical Vibration	3	2

Winter Quarter

ME4613	Finite Element Methods	4	0

Spring Quarter

ME3611	Mechanics of Solids II	4	0

Summer Quarter

MS4811	Mechanical Behavior of Engineering Materials	4	0

Summer Quarter Option

ME4731	Engineering Design Optimization	4	0

Mechanical Engineering (Thermo/Fluids) Certificate - Curriculum 123 (DL)

Program Officer

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Brief Overview

The Mechanical Engineering program is designed to provide graduate education, with an emphasis in the field of Naval Mechanical Engineering, to produce graduates with the technical competence to operate and maintain modern warships and military combat systems. It establishes a broad background of basic engineering knowledge leading to advanced studies in heat transfer, fluid mechanics, control systems, solid mechanics and vibrations and material science, by applying U.S. military standards and industry practices to solve engineering problems and analyze structural components of mechanical systems.

The Mechanical Engineering certificates provide students with scientific and technical knowledge of mechanical engineering. Students will gain an understanding of the role that engineering, and technology have in military operations environment. Emphasis is on naval engineering and its applications to surface vessels, submarines, and spacecraft. These Mechanical Engineering certificates bring the core of the on-campus courses together with proven DL technology and faculty expertise to deliver a unique curriculum focused on mechanical engineering.

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The Master of Science in Mechanical Engineering is part of a proud heritage.   On June 9, 1909, Secretary of the Navy George von L. Meyer established a school of marine engineering at Annapolis. This small program, consisting of 10 0fficer students and two Navy instructors, was the first Naval / Mechanical Engineering Program and would later become today's Naval Postgraduate School.

Convenes

Fall, Winter, Spring, Summer

Program Length

12 months

The ability to:

1. identify,
2. formulate,
3. and solve technical and engineering problems in mechanical engineering and other engineering disciplines. Examples: thermal-fluid sciences, structural mechanics, ship systems engineering, spacecraft designs, and others.

Course Requirements

The objective of the program is to provide personnel with the conceptual knowledge and practical applications in fluid mechanics, heat transfer, thermodynamics, and power and propulsion systems common in Naval Mechanical Engineering. The Thermo/Fluids Certificate is intended for working engineers in mechanical, chemical, or a closely related field of engineering.

Student must take four of these seven courses:

Course	Title	Lecture	Lab
ME3201	Applied Fluid Mechanics	4	1
ME3450	Computational Methods in Mechanical Engineering	3	2
ME4101	Advanced Thermodynamics	4	0
ME4220	Viscous Flow	4	0
ME4225	Computational Fluid Dynamics and Heat Transfer	3	2
ME4420	Advanced Power and Propulsion	4	0
AE4502	Supersonic and Hypersonic Flows	4	0

Robotics Engineering Certificate - Curriculum 223 (DL)

Program Officer

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Brief Overview

The Robotics Engineering graduate certificate is intended to provide a technical foundation and supplemental credential for practicing engineers. The objective of the program to provide the civilian and active-duty workforce with a flexible, self-paced learning experience that includes the essential concepts and skills necessary to understand, design, and operate robotic systems. Each course is comprised of both instruction and hands-on activities to support student learning.

This certificate program consists of a four graduate course sequence in computation and engineering topics fundamental to robotics in defense-related contexts.

Requirements for Entry

Acceptance by the MAE Department

Convenes

Summer

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR to be awarded a certificate.

Required Courses

Course	Title	Lecture	Lab
ME3420	Computational Foundations for Robotics	3	2
EC4310	Fundamentals of Robotics	3	2
ME4828	Fundamental GNC Algorithms of Autonomous Robotics -or-	3	2
ME4822	Guidance, Navigation, and Control of Marine Systems	3	2
ME4800/AE4800	Machine Learning for Autonomous Operations -or-	3	2
AE4820	Robotic Multibody Systems	3	2

The prerequisites for AE4820 are currently ME3801 and AE3818 (which in turn has a prerequisite of AE3815). The prerequisite for ME4800 and ME4822 is ME3801.

Robotics Engineering Certificate - Curriculum 224

Program Officer

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Brief Overview

The Robotics Engineering graduate certificate is intended to provide a technical foundation and supplemental credential for practicing engineers. The objective of the program is to provide the civilian and active-duty workforce with a flexible, self-paced learning experience that includes the essential concepts and skills necessary to understand, design, and operate robotic systems. Each course is comprised of both instruction and hands-on activities to support student learning.

This certificate program consists of a four graduate course sequence including both foundation courses, in computation and engineering topics fundamental to robotics, and application courses, in which students are challenged to put this knowledge to work in defense-related contexts.

Requirements for Entry

Acceptance by the MAE Department

Convenes

Fall, Summer

Program Length

Four quarters

- Provide foundational knowledge to begin working on NR&DE topics in robotics and autonomous systems.
- Focus on uniquely relevant defense (NAVSEA/NAVAIR) examples and applications, e.g., Sensor integration and Mission-centric.
- Combine NPS expertise in distance learning and hands-on education.
- Foster collaboration and alignment across NR&DE.

Course of Study

The academic certificate program must be completed within three years of enrollment in the program. A student must maintain a 3.0 GQPR to be awarded a certificate. The certificate requires the completion of four courses, which total at least 12 hours of credit and are not counted for another certificate.

Foundation Required Courses

Students take one foundation course.

Course	Title	Lecture	Lab
EC4310	Fundamentals of Robotics -or-	3	2
CS4313	Advanced Robotic Systems -or-	3	2
ME3720	Introduction to Unmanned Systems	3	2

Elective Courses

Students take three elective courses with focus on robotics engineering.

AE4500/ME4500	Advanced Space Flight Mechanics and Orbital Robotics	3	2
AE4850	Dynamic Optimization	3	2
CS4310	Sensory Artificial Intelligence	4	1
CS4315	Introduction to Machine Learning and Data Mining	3	1
ME3420	Computational Foundations for Robotics	3	2
ME4500/AE4500	Advanced Space Flight Mechanics and Orbital Robotics	3	2
ME4800/AE4800	Machine Learning for Autonomous Operations	3	2
ME4811	Multivariable Control of Ship Systems	3	2

ME4821	Marine Navigation	3	2
ME4822	Guidance, Navigation, and Control of Marine Systems	3	2
ME4823	Cooperative Control of Multiple Marine Autonomous Vehicles	4	0

Engineering Modeling and Simulation Certificate- Curriculum 279

Program Manager

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Brief Overview

The Engineering Modeling & Simulation certificate is comprised of four courses (MX-2001, MX-3001, MX-3002 and MX-4000). Upon completion of this certificate program, students will be awarded a certificate of completion from the Naval Postgraduate School. The Engineering Modeling & Simulation Certificate program is targeted primarily at personnel in the DoD Acquisition Workforce but has great benefit for all students who seek further knowledge regarding the application of physics-based modeling and simulation in support of the acquisition lifecycle.

Requirements for Entry

For entry, the student must have a baccalaureate degree.

Program Length

Four quarters.

Graduate Certificate Requirements

To earn the academic certificate students must pass all four courses with a C+ (2.3 Quality Point Rating (QPR)) or better in each course and an overall QPR of 3.0 or better. Students earning grades below these standards will need to retake the courses to bring their grades within standards or they will be withdrawn from the program.

Required Courses

Quarter 1

Course	Title	Lecture	Lab
MX2001	Introduction to Physics-Based Modeling and Simulation	4	0

Quarter 2

MX3001	Basic Engineering Concepts in Modeling & Simulation I	4	0

Quarter 3

Course	Title	Lecture	Lab
MX3002	Overview of Computers, Weapons Platforms and Electrical Systems	4	0

Quarter 4

Course	Title	Lecture	Lab
MX4000	Selected Topics in the Application of Engineering Modeling & Simulation	4	0

Applied Trajectory Optimization Certificate-Curriculum 299

Program Manager

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Brief Overview

This certificate program provides students a suite of practical mathematical tools for applying trajectory optimization techniques to solve various problems in engineering design and optimization. The coursework equips students with an ability to model various dynamical systems and formulate a collection of dynamic optimization problems that explore the engineering trade-space. Two of the four-course sequence may be chosen as track electives to meet a student's particular interest in an engineering system. A capstone course provides the mathematical and computational framework that are necessary to apply the tools to address a trajectory optimization problem related to a practical system chosen by the student.

A minimum of 15 credit hours must be completed.

Requirements for Entry

For entry, the student must have a baccalaureate degree with:

1. An APC score of 222
2. Acceptance by the MAE Department

Program Length

Four quarters.

Graduate Certificate Requirements

To earn the academic certificate students must pass all four courses with a C+ (2.3 Quality Point Rating (QPR)) or better in each course and an overall QPR of 3.0 or better. Students earning grades below these standards will need to retake the courses to bring their grades within standards or they will be withdrawn from the program.

Required Courses

Quarter 1

Track Electives (choose one)

Course	Title	Lecture	Lab
AE3818	Spacecraft Attitude Dynamics and Control	3	2
AE4816	Dynamics and Control of Space Structures	4	0
AE4818	Acquisition, Tracking, and Pointing of Military Spacecraft	3	2
AE4820	Robotic Multibody Systems	3	2
EC4310	Fundamentals of Robotics	3	2
AE4362	Astrodynamics	3	0
ME3801	Dynamics and Control of Marine and Autonomous Vehicles I	3	2
ME4703	Missile Flight and Control	4	1
ME4822	Guidance, Navigation, and Control of Marine Systems	3	2
MV3472	Graphical Simulation of Physical Systems in Virtual Worlds	3	2
MX3001	Basic Engineering Concepts in Modeling & Simulation I	4	0
PH3152	Analytical Mechanics	4	0
PH4153	Advanced Classical Mechanics I	4	1
AE3820	Advanced Mechanics and Orbital Robotics	3	2
AE3815	Spacecraft Rotational Mechanics	3	2

Quarter 2

Track Electives (choose one)

Course	Title	Lecture	Lab
AE3830	Aerospace Guidance and Control	3	2
EC3320	Optimal Control Systems	3	2
MA4311	Calculus of Variations	4	0

Quarter 3

Course	Title	Lecture	Lab
AE4850	Dynamic Optimization	3	2

Quarter 4

Course	Title	Lecture	Lab
ME4881	Aerospace Trajectory Planning and Guidance	2	4

Naval/Mechanical Engineering (Energy Focus) - Curriculum 563

Program Officer

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Brief Overview

The objective of this program is to provide graduate education, primarily in the field of Naval/Mechanical Engineering with a focus on Energy, including production, storage, and use. This program is designed to produce graduates with the technical competence to operate and maintain modern warships and naval systems. It establishes a broad background of basic engineering knowledge leading to advanced studies in heat transfer, fluid mechanics, control systems, solid mechanics and vibrations, material science, energy production, storage and usage. The graduate will be able to participate in technical aspects of naval systems acquisition for technological advances in naval ships and systems, particularly as they apply to energy. Through emphasis on the design aspect within the program, the graduate will be well prepared to apply these advances in technology to the warships of the future. An original research project focusing on either Energy, Power and Propulsion Systems or Energy Materials resulting in a satisfactory thesis is an integral part of the curriculum.

Requirements for Entry

A baccalaureate degree or its equivalent is required, preferably in an engineering discipline. A minimum academic profile code (APC) of 323 is required (334 with one quarter refresher). This equates to a minimum grade point average of 2.20, with mathematics through differential and integral calculus and one year of calculus-based physics as non-waiverable requirements. The program is open to naval officers in the rank of LTJG through LCDR and equivalent grade officers of other U.S. services and qualified foreign military officers. DoD civilian employees and DoD Contractors are also eligible.

Convenes

June or December, with refresher in March or September. For further information, contact the Program Officer or the Academic Associate.

Program Length

Naval/Mechanical Engineering (Energy Specialty) is typically an eight-quarter program.

Degree

Requirements for the Master of Science in Mechanical Engineering degree, which is an ABET EAC accredited degree are met as a milestone en route to satisfying the educational skill requirements of the curricular program.

Subspecialty

Completion of this curriculum qualifies an officer as a Naval/Mechanical Engineering Specialist with a subspecialty code of 5603P. The curriculum sponsors are Naval Sea Systems Command and Navy Energy Coordination Office.

Typical Course of Study

Quarter 0

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
ME2501	Statics	4	0
AE2440	Introduction to Scientific Programming	3	2
EN3000	Defense Energy Seminar	2	0

Quarter 1

MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
ME2502	Dynamics	4	1
ME2101	Engineering Thermodynamics	4	2
NW3230	Strategy & War	4	2
EN3000	Defense Energy Seminar	2	0

Quarter 2

MA2043	Introduction to Matrix and Linear Algebra	4	0
MA2121	Differential Equations	4	0
ME2601	Mechanics of Solids I	4	1
MS2201	Introduction to Materials Science and Engineering	3	2
EN3000	Defense Energy Seminar	2	0

Quarter 3

MA3132	Partial Differential Equations and Integral Transforms	4	0
MA3232	Numerical Analysis	4	0
ME3611	Mechanics of Solids II	4	0
ME2201	Introduction to Fluid Mechanics	3	2
PH3700	Fundamentals of Energy	4	0
EN3000	Defense Energy Seminar	2	0

Quarter 4

EO2102	Basic Electronics and Electrical Machines	4	2
ME3521	Mechanical Vibration	3	2
ME3201	Applied Fluid Mechanics	4	1
ME3150	Heat Transfer	4	1
OS3007	Operations Research for Energy Systems Analysts	4	0
EN3000	Defense Energy Seminar	2	0

Quarter 5

ME2801	Introduction to Control Systems	3	2
ME3450	Computational Methods in Mechanical Engineering	3	2
ME3711	Design Of Machine Elements	4	1
MS3202	Properties, Performance & Failure of Engineering Materials	3	2
EN3000	Defense Energy Seminar	2	0

Quarter 6

ME3240	Marine Power and Propulsion	4	2
ME3712	Capstone Design Project	1	6
ME3801	Dynamics and Control of Marine and Autonomous Vehicles I	3	2
ELECT	Energy Specialization Elective ME4XXX		
EN3000	Defense Energy Seminar	2	0

Quarter 7

ME0810	Thesis Research	0	8
ME0810	Thesis Research	0	8
ELECT	Energy Specialization Elective ME4XXX		
MS3304	Corrosion and Marine Environmental Deterioration	3	2
EN3000	Defense Energy Seminar	2	0

MS3304: can substitute MS3606 Welding

Quarter 8

ME0810	Thesis Research	0	8
ME0810	Thesis Research	0	8
TS3001	Fundamental Principles of Naval Architecture	3	2
ELECT	Energy Specialization Elective ME4XXX		
EN3000	Defense Energy Seminar	2	0

Naval/Mechanical Engineering - Curriculum 569 (DL)

Program Officer

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Academic Associate

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Brief Overview

The objective of this program is to provide graduate education, primarily in the field of Mechanical Engineering, in order to produce graduates with the technical competence to operate and maintain modern military & space systems.

The Mechanical Engineering program is designed to meet the specific needs of the U.S. Military, U.S. Coast Guard, Industry partners and international partners with a broad-based graduate education in Mechanical Engineering with a focus on thermos fluids, structures, autonomous systems, and space systems. The program is intended to be completed within 36 months, assuming one course or thesis slot per quarter and gives the student a broad naval / mechanical engineering education.

An original research project resulting in a finished thesis, or additional course work and a project is an integral part of the curriculum.

Requirements for Entry

A baccalaureate degree from a school that has Institutional Accreditation is required, preferably in an engineering discipline.

While an undergraduate degree in engineering is preferred, special preparatory programs can accommodate officers with other backgrounds.

The following are eligible for this program:
• U.S. Military Officers & Enlisted Personnel
• U.S. Government Civilians
• Select Department of Defense Contractors
• Qualified International Personnel

Convenes

Fall, Winter, Spring or Summer.

Program Length

36 months/12 quarters

Degree

Requirements for the Master of Science in Mechanical Engineering - MSME or a Master of Science in Engineering Science with a major in Mechanical Engineering – MSES(ME) are met as a milestone enroute to satisfying the educational skill requirements of the curricular program. There must be a minimum of 32 quarter hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter hours at the 4000 level. Of the 32 quarter hours at least 24 quarter-hours must be in courses offered by the MAE Department.

Graduation research requirements: a thesis (16 credit hours) with 32 credit hours (a total of 8 grad course) or the chair can approve an optional research project (8 credit hours) with 40 credit hours (a total of 10 grad courses).

Graduating students will meet the ABET 1 through 7 outcomes either by previous attainment of an ABET BSME

Degree, or by having the knowledge and skills equivalent to an ABET-accredited BSME.

Graduating students will have a minimum of one (1) year of advanced study beyond the bachelor's level and have advanced level knowledge in Mechanical Engineering as demonstrated by the ability to apply master's level knowledge in one of the available specialized disciplines of Mechanical Engineering.

Graduating students will have the ability to apply technical knowledge in a leadership role related to national security.

Typical Course of Study

Upon entry into the program students will typically enroll in one course per quarter to be taken via distance learning. Typically, students may stack certificates to complete the coursework requirement of either 8 or 10 courses. Four specialty tracks within the course of study are also offered: Structures, Fluid Thermodynamics, Applied Trajectory Optimization, and Robotics in addition to some Aerospace Engineering and Space Systems courses.

The program of study for each student will be submitted for approval by the Chairman of the Department of Mechanical and Aerospace Engineering.

Aerospace Engineering (Certificate 118 Track)

Student must take four of these six courses:

Course	Title	Lecture	Lab
AE4452	Advanced Missile Propulsion	4	1
ME3205	Missile Aerodynamics	4	1
ME3611	Mechanics of Solids II	4	0
ME4703	Missile Flight and Control	4	1
ME4704	Missile Design	3	2
ME4751	Combat Survivability, Reliability and Systems Safety Engineering	4	1

Applied Trajectory Optimization (Certificate 299 Track)

AE3820	Advanced Mechanics and Orbital Robotics	3	2
AE3830	Aerospace Guidance and Control	3	2
AE4850	Dynamic Optimization	3	2
ME4881	Aerospace Trajectory Planning and Guidance	2	4

Structures (Certificate 122 Track)

ME3521	Mechanical Vibration	3	2
ME3611	Mechanics of Solids II	4	0
ME4613	Finite Element Methods	4	0
ME4731	Engineering Design Optimization	4	0

Thermodynamics/Fluids (Certificate 123 Track)

Student must take four of these seven courses to complete the certificate:

AE4502	Supersonic and Hypersonic Flows	4	0
ME3201	Applied Fluid Mechanics	4	1
ME3450	Computational Methods in Mechanical Engineering	3	2
ME4101	Advanced Thermodynamics	4	0
ME4220	Viscous Flow	4	0
ME4420	Advanced Power and Propulsion	4	0

Robotics Engineering (Certificate 223 Track)

EC4310	Fundamentals of Robotics	3	2
ME3420	Computational Foundations for Robotics	3	2
ME4800/AE4800	Machine Learning for Autonomous Operations	3	2
ME4828	Fundamental GNC Algorithms of Autonomous Robotics	3	2

Total Ship Systems Engineering (Under Department of Mechanical and Aerospace Engineering)

Program Director

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Total Ship Systems Engineering

The objective of this program is to provide a broad-based, design-oriented education focusing on the warship as a total engineering system, including hull, mechanical, electrical and combat systems. The program is for selected Naval/Mechanical Engineering, Electrical Engineering, and Combat Systems Sciences and Engineering students and is structured to lead to the MSME, MSEE, or MS in Physics. Entry to the Total Ship Systems Engineering program is through the standard 533, 570, 590, 591 curricula.

Convenes

Total Ship Systems Engineering will generally fit as part of an eight-or nine-quarter program, with TSSE elective commencing in October. The ease of accommodating TSSE in a student's program is influenced by the student's NPS entry quarter and undergraduate background and performance. Individuals interested in the program should explore the necessary course sequencing with the program officer or academic associate as early as possible.

Subspecialty

Completion of this program will contribute toward the graduates' subspecialty code within his/her designated curriculum. The student will also receive the 5602P subspecialty code for completion of the TSSE Program.

Typical Subspecialty Jobs

Upon award of the subspecialty code, a Naval officer would be eligible for assignments typical of the Navy P-Code. The expectation is that the combination of education and experience would lead to individuals qualified for assignment later in their career to more responsible positions in systems design and acquisition in NAVSEA, SPAWAR and OPNAV, and as Program Managers.

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
ME2101	Engineering Thermodynamics	4	2
MA2121	Differential Equations	4	0
ME2502	Dynamics	4	1
NW3230	Strategy & War	4	2
AE2440	Introduction to Scientific Programming	3	2

Quarter 2

MA2043	Introduction to Matrix and Linear Algebra	4	0
ME2601	Mechanics of Solids I	4	1
MS2201	Introduction to Materials Science and Engineering	3	2

Quarter 3

ME2201	Introduction to Fluid Mechanics	3	2
ME3611	Mechanics of Solids II	4	0
MA3132	Partial Differential Equations and Integral Transforms	4	0
MA3232	Numerical Analysis	4	0

Quarter 4

TS3001	Fundamental Principles of Naval Architecture	3	2
ME3150	Heat Transfer	4	1
ME3201	Applied Fluid Mechanics	4	1
EO2102	Basic Electronics and Electrical Machines	4	2
ME3521	Mechanical Vibration	3	2

Quarter 5

TS3000	Electrical Power Engineering	3	2
ME2801	Introduction to Control Systems	3	2
ME3711	Design Of Machine Elements	4	1
MS3202	Properties, Performance & Failure of Engineering Materials	3	2

Quarter 6

SE3100	Fundamentals of Systems Engineering	3	2
TS3003	Naval Combat System Elements	3	2
ME3801	Dynamics and Control of Marine and Autonomous Vehicles I	3	2
ELECT	Specialization Elective ME4XXX		

Quarter 7

TS4000	Naval Combat System Engineering	3	2
TS4001	Integration of Naval Engineering Systems	3	2
ME3450	Computational Methods in Mechanical Engineering	3	2
ELECT	Specialization Elective ME4XXX		

Quarter 8

TS4002	Ship Design Integration	2	4
ME0810	Thesis Research	0	8
ME0810	Thesis Research	0	8
ME3240	Marine Power and Propulsion	4	2

Quarter 9

TS4003	Total Ship Systems Engineering	2	4
MS3606	Introduction to Welding and Joining Metallurgy	3	2
ME0810	Thesis Research	0	8
ME0810	Thesis Research	0	8

Mechanical, Naval and Aerospace Engineering - Curriculum 570

Naval/Mechanical Engineering (Resident Program)

Program Officer

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Brief Overview

The objective of this program is to provide graduate education, primarily in the field of Naval Mechanical Engineering, in order to produce graduates with the technical competence to operate and maintain modern warships and naval systems. It establishes a broad background of basic engineering knowledge leading to advanced studies in heat transfer, fluid mechanics, control systems, solid mechanics and vibrations and material science. The graduate will be able to participate in technical aspects of naval systems acquisition for technological advances in naval ships and systems. Through emphasis on the design aspect within the program, the graduate will be well prepared to apply these advances in technology to the warships of the future. An original research project resulting in a finished thesis is an integral part of the curriculum.

Requirements for Entry

A baccalaureate degree or its equivalent is required, preferably in an engineering discipline. A minimum academic profile code (APC) of 323 is required (334 with one quarter refresher). This equates to a minimum grade point average of 2.20, with mathematics through differential and integral calculus and one year of calculus-based physics as non-waiverable requirements. The program is open to naval officers in the rank of LTJG through LCDR in the 11XX/14XX community, equivalent grade officers of other U.S. services and qualified foreign military officers. DoD employees are also eligible.

Convenes

January or June. Refresher quarters are offered in March and September and is recommended for non-engineering undergraduates and those out of school greater than 5 years.

Program Length

Naval/Mechanical Engineering is typically an eight-quarter program. Time in residence may be reduced by course validations depending on the officer's specific academic background. If further information is needed, contact the Program Officer or the Academic Associate.

Degree

Requirements for the Master of Science in Mechanical Engineering degree are met as a milestone en route to satisfying the educational skill requirements of the program.

Subspecialty

5000P-5402(P,U)-5601(I,N,P)-5602P-5603P

Typical Subspecialty Billets

Upon award of the subspecialty code, the officer becomes eligible for assignment to those billets identified as requiring graduate education in Naval/Mechanical Engineering. Typical of these billets are the following:

Industrial Activities - Shipyard, SUPSHIP, Ship Repair

Facility, SIMA
Mechanical Engineering Instructor, USNA
Tender Repair Officer (Engineering Duty Officer)
Fleet/Type Commander Staff
Board of Inspection and Survey
Propulsion Examining Board
OPNAV/NAVSEA
Chief Engineer (Ships and Submarines)

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
ME2502	Dynamics	4	1
MS2201	Introduction to Materials Science and Engineering	3	2
NW3230	Strategy & War	4	2

Quarter 2

Course	Title	Lecture	Lab
MA2043	Introduction to Matrix and Linear Algebra	4	0
MA2121	Differential Equations	4	0
ME2101	Engineering Thermodynamics	4	2
ME2201	Introduction to Fluid Mechanics	3	2
ME2801	Introduction to Control Systems	3	2

Quarter 3

Course	Title	Lecture	Lab
MA3132	Partial Differential Equations and Integral Transforms	4	0
MA3232	Numerical Analysis	4	0
ME2601	Mechanics of Solids I	4	1
ME3801	Dynamics and Control of Marine and Autonomous Vehicles I	3	2
EO2102	Basic Electronics and Electrical Machines	4	2

Quarter 4

Course	Title	Lecture	Lab
ME3711	Design Of Machine Elements	4	1
ME2201	Introduction to Fluid Mechanics	3	2
MS3202	Properties, Performance & Failure of Engineering Materials	3	2
ME3611	Mechanics of Solids II	4	0

Quarter 5

Course	Title	Lecture	Lab
ME3201	Applied Fluid Mechanics	4	1
ME3712	Capstone Design Project	1	6

Quarter 6

MS3304	Corrosion and Marine Environmental Deterioration	3	2
ME0810	Thesis Research	0	8
ELECT	Specialization Elective ME4XXX		
ELECT	Specialization Elective ME4XXX		

Quarter 7

ME0810	Thesis Research	0	8
TS3001	Fundamental Principles of Naval Architecture	3	2
ME3521	Mechanical Vibration	3	2
ME3240	Marine Power and Propulsion	4	2

Quarter 8

ME0810	Thesis Research	0	8
ME0810	Thesis Research	0	8
ME3450	Computational Methods in Mechanical Engineering	3	2
ELECT	Elective ME4XXX		

Aerospace Engineering (Resident Program)

Program Officer

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Academic Associate

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Brief Overview

The objective of this program is to provide graduate education, primarily in the field of Aerospace Engineering, in order to produce graduates with the technical competence to operate and maintain modern military aerospace systems.

The Aerospace Engineering program is designed to meet the specific needs of the U.S. Marine Corps, U.S. Army, and international partners with a broad-based graduate education in Aerospace Engineering with a focus on missile design, autonomous systems, and rotorcraft. The program is intended to be completed within 24 months.

This program gives the student a broad aerospace engineering education in the areas of aerodynamics, flight mechanics, propulsion, flight structures, and systems integration. Additionally, officers receive graduate level instruction in aircraft/missile design and aero-computer science.

An original research project resulting in a finished thesis is an integral part of the curriculum.

Requirements for Entry

A baccalaureate degree from a regionally accredited institution or its equivalent is required, preferably in an engineering discipline. A minimum academic profile code (APC) of 323 is required.

While an undergraduate degree in engineering is preferred, special preparatory programs can accommodate officers with other backgrounds.

The program is open to military officers in the rank equivalent grade officers of O3 through O5 (U.S. services), and qualified foreign military officers. DoD employees are also eligible.

Convenes

Aerospace Engineering is typically an eight-quarter program with preferred entry dates in January or June. Refresher quarters are offered in March and September and are recommended for non-engineering undergraduates and those out of school greater than 5 years. Time in residence may be reduced by course validations depending on the officer's specific academic background. If further information is needed, contact the Program Officer or the Academic Associate.

Degree Requirements

Requirements for the Master of Science in Aerospace Engineering – MSAE; or Master of Science in Engineering Science with a major in Aerospace Engineering – MSES(AE) are met as a milestone en route to satisfying the educational skill requirements of the program.

Aerospace Engineering Typical Course

Quarter 1

MA1115 (4-0) Multivariable Calculus

MA1116 (3-0) Vector Calculus

MS2201 (3-2) Materials Science

AE/EC2440 (3-2) Introduction to Digital Computation

ME2502 (4-1) Dynamics

Quarter 2

MA2043 (4-0) Matrix and Linear Algebra

MA2121 (4-0) Differential Equations

ME2101 (4-2) Engineering Thermodynamics

ME2201 (3-2) Introduction to Fluid Mechanics

Quarter 3

MA3132 (4-0) Partial Differential Equations

ME3201 (4-1) Applied Fluid Mechanics

ME3240 (4-2) Power and Propulsion

ME2801 (3-2) Introduction to Control Systems

Quarter 4

ME2601 (4-1) Solids I

ME3205 (4-1) Missile Aerodynamics

ME4702 (3-2) Engineering Sys Risk Benefit Analysis

ME3450 (3-2) Computational Methods in Engineering

MA3132 (4-0) Numerical Methods

Quarter 5

SE3100 (3-2) Fundamentals of Systems Engineering

ME3801 (3-2) Dynamics/Control of Auto Vehicles I

MS3202 (3-2) Properties, Performance and Failure of Engineering Materials

AE3840 (3-2) Analysis of Spacecraft Structures

ME4703 (4-1) Missile Flight and Control

Quarter 6

AE/ME4XXX Elective

ME0810 (0-8) Thesis Research

AE4452 (4-0) Advanced Missile Propulsion

ME4704 (3-2) Missile Design

Quarter 7

AE/ME4XXX Elective

ME0810 (0-8) Thesis Research

ME0810 (0-8) Thesis Research

AE4502 (4-0) Supersonic and Hypersonic Flows

Quarter 8

AE/ME4XXX Elective

ME4751 (4-1) Combat Aircraft Survivability

ME4700 (4-0) Weaponeering

ME0810 (0-8) Thesis Research

Other Courses Available

ME3521 Mechanical Vibrations

ME3150 Heat Transfer

ME3611 Solids II

ME3711 Design of Machine Elements

ME3720 Introduction to Unmanned Systems

MS3304 Marine Corrosion

MS3606 Welding

ME4101 Advanced Thermodynamics (4-0)

ME4160 Applications of Heat Transfer (4-0)

ME4161 Conduction Heat Transfer (4-0)

ME4162 Convection Heat Transfer (4-0)

ME4163 Radiation Heat Transfer 4/0 0 0 0 0

ME4202 Compressible and Hypersonic Flow (4-0)

ME4211 Applied Hydrodynamics (4-0)

ME4220 Viscous Flow (4-0)

ME4225 Computational Fluid Dynamics and Heat Transfer (3-2)

ME4231 Advanced Turbomachinery (3-2)

ME4240 Advanced Topics in Fluid Dynamics (4-0)

ME4251 Engine Design and Integration (3-2)

ME4420 Advanced Power and Propulsion (4-0)

ME4522 Structural Dynamics (4-0)

ME4525 Naval Ship Shock Design and Analysis (4-0)

ME4550 Random Vibrations & Spectral Analysis (3-2)

ME4612 Advanced Mechanics of Solids (4-0)

ME4613 Finite Element Methods (4-0)

ME4731 Engineering Design Optimization (4-0)

ME4811 Multivariable Control of Systems (4-0)

ME4821 Marine Navigation (4-0)

ME4822 Guidance, Navigation, and Control (3-2)

ME4823 Cooperative Control of Multiple Marine Autonomous Vehicles (4-0)

ME/AE4901 Advanced Topics in Mechanical (Aerospace) Engineering (V-V)

ME/AE4902 Advanced Study in Mechanical (Aerospace) Engineering (V/V)

Educational Skills Requirements

The ESRs consist of a core of prescribed aerospace engineering skills, which all graduates must acquire; plus specialization options of advanced topics in missile design, autonomous systems, or rotorcraft, which the student may pursue as electives.

1. AEROSPACE STRUCTURES AND MATERIALS: Be able to apply U.S. military standards and practices to analyze structural components of missiles systems & autonomous vehicles, using engineering analytic methods on idealized models and automated finite element methods on realistic models to determine stresses, strains, deformations and appropriate limiting conditions of yielding, fracture, buckling and fatigue.

2. FLIGHT MECHANICS: Be able to calculate all performance parameters for rotorcraft, military autonomous aircraft, and missile systems to determine their longitudinal and lateral-directional, static and dynamic stability characteristics. Be able to analyze and design aircraft and missile guidance and control systems, including feedback stabilization schemes and stochastic processes, using classical and modern control techniques.

3. AIRCRAFT AND MISSILE PROPULSION: Understand the principles and operating characteristics of fixed wing, rotorcraft and missile propulsion engines and be able to analyze the performance of rocket motor and turbines

through knowledge of the behavior and design characteristics of the individual components. Be able to calculate performance parameters used in engine selection and know the state-of-the-art reasons for limitations on gas turbine engine performance, as well as the potential for future gains in the field. Be able to analyze the performance of rockets and ramjets through knowledge of the behavior of individual components, and be able to make steady-state, internal ballistic calculations for solid rocket motors.

4. AERODYNAMICS: Be able to use classical analytic, experimental and modern computational techniques of subsonic and supersonic aerodynamics, including laminar and turbulent boundary-layer viscous effects, without heat addition, to calculate internal flow properties through inlets, nozzles and engines and external air flow pressure distributions over wings, canards, tails, and other lifting surfaces to determine the resulting lift, drag and pitching moment.

5. INFORMATION PROCESSING: Be able to use current computer methods to solve aerospace engineering problems and possess knowledge of the application of dedicated avionic and systems computers on board military aircraft.

6. ENGINEERING MATHEMATICS: Demonstrate analytic ability to apply differential and integral calculus, ordinary and partial differential equations, vector calculus, matrix algebra, probability and statistics and numerical analysis in the development of engineering theory and its application to engineering problems.

7. ELECTRICAL ENGINEERING: Understand basic electrical circuits, systems and electronic devices as a foundation for interfacing mechanical and electronic systems in aerospace systems.

8. SYSTEMS DESIGN: Be able to integrate all of the disciplines of aerospace engineering into a design of a missile or autonomous system or rotorcraft in response to a realistic set of military requirements, specifications, constraints and cost limitations. The design must include considerations for safety, reliability, maintainability and survivability.

9. RESEARCH, DEVELOPMENT, TEST, AND EVALUATION: Apply principles of project scoping, planning, design and execution to investigate a current research, development, test or evaluation problem of interest to the Department of Defense that culminates in the publication of a thesis.

Naval Reactors-Mechanical/Electrical Engineering Program - Curriculum 571

Primary Consultant

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Director, Management and Administration

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Brief Overview

The objective of this special program is to provide both naval officers and civilian employees of Naval Reactors (NR), an advanced education leading to a Master of Science in Engineering Science with major in either Mechanical or Electrical Engineering. This is a non-thesis program for individuals who work as engineers and who wish to pursue a master's degree via Distance Learning. The program sponsor is NAVSEA and the subject matter expert is SEA-08.

Requirements for Entry

Entrance into this program is restricted to individuals who have successfully completed the Bettis Reactor Engineering School (BRES). Further requirements include an Academic Profile Code of 121. All entrants must be nominated for the program by the designated program coordinator and primary consultant for Naval Reactors. The nomination to the Director of Admissions must include original transcripts of the student's undergraduate and BRES records. The Director of Admissions will provide copies of all records to the Academic Associate in Mechanical or Electrical Engineering depending on the degree the student is pursuing.

Convenes

Students usually enter this program at the beginning of the academic quarter following completion of the BRES. Application for entry is to be made through the program coordinator and primary consultant for Naval Reactors. The program is also available to civilian employees of Naval Reactors who have completed BRES. For further information, contact the Academic Associate, or the Primary Consultant for this program.

Degree Requirements for Mechanical Engineering

The student must complete 20 hours of advanced graduate level (ME4XXX) NPS courses. This requirement may be met by completing a sequence of five courses via Distance Learning in a program approved by the Chairman of the Department of Mechanical and Aerospace Engineering. This Master of Science in Engineering Science (Major in Mechanical Engineering) program may be

completed in five academic quarters following completion of BRES.

Degree Requirements for Electrical Engineering

The student must complete 28 hours of graduate level (EC3XXX and EC4XXX) NPS courses. This requirement may be met by completing a sequence of seven courses via Distance Learning in a program approved by the Chairman of the Department of Electrical and Computer Engineering. This Master of Science in Engineering Science (Major in Electrical Engineering) program may be completed in seven academic quarters following completion of BRES.

Credit for Completion of BRES

This program is designed to build upon the BRES courses and the power plant design experience. The following BRES courses are considered as integral to this program and equivalent to 16 credit hours of ME3XXX level NPS courses:

• BRES 200 Mathematics
• BRES 340 Applied Structural Mechanics
• BRES 350 Heat Transfer and Fluid Flow
• BRES 360 Reactor Dynamics, Control and Safeguards

In addition, BRES 370 Reactor and Power Plant Design Project is considered partially in lieu of a thesis.

The NPS transcript will include 16 credits for the BRES program. The Quality Point Rating (QPR) for the NPS transcript will be computed based only on the NPS courses completed by the student.

Subspecialty

Graduates of BRES earn a Navy Subspecialty Code of 5200, which applies to their reactor design training. This Naval Postgraduate School curriculum will not affect that subspecialty code nor provide any additional subspecialty code(s).

Typical Course of Study

Upon entry into the program students will typically enroll in one course per quarter, to be taken via Distance Learning. All requirements must be completed within three calendar years from entry. Students will select a program of study from available courses and submit a program for approval by the Chairman of Mechanical or Electrical Engineering.

Course	Title	Lecture	Lab
ME4161	Conduction Heat Transfer	4	0
ME4162	Convection Heat Transfer	4	0
ME4220	Viscous Flow	4	0
ME4522	Finite Element Methods in Structural Dynamics	4	0
ME4525	Naval Ship Shock Design and Analysis	4	0
ME4550	Random Vibrations and Spectral Analysis	4	0

Course	Title	Lecture	Lab
ME4612	Advanced Mechanics of Solids	4	0
ME4613	Finite Element Methods	4	0
ME4731	Engineering Design Optimization	4	0

Educational Skill Requirements (ESRs)
Reactors - Mechanical or Electrical Engineering Program - Curriculum 571
Subspecialty Code: None

The ESRs required by Naval Reactors are met upon completion of the BRES. This is a degree program only, leading to the Master of Science in Engineering Science with Major in Mechanical or Electrical Engineering.

Distance Learning Program in Mechanical Engineering for Nuclear Trained Officers - Curriculum 572

Program Officer

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Program Administrator

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Brief Overview

This special program provides the opportunity for nuclear trained naval officers (those who have successfully completed Naval Nuclear Power School, Officers Course) to obtain a Master of Science in Engineering Science with a major in Mechanical Engineering - MSES(ME), while on sea or shore duty. This is a non-thesis program, but a capstone research or design project is required. This is a distance learning program, with content primarily offered via asynchronous course packages, in which pre-recorded lectures are provided to students on DVDs, and the student communicates directly with the professor. Synchronous course options are occasionally offered via video teleconference (VTC) facilities when available. For more information, see: www.nps.edu/web/mae/nnps

Requirements for Entry

Admission into this program is restricted to individuals who have successfully completed the Officer's Course at the Naval Nuclear Power School (NPS). Further

requirements include a minimum Academic Profile Code of 323 and a B.S. in Engineering (or closely related field). All entrants must be nominated by their commands. The nomination to the Director of Admissions must include original transcripts of the student's undergraduate records.

Convenes

Students may enter this program in any quarter. Because the program is asynchronous, students may begin coursework immediately upon acceptance to the program.

Degree Requirements for Mechanical Engineering

NPS courses may be taken via VTC or via special asynchronous courses packages which have been developed so that this program may be completed while you are on shore, sea, or overseas assignment. The final two (2) quarters are devoted to a capstone research or design project and presentation, and the student will be registered for ME0810 during these quarters. A degree plan must be submitted and pre-approved by the Chairman of the Department of Mechanical and Aerospace Engineering. This special program fully considers the 28.5 quarter credits earned in NPS, and therefore none of these credits may be used to fulfill the degree requirements. Each course must be completed within six months. Nominal program duration is two (2) years.

Subspecialty

This is a degree program only and does not provide an additional subspecialty code.

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
ME3201	Applied Fluid Mechanics	4	1

Quarter 2

ME3150	Heat Transfer	4	1

Quarter 3

ME4220	Viscous Flow	4	0

Quarter 4

ME4162	Convection Heat Transfer	4	0

Quarter 5

ME4420	Advanced Power and Propulsion	4	0

Quarter 6

ME0810	Thesis Research	0	8

Quarter 7

ME0810	Thesis Research	0	8

Mechanical Engineering PhD, Astronautical Engineering PhD, Aeronautical Engineering PhD - Curriculum 573

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Overview

The Department offers Doctor of Philosophy (Ph.D.) degrees in Mechanical Engineering, Astronautical Engineering, and Aeronautical Engineering. Students having a superior academic record may request entrance into the doctoral program. All applicants will be screened by the departmental doctoral committee for admission. The department also accepts officer students selected in the Navy-wide doctoral program, qualified international officers, and DoD civilian students.

An applicant to the doctoral program who is not already at NPS should submit transcripts of previous academic and professional work. Also all applicants are required to submit a current Graduate Record Examination (GRE) general test to the Director of Admissions, Naval Postgraduate School, 1 University Circle, He-022, Monterey, California 93943.

Every applicant who is accepted for the doctoral program will initially be enrolled in one of the following programs: Mechanical Engineer, Astronautical Engineer, or Aeronautical Engineer Program; under a special option which satisfies the broad departmental requirements for the Engineer's degree, which includes research work. As soon as feasible, the student must identify a faculty advisor to supervise research and to help formulate a plan for advanced study. As early as practicable thereafter, a doctoral committee shall be appointed to oversee that student's individual doctoral program as provided in the school-wide requirements for the doctor's degree. Joint programs with other departments are possible.

Convenes

Winter, Summer

Program Length

36 months

Subspecialty

5601D

Aerospace Engineering - Curriculum 608 (DL)

Program Officer

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Brief Overview

The objective of this program is to provide graduate education, primarily in the field of Aerospace Engineering, in order to produce graduates with the technical competence to operate and maintain modern military aerospace systems.

The Aerospace Engineering program is designed to meet the specific needs of the U.S. Military, U.S. Coast Guard, and international partners with a broad-based graduate education in Aerospace Engineering with a focus on missile design, autonomous systems, and space systems. The program is intended to be completed within 36 months, assuming one course or thesis slot per quarter.

This program gives the student a broad aerospace engineering education in the areas of aerodynamics, flight mechanics, propulsion, flight structures, astronautical systems and systems integration. Additionally, officers receive graduate level instruction in aerospace systems design.

An original research project resulting in a finished thesis, or additional course work and a project is an integral part of the curriculum.

Requirements for Entry

A baccalaureate degree from a school that has Institutional Accreditation is required, preferably in an engineering discipline. While an undergraduate degree in engineering is preferred, special preparatory programs can accommodate officers with other backgrounds.

The following are eligible for this program:
- U.S. Military Officers & Enlisted Personnel
- U.S. Government Civilians
- Select Department of Defense Contractors
- Qualified International Personnel

Convenes

Fall, Winter, Spring or Summer.

Program Length

36 months/12 quarters

Degree

Requirements for the Master of Science in Aerospace Engineering - MSAE or a Master of Science in Engineering Science with a major in Aerospace Engineering – MSES(AE) are met as a milestone enroute to satisfying the educational skill requirements of the curricular program. There must be a minimum of 32 quarter hours of credits in 3000 and 4000 level courses, including a minimum of 12 quarter hours at the 4000 level. Of the 32 quarter hours at least 24 quarter-hours must be in courses offered by the MAE Department.

Graduation research requirements: a thesis (16 credit hours) with 32 credit hours (a total of 8 grad course) or the chair can approve an optional research project (8 credit hours) with 40 credit hours (a total of 10 grad courses).

Typical Course of Study

Upon entry into the program students will typically enroll in one course per quarter to be taken via distance learning. Typically, students may stack certificates to complete the coursework requirement of either 8 or 10 courses. In addition to the Aero tracks of Aerospace Engineering and Applied Trajectory Optimization, three specialty tracks within the course of study are also offered: Structures, Fluid Thermodynamics and Robotics Engineering. The program of study for each student will be submitted for approval by the Chairman of the Department of Mechanical and Aerospace Engineering.

Aerospace Engineering (Certificate 118 Track)

Students must take four of these six courses to complete the certificate:

Course	Title	Lecture	Lab
ME3205	Missile Aerodynamics	4	1
ME3611	Mechanics of Solids II	4	0
ME4703	Missile Flight and Control	4	1
ME4704	Missile Design	3	2
ME4751	Combat Survivability, Reliability and Systems Safety Engineering	4	1
AE4452	Advanced Missile Propulsion	4	1

Applied Trajectory Optimization (Certificate 299 Track)

AE3820	Advanced Mechanics and Orbital Robotics	3	2
AE3830	Aerospace Guidance and Control	3	2
AE4850	Dynamic Optimization	3	2
AE4881	Aerospace Trajectory Planning and Guidance	2	4

Robotics Engineering (Certificate 223 Track)

ME3420	Computational Foundations for Robotics	3	2
ME4800/AE4800	Machine Learning for Autonomous Operations	3	2

| ME4828 | Fundamental GNC Algorithms of Autonomous Robotics | 3 | 2 |
| EC4310 | Fundamentals of Robotics | 3 | 2 |

Structures (Certificate 122 Track)

ME4731	Engineering Design Optimization	4	0
ME3521	Mechanical Vibration	3	2
ME4613	Finite Element Methods	4	0
ME3611	Mechanics of Solids II	4	0

Thermodynamics/Fluids (Certificate 123 Track)

Student must take four of these seven courses to complete the certificate:

ME4420	Advanced Power and Propulsion	4	0
ME3450	Computational Methods in Mechanical Engineering	3	2
ME4220	Viscous Flow	4	0
ME3201	Applied Fluid Mechanics	4	1
ME4101	Advanced Thermodynamics	4	0
AE4502	Supersonic and Hypersonic Flows	4	0

Educational Skill Requirements (ESRs)
Aerospace Engineering Program – Curriculum 608
Subspecialty Code: None

The ESRs consist of a core of prescribed aerospace engineering skills, which all graduates must acquire; plus specialization options of advanced topics in missile design, autonomous systems, or rotorcraft, which the student may pursue as electives.

1. **AEROSPACE STRUCTURES AND MATERIALS:** Be able to apply U.S. military standards and practices to analyze structural components of missiles systems & autonomous vehicles, using engineering analytic methods on idealized models and automated finite element methods on realistic models to determine stresses, strains, deformations and appropriate limiting conditions of yielding, fracture, buckling and fatigue.

2. **FLIGHT MECHANICS:** Be able to calculate all performance parameters for rotorcraft, military autonomous aircraft, and missile systems to determine their longitudinal and lateral-directional, static and dynamic stability characteristics. Be able to analyze and design aircraft and missile guidance and control systems, including feedback stabilization schemes and stochastic processes, using classical and modern control techniques.

3. **AIRCRAFT AND MISSILE PROPULSION:** Understand the principles and operating characteristics of fixed wing, rotorcraft and missile propulsion engines and be able to analyze the performance of rocket motor and turbines through knowledge of the behavior and design characteristics of the individual components. Be able to

calculate performance parameters used in engine selection and know the state-of-the-art reasons for limitations on gas turbine engine performance, as well as the potential for future gains in the field. Be able to analyze the performance of rockets and ramjets through knowledge of the behavior of individual components, and be able to make steady-state, internal ballistic calculations for solid rocket motors.

4. **AERODYNAMICS:** Be able to use classical analytic, experimental and modern computational techniques of subsonic and supersonic aerodynamics, including laminar and turbulent boundary-layer viscous effects, without heat addition, to calculate internal flow properties through inlets, nozzles and engines and external air flow pressure distributions over wings, canards, tails, and other lifting surfaces to determine the resulting lift, drag and pitching moment.

5. **INFORMATION PROCESSING:** Be able to use current computer methods to solve aerospace engineering problems and possess knowledge of the application of dedicated avionic and systems computers on board military aircraft.

6. **ENGINEERING MATHEMATICS:** Demonstrate analytic ability to apply differential and integral calculus, ordinary and partial differential equations, vector calculus, matrix algebra, probability and statistics and numerical analysis in the development of engineering theory and its application to engineering problems.

7. **ELECTRICAL ENGINEERING:** Understand basic electrical circuits, systems and electronic devices as a foundation for interfacing mechanical and electronic systems in aerospace systems.

8. **SYSTEMS DESIGN:** Be able to integrate all of the disciplines of aerospace engineering into a design of a missile or autonomous system or rotorcraft in response to a realistic set of military requirements, specifications, constraints and cost limitations. The design must include considerations for safety, reliability, maintainability and survivability.

9. **RESEARCH, DEVELOPMENT, TEST, AND EVALUATION:** Apply principles of project scoping, planning, design and execution to investigate a current research, development, test or evaluation problem of interest to the Department of Defense that culminates in the publication of a thesis.

U.S. Naval Test Pilot School/Mechanical and Aerospace Engineering Program – Curriculum 613

Primary Consultant

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Chief of Academics

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Program Coordinator

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Brief Overview

The objective of this special program is to provide an opportunity for graduates of the U.S. Naval Test Pilot School (USNTPS), who are trained in aircraft, rotorcraft, and airborne systems flight test, to obtain a Master of Science in Engineering Science with a major in Aerospace Engineering – MSES(AE). This is a distance learning program building upon the USNTPS academic and flight test instruction, with the student's USNTPS final flight test project and report serving in lieu of a thesis, and will provide advanced aerospace engineering knowledge to the test pilot and flight test engineer. NPS instruction will include advanced aerodynamics, aircraft structures, stability and control, and propulsion, and may also include systems engineering, autonomous vehicles, and air vehicle survivability. Instruction in flight system testing from the USNTPS as well as advanced graduate education in aerospace engineering topics from the NPS will qualify graduates of this program to participate in all technical aspects of naval air weapon systems acquisition.

Requirements for Entry

Entrance into this program is restricted to graduates of the U.S. Naval Test Pilot School (USNTPS) Main Curriculum, currently a 48-week program. Further requirements include an Academic Profile Code of 323. All entrants must be nominated for the program by the designated program coordinator and the primary consultant for USNTPS. The nomination to the Director of Admissions must include official transcripts from all undergraduate and graduate institutions attended plus USNTPS records. The Director of Admissions will provide copies of all records to the Academic Associate in Aerospace Engineering.

Convenes

Students will enter this program during the Spring or Fall NPS academic quarters, typically 3 months following their graduation from USNTPS. Application for entry is to be made through the program coordinator and primary consultant for USNTPS. For further information, contact the Academic Associate, Program Coordinator, or the Primary Consultant for this program.

Degree Requirements

The student must complete 24 credit hours of advanced graduate level NPS (AE/ME/MS/SE 3000- and 4000-level) courses, with a minimum of 12 of the 24 hours at the 4000-level. This requirement may be met by completing a sequence of six courses via Distance Learning in a program approved by the Chairman of the Department of Mechanical and Aerospace Engineering. This Master of Science in Engineering Science (Major in Aerospace Engineering) program may be completed in six academic quarters following USNTPS graduation.

Credit for Completion of U.S. Naval Test Pilot School

This program is designed to build upon the USNTPS academic instruction and final flight test project and report. The following USNTPS courses are considered as integral to this program and equivalent to 6 credit hours of ME/AE 3000- level and 8 credit hours of ME/AE 4000-level NPS courses:

USNTPS	MM503	Dynamic Systems Analysis Techniques
USNTPS	PP501	Thermodynamics
USNTPS	PP801	Propulsion Systems
USNTPS	SC507	Airplane Stability and Control
USNTPS	SC604	Airplane Dynamics
USNTPS	SC502	Helicopter Rotor Systems
USNTPS	AP501	Helicopter Performance and Aerodynamics
USNTPS	SC506	Helicopter Stability and Control
USNTPS	SY503	Airborne Navigation Systems
USNTPS	SY601	Airborne Electro-optical Systems

In addition, the USNTPS DT-II flight test project and report is considered in lieu of a thesis. The NPS transcript will include 14 credits for the USNTPS program. The Quality Point Rating (QPR) for the NPS transcript will be computed based only on the NPS courses completed by the student.

Subspecialty

Graduates of USNTPS earn a Navy Subspecialty Code of 5403 which applies to their flight test training. Completion of this curriculum qualifies an officer as an Aerospace Engineering Specialist with a subspecialty code of 5402P. The curriculum sponsor is Naval Air Systems Command.

Typical Course of Study

Upon entry into the program students will typically enroll in one course per quarter to be taken via distance learning. All requirements must be completed within three calendar years from entry. The program of study for each student will be submitted for approval by the Chairman of Mechanical and Aerospace Engineering. A typical course sequence would include:

Core Courses:

Course	Title	Lecture	Lab
AE4452	Advanced Missile Propulsion	4	1
ME3205	Missile Aerodynamics	4	1
ME3611	Mechanics of Solids II	4	0
ME4703	Missile Flight and Control	4	1
ME4704	Missile Design	3	2

Other Courses:

Course	Title	Lecture	Lab
SE3100	Fundamentals of Systems Engineering	3	2
ME4751	Combat Survivability, Reliability and Systems Safety Engineering	4	1

Educational Skill Requirements (ESRs)

USNTPS – Aerospace Engineering Program – Curriculum 613

Subspecialty Code: None

The ESRs required by the Naval Air Systems Command are met upon graduation from USNTPS. This is a degree program only, leading to the Master of Science in Engineering Science with Major in Aerospace Engineering.

Department of Meteorology

Chair

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Associate Chair, Research

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Hway-Jen Chen, Research Associate (2000); M.S., University of California - Los Angeles, 1993.

Philip A. Durkee, Professor (1984); Ph.D., Colorado State University, 1984.

Paul A. Frederickson, Research Associate (1999); M.S., University of Maryland, 1989.

Eric A. Hendricks, Associate Professor (2015); Ph.D. Colorado State, 2008.

Peter S. Guest, Research Professor (1992); Ph.D., Naval Postgraduate School, 1992.

Patrick A. Harr, Professor (1989); M.S., Colorado State University, 1978; Ph.D. Naval Postgraduate School, 1993.

Mary S. Jordan, Research Associate (1999); M.S., Naval Postgraduate School, 1985.

Michael T. Montgomery, Professor (2006); Ph.D., Harvard, 1986.

James T. Murphree, Research Associate Professor (1991); Ph.D., University of California at Davis, 1989.

Kurt E. Nielsen, Research Associate (1999); M.S., University of Oklahoma, 1988.

Wendell A. Nuss, Professor and Department Chair (1986); Ph.D., University of Washington, 1986.

John M. Peters, Assistant Professor (2017); Ph.D., Colorado State University, 2015.

Qing Wang, Professor and Associate Chair for Research (1995); Ph.D., Pennsylvania State University, 1993.

Professors Emeriti:

Chih-Pei Chang, Distinguished Professor Emeritus (1972); Ph.D., University of Washington, 1972.

Kenneth L. Davidson, Professor Emeritus (1970); Ph.D., University of Michigan, 1970.

Russell L. Elsberry, Distinguished Professor Emeritus (1968); Ph.D., Colorado State University, 1968.

Robert L. Haney, Professor Emeritus (1970); Ph.D., University of California at Los Angeles, 1971.

Robert J. Renard, Distinguished Professor Emeritus (1952); Ph.D., Florida State University, 1970.

Carlyle H. Wash, Professor Emeritus (1980); Ph.D., University of Wisconsin, 1978.

Forest Williams, Senior Lecturer Emeritus (1975); M.S., Naval Postgraduate School, 1962; M.S., Massachusetts Institute of Technology, 1972.

Roger T. Williams, Professor (1968); Ph.D., University of California at Los Angeles, 1963.

* The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

Brief Overview

The Department of Meteorology's history dates back to the 1940s when it was part of the Postgraduate Department at the Naval Academy. The department's academic function is interdisciplinary in nature in that it supports separate Master of Science Degree programs: Meteorology, Meteorology and Physical Oceanography, and Oceanography; and, provides courses for the Space Systems, Undersea Warfare, Information/Electronic

Warfare, and Joint Command, Control, Communications, Computers and Intelligence (C4I) curricula. Offerings in the Special Operations and Joint Warfare Analysis are under development.

Department academic strengths include air/ocean dynamics and numerical modeling and prediction, structure and dynamics of the atmospheric boundary layer, satellite remote sensing and its applications and synoptic meteorology, including analysis and prediction in tropical, mid-latitude, and polar regions in both hemispheres. More than forty courses are offered in meteorology, primarily at the graduate level. The department has fourteen faculty (7 tenure track, 7 non-tenure track, 2 military, and 7 emeritus), with graduate student participation as research-team members through the M.S. thesis and Ph.D. dissertation process. The current areas of research concentration encompass numerical and analytic air/ocean modeling and prediction, tropical meteorology (including monsoon circulations and tropical cyclone dynamics and forecasting), coastal meteorology and oceanography, climate dynamics, marine boundary layer studies with emphasis on air/sea interactions and electromagnetic/optic propagation, remote sensing/satellite meteorology and a wide range of synoptic studies (e.g., regional studies, maritime cyclogenesis, short range forecasting, and numerical-model verification). The Ph.D. program in the department is active with Navy officers, Air Force officers, DoD civilians and international officers among its recent graduates.

Degree

A student is able to earn an academic degree listed below while enrolled in Meteorology (Curriculum 372) and Meteorology and Oceanography (Curriculum 373).

Master of Science in Meteorology

Entrance to a program leading to a Master of Science in Meteorology degree requires a baccalaureate degree with completion of mathematics through differential and integral calculus and a minimum of one year of college physics.

The Master of Science in Meteorology degree requires completion of:

1. Necessary prerequisite courses in mathematics (through partial differential equations) and meteorology,
2. The sequence of core courses in the fields of dynamical, numerical, physical and synoptic meteorology,
3. An approved selection of graduate elective courses,
4. An acceptable thesis.

The total number of quarter-hours in (2) and (3) above must be at least 36. These 36 hours must include 18 quarter-hours at the 4000 level in courses other than directed study.

Master of Science in Meteorology and Physical

Oceanography

Direct entrance to a program leading to the Master of Science in Meteorology and Physical Oceanography degree requires a baccalaureate degree in one of the physical sciences, mathematics or engineering. This normally permits the validation of a number of required undergraduate courses such as physics, differential equations, linear algebra, vector analysis, and various courses in meteorology and/or oceanography which are prerequisites to the graduate program. These prerequisites may be taken at the Naval Postgraduate School; however, in that event, the program may be lengthened by one or more quarters.

The Master of Science in Meteorology and Physical Oceanography degree requires completion of:

1. Necessary prerequisite courses in mathematics (through partial differential equations), meteorology, and physical oceanography,
2. The sequence of core courses in the fields of dynamical, numerical, physical and synoptic meteorology and oceanography,
3. An approved selection of graduate elective courses in meteorology and oceanography,
4. A significant educational experience in the field using instruments.
5. An acceptable thesis on a topic approved by the department.

The total number of quarter-hours in (2) and (3) above must be at least 48. These 48 hours must include 20 hours at the 4000 level in courses other than directed study, and they should show an approximate balance between the disciplines of meteorology and oceanography.

Dual Degree in Meteorology and Physical Oceanography

The Meteorology and Oceanography Departments have adopted a policy to not recommend the award of dual master's degrees in Meteorology and Physical Oceanography.

Doctor of Philosophy

The Ph.D. program is offered in the Department of Meteorology in the following areas of study: numerical weather prediction, geophysical fluid dynamics, boundary-layer meteorology, analysis of atmospheric systems and tropical meteorology.

The requirements for the degree are grouped into three categories: course work, research in conjunction with an approved dissertation and examination in both the major and, if elected, a minor field. The minor field is usually in physical oceanography, mathematics or physics.

The Department of Meteorology also may require a preliminary examination to show evidence of acceptability as a doctoral student.

Prospective students should consult with the Chairman of the Department of Meteorology for further guidance regarding doctoral programs.

Laboratories

As described below, the department is served by four major laboratory facilities: An interactive computer lab, a synoptic meteorology lab, a meteorological measurements lab, and a tactical applications lab.

The Interactive Digital Environmental Analysis (IDEA) Laboratory, which is shared with Oceanography, provides real-time acquisition and analysis of conventional and remotely-sensed data in support of the synoptic and physical meteorology and oceanography programs. The laboratory consists of 22 image analysis and graphics workstations. The laboratory accesses real-time GOES, NOAA, Navy (FNMOC), and DMSP data for use in instruction and research.

The department has developed a modern Synoptic Analysis and Forecasting Laboratory which receives environmental products and observations for instruction on the preparation of real-time weather analyses and forecasts. Fleet Numerical Meteorology and Oceanography Center (FNMOC) and the National Center for Environmental Prediction (NCEP) weather analysis and forecast products are received through a variety of channels that include UNIDATA and the World-Wide Web. UNIX workstations and PC-based systems provide multiple software capabilities for displaying, animating, and visualizing current weather observations, satellite images, radar observations, and numerical model products obtained from FNMOC, NCEP or generated locally.

The Marine Atmospheric Measurements Laboratory utilizes in-situ and remote sensing instrumentation systems for both teaching and research. Instrumentation includes: A 404 MHz and 915 MHz Doppler radar wind profiler with radio acoustic sounding system (RASS); rawinsonde systems with GPS navigational aids; a laser ceilometer; and a fully instrumented surface weather station. Access to other instrumentation (measuring turbulent fluxes, aerosols, etc.), measuring platforms (research vessel, buoys, and remotely piloted aircraft) and data from a variety of networked local measurement sites enables the laboratory to provide near "real-time" data from the coastal region.

Meteorology Course Descriptions

MR Courses (p. 433)

Certificate in Meteorology - Curriculum 264

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Academic Associate

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Brief Overview

The Certificate in Meteorology is an intensive program in Meteorology designed to meet the requirements of the Basic Instruction Package for Meteorology (BIP-M) as set forth by the World Meteorological Organization (WMO) requirements for all practicing professional Meteorologists. These are set forth in their publication WMO-1083 Manual on the Implementation of Education and Training Standards in Meteorology and Hydrology (2012). The overall aim of the Certificate in Meteorology is to provide an individual with a robust and broad range of knowledge of atmospheric phenomena and processes, together with skills related to the application of this knowledge. Specifically, as stated in WMO-1083, the individual must achieve learning outcomes that cover;

• the acquisition of knowledge about physical principles and atmospheric interactions, methods of measurement and data analysis, behavior of weather systems (through the synthesis of current weather data and conceptual models), and the general circulation of the atmosphere and climate variations;

• the application of knowledge based on the use of scientific reasoning to solve problems in atmospheric science, and participation in the analysis, prediction, and communication of the impacts of weather and climate on society.

Five core courses in meteorology are required for completion of this certificate but prerequisite courses in meteorology and mathematics must be satisfactorily completed (at NPS or elsewhere) in order to enroll in the certificate and meet the educational requirements set forth in WMO-1083. This course of study is the equivalent of a Bachelor's of Science in Meteorology (major only) but the certificate is awarded in place of an undergraduate degree.

This program is primarily intended for U.S. Air Force students seeking a career in weather that do not already have an undergraduate degree in Meteorology or Atmospheric Science. Other services (except U.S. Navy or Marines), Federal civilians, or Internationals may apply if they require WMO-1083 compliance in Meteorology.

Convenes

Winter, Summer

Program Length

Four quarters

Typical Course of Study:

Quarter 1

MR4322 Dynamic Meteorology and MR4413 Air-Sea Interaction are required for the certificate and lay the initial groundwork in atmospheric dynamics and boundary layer processes.

Prerequisite Courses (must have previously been completed)

- MR3222 Meteorological Analysis
- MR3321 Air-Ocean Fluid Dynamics
- MR3480 Atmospheric Thermodynamics

Course	Title	Lecture	Lab
MR4322	Dynamic Meteorology	4	0
MR4413/OC4413	Air-Sea Interaction	4	0

Quarter 2

MR3234 Tropospheric and Stratospheric Meteorology (Weather Systems) and MR4323 Numerical Weather Prediction are required for the certificate.

Prerequisite Courses (must be taken prior to these courses)

- MR3522 Remote Sensing of the Atmosphere
- MA2121 Ordinary Differential Equations

MR3234	Tropospheric and Stratospheric Meteorology/Laboratory	4	4
MR4323	Air and Ocean Numerical Prediction Systems	4	2

Quarter 3

MR3262 Operational Weather Prediction is culminating certificate course utilizing aspects from all prior courses to gain practice in weather forecasting utilizing numerical forecasts and understanding of weather processes and systems.

MR3262	Operational Atmospheric Prediction/Laboratory	3	5

Meteorology and Oceanography (METOC) - Curriculum 373 (ME)

Meteorology

Program Officer

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Brief Overview

This Program will provide qualified personnel with a sound understanding of the science of meteorology. The program is designed to provide the student with:

- A thorough understanding of the principles governing the physical and dynamic properties of the atmosphere.
- The ability to observe, assimilate, analyze, interpret, and predict atmospheric parameters and conditions

using field experimentation, direct and remote sensing observational techniques, statistical analyses and numerical models.
- A thorough understanding of the effects of atmospheric properties and conditions on weapon, sensor and platform performance while conducting and supporting military warfare.
- A meteorological research experience germane to military warfare, culminating in a thesis of professional quality.

Requirements for Entry

The master's program is open to International Officers, officers from other services, and DoD civilians. It is open to Information Dominance Corp (18xx) and Unrestricted Line officers of the U.S. Navy and officers from other services. Students in the USAF Basic Meteorology Program (BMP) are also listed in this curriculum. The remainder of this section applies to the MS degree program.

For the master's program, a baccalaureate degree with completion of mathematics through differential and integral calculus and a minimum of one year of college physics is required. An APC of 233 is required for direct entry. A refresher quarter is available for candidates who do not meet all admission requirements for direct entry and is normally offered in the Summer quarter prior to enrollment.

Convenes

Fall quarter

Program Length

Meteorology is a six-quarter course of study. For further information, contact the Program Officer. Academic questions may be referred directly to the Academic Associate.

Degree

Master of Science in Meteorology.

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
MR2020	Computer Computations in Air-Ocean Sciences	2	2
MR3140	Probability and Statistics for Air-Ocean Science	3	2
MR3252	Tropical Meteorology/Laboratory	3	4

MA1115, MA1116: 6wks

Quarter 2

MA3132	Partial Differential Equations and Integral Transforms	4	0

MR3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
MR4322	Dynamic Meteorology	4	0
MR4413/OC4413	Air-Sea Interaction	4	0

Quarter 3

MR3610	Modern Climatology	4	0
MR4234	Advanced Topics in Mid-Latitude Weather Systems	4	0
MR4323	Air and Ocean Numerical Prediction Systems	4	2
MR4900	Directed Study in Meteorology	V	0

Quarter 4

MR4241	Mesoscale Meteorology	3	0
MR4800	Advanced Topics in Meteorology	V	0
MR0810	Thesis Research	0	8
MR0810	Thesis Research	0	8

Quarter 5

MR4262	Advanced Meteorological Prediction	3	2
MR4800	Advanced Topics in Meteorology	V	0
MR0810	Thesis Research	0	8
MR0810	Thesis Research	0	8

Quarter 6

MR4800	Advanced Topics in Meteorology	V	0
MR0810	Thesis Research	0	8
MR0810	Thesis Research	0	8
MR0999	Seminar in Meteorology	2	0

Educational Skill Requirements (ESR)
Meteorology (Masters) Program
Subspecialty Code: Not Applicable for MS Degree

Note -This program primarily supports USAF and International graduate education, thus there is no Navy p-code or subspecialty associated with this master's program, and no official ESRs . This list describes the skills this program will provide students upon successful completion.

The Meteorology program will provide qualified personnel with a sound understanding of the science of meteorology. The program is designed to provide the student with:

1. A thorough understanding of the principles governing the physical and dynamic properties of the atmosphere.
2. The ability to observe, assimilate, analyze, interpret, and predict atmospheric parameters and conditions using field experimentation, direct and remote sensing observational techniques, statistical analyses and numerical models.

3. A thorough understanding of the effects of atmospheric properties and conditions on weapon, sensor and platform performance, while conducting and supporting military warfare.
4. A meteorological research experience germane to military warfare, culminating in a thesis of professional quality.

Educational Skill Requirements (ESR)
Meteorology (Ph.D.)
Subspecialty Code: 6403D

The officer must have a thorough theoretical and functional knowledge (obtained at the doctorate level) of the principles of meteorology and its effects on naval warfare and weapons systems.

Meteorology and Oceanography (METOC under Dept. of Meteorology)

Program Officer

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Brief Overview

The program in meteorology and oceanography involves approximately 109 quarter-hours of classroom lectures, supplemented by an additional 42 quarter-hours of laboratory exercises. This program is designed to provide the student with:

- A thorough understanding of the principles governing the physical and dynamic properties of the oceans and atmosphere.
- The ability to observe, assimilate, analyze, interpret, and predict oceanic and atmospheric parameters and conditions using field experimentation, direct and remote sensing observational techniques, statistical analyses, and numerical models.
- A thorough understanding of the effects of oceanic and atmospheric properties and conditions on weapon, sensor and platform performance while conducting and supporting naval warfare, with particular emphasis on ocean acoustics and electromagnetic/optical propagation.
- An oceanographic or meteorological research

experience germane to naval warfare culminating in a thesis of professional quality.

- A knowledge of Joint Strategy and Policy.
- Thesis with multi-authors is not allowed.

This education will enhance performance in all duties throughout a career, including operational billets, technical management assignments and policy making positions. Students will develop graduate-level technical ability based upon scientific principles, acquire diverse professional knowledge, and develop analytical ability for practical problem solving.

Requirements for Entry

This program is open to METOC (1800) Officers, officers from other services, International Officers and DoD civilians.

A baccalaureate degree in the physical sciences, mathematics or engineering is required. Completion of mathematics through differential and integral calculus and one year of calculus-based college physics are required. An APC of 233 is required for direct entry. Waivers may be obtained with a one-quarter refresher.

Convenes

January and July

Program Length

The METOC program is normally a ten-quarter course of study. If further information is needed, contact the Program Officer. Academic questions may be referred directly to either of the Academic Associates.

Degree

Master of Science in Meteorology and Physical Oceanography.

Subspecialty

Completion of this program qualifies an officer as a METOC Subspecialist with a subspecialty code of 6401P. The Program Sponsor is the Oceanographer of the Navy (CNO N2/N6E).

Typical Subspecialty Jobs

METOC Officer aboard CV(N)/LHD
Submarine Group Staff
Numbered Fleet Staff
CARSTRKGRU Staff
OIC Naval Meteorology and Oceanography Command Detachment
NAVMETOCCOM Mobile Warfare Teams
National Geospatial Agency
Office of Naval Research

Typical Course of Study - Summer Start

Quarter 1

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0

Course	Title	Lecture	Lab
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
MR0001	METOC Colloquium -or-	0	1
OC0001	METOC Colloquium	0	1

Quarter 2

Course	Title	Lecture	Lab
OC3230	Descriptive Physical Oceanography	3	1
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
MA2121	Differential Equations	4	0
MR0001	METOC Colloquium -or-	0	1
OC0001	METOC Colloquium	0	1

Quarter 3

Course	Title	Lecture	Lab
MR3480	Atmospheric Thermodynamics and Radiative Processes	4	1
MR2020	Computer Computations in Air-Ocean Sciences -or-	2	2
OC2020	Computer Computations in Air-Ocean Sciences	2	2
MA3132	Partial Differential Equations and Integral Transforms	4	0
MR3140	Probability and Statistics for Air-Ocean Science -or-	3	2
OC3140	Probability and Statistics for Air-Ocean Science	3	2
MR0001	METOC Colloquium -or-	0	1
OC0001	METOC Colloquium	0	1

Quarter 4

Course	Title	Lecture	Lab
MR3222	Meteorological Analysis/Laboratory	4	3
MR3150	Analysis of Air/Ocean Time Series -or-	3	2
OC3150	Analysis of Air Ocean Time Series	3	2
OC3260	Fundamentals of Ocean Acoustics	4	1
MR3321	Air-Ocean Fluid Dynamics -or-	4	0

Course	Title		
OC3321	Air-Ocean Fluid Dynamics	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 5

Course	Title		
MR4322	Dynamic Meteorology	4	0
MR4413/OC4413	Air-Sea Interaction	4	0
	-or-		
OC4413/MR4413	Air/Sea Interaction	4	0
MR3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
	-or-		
OC3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
OC3240	Ocean Circulation Analysis	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 6

Course	Title		
MR4323	Air and Ocean Numerical Prediction Systems	4	2
	-or-		
OC4323	Air and Ocean Numerical Prediction Systems	4	2
MR3234	Tropospheric and Stratospheric Meteorology/Laboratory	4	4
OC4800	Advanced Courses in Oceanography	V	0
OC3212	Polar Meteorology/Oceanography	4	0
OC4211	Ocean Dynamics II	4	0
MR4900	Directed Study in Meteorology	V	0
	-or-		
OC4900	Directed Study in Oceanography	V	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 7

Course	Title		
MR3252	Tropical Meteorology/Laboratory	3	4
MR4800	Advanced Topics in Meteorology	V	0
	-or-		
OC4800	Advanced Courses in Oceanography	V	0
NW3230	Strategy & War	4	2
OC3212	Polar Meteorology/Oceanography	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 8

Course	Title		
MR4240	Coastal Meteorology	3	1
OC4335	Naval Ocean Analysis and Prediction	3	2
OC4210	Littoral Field Studies	2	4
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 9

Course	Title		
MR4416	Atmospheric Factors in Electromagnetic and Optical Propagation	3	0
OC4270	Tactical Oceanography	3	4
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 10

Course	Title		
MR3262	Operational Atmospheric Prediction/Laboratory	3	5
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8

MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0999	Seminar in Meteorology	2	0
	-or-		
OC0999	Thesis Seminars	2	0

Typical Course of Study-Winter Start

Quarter 1

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 2

OC3230	Descriptive Physical Oceanography	3	1
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
MA2121	Differential Equations	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 3

MR3480	Atmospheric Thermodynamics and Radiative Processes	4	1
MR2020	Computer Computations in Air-Ocean Sciences	2	2
	-or-		
OC2020	Computer Computations in Air-Ocean Sciences	2	2
MA3132	Partial Differential Equations and Integral Transforms	4	0
MR3140	Probability and Statistics for Air-Ocean Science	3	2
	-or-		
OC3140	Probability and Statistics for Air-Ocean Science	3	2
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 4

MR3222	Meteorological Analysis/Laboratory	4	3
MR3150	Analysis of Air/Ocean Time Series	3	2
	-or-		
OC3150	Analysis of Air Ocean Time Series	3	2
OC3260	Fundamentals of Ocean Acoustics	4	1
MR3321	Air-Ocean Fluid Dynamics	4	0
	-or-		
OC3321	Air-Ocean Fluid Dynamics	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 5

MR4322	Dynamic Meteorology	4	0
MR4413/OC4413	Air-Sea Interaction	4	0
	-or-		
OC4413/MR4413	Air/Sea Interaction	4	0
MR3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
	-or-		
OC3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
OC3240	Ocean Circulation Analysis	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 6

MR4323	Air and Ocean Numerical Prediction Systems	4	2
	-or-		
OC4323	Air and Ocean Numerical Prediction Systems	4	2
MR3234	Tropospheric and Stratospheric Meteorology/Laboratory	4	4
OC4800	Advanced Courses in Oceanography	V	0
MR4900	Directed Study in Meteorology	V	0

	-or-		
OC4900	Directed Study in Oceanography	V	0
OC4211	Ocean Dynamics II	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 7

MR3252	Tropical Meteorology/Laboratory	3	4
MR4800	Advanced Topics in Meteorology	V	0
	-or-		
OC4800	Advanced Courses in Oceanography	V	0
MR4416	Atmospheric Factors in Electromagnetic and Optical Propagation	3	0
NW3230	Strategy & War	4	2
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 8

MR3262	Operational Atmospheric Prediction/Laboratory	3	5
MR4325	METOC for Warfighter Decision Making	3	2
OC4210	Littoral Field Studies	2	4
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 9

OC4270	Tactical Oceanography	3	4
OC3212	Polar Meteorology/Oceanography	4	0
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 10

MR4240	Coastal Meteorology	3	1
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0999	Seminar in Meteorology	2	0
	-or-		
OC0999	Thesis Seminars	2	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Educational Skill Requirements (ESR)
Meteorology & Oceanography (METOC) Program
Subspecialty Code: 6401P

1. **Integration of Oceanic & Atmospheric Parameters:** The officer must be able to observe, assimilate, analyze, and predict oceanic and littoral water conditions, and atmospheric conditions using direct and remote sensing observation techniques, statistical analysis, and numerical models. The officer will have a sound understanding of polar, mid-latitude and tropical atmospheric and oceanographic dynamics, including the impact of these region's conditions on military operations and systems.

2. **Numerical Prediction Systems:** The officer will have a thorough understanding of numerical prediction systems as it applies to the physics and dynamics of the ocean and the atmosphere. This understanding should include a broad understanding of the modeling systems to include strengths, weaknesses, and vulnerabilities; the state of current models and techniques; and appropriate applications of deterministic and stochastic techniques.

3. **Ocean/Atmosphere Problem Solving:** The officer must develop critical thinking skills and conduct independent analyses to solve environmentally challenging problems in the fields of Physical Oceanography and/or Meteorology as they apply to Naval/Joint operations, using modern scientific research techniques, field experience, tools, and equipment.

4. **Decision Superiority:** The officer must have a thorough understanding of open-ocean and near-shore oceanographic and atmospheric dynamics and properties. The officer must have the ability to apply this knowledge to warfighter decisions using sound

decision theory, taking into account available courses of action, assessments of vulnerability, uncertainty, and risk.

5. **Other NPS Requirements:** The officer must successfully complete all NPS requirements for the Master's Degree in Meteorology and Physical Oceanography.

Meteorology PhD - Curriculum 387
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Academic Associate
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Brief Overview

The Ph.D. program is offered in the Department of Meteorology in the following areas of study: numerical weather prediction, geophysical fluid dynamics, boundary-layer meteorology, analysis of atmospheric systems and tropical meteorology. The requirements for the degree are grouped into three categories: course work, research in conjunction with an approved dissertation and examination in both the major and, if elected, a minor field. The minor field is usually in physical oceanography, mathematics or physics. The Department of Meteorology also may require a preliminary examination to show evidence of acceptability as a doctoral student. Prospective students should consult with the Chairman of the Department of Meteorology for further guidance regarding doctoral programs.

Department of National Security Affairs
Website
www.nps.edu/nsa
Chairman
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Donald Abenheim, Professor Emeritus (1985); Ph.D., Stanford University, 1985.

Anne Marie Baylouny, Professor (2003); Ph.D., University of California Berkeley, 2003.

Thomas C. Bruneau, Distinguished Professor Emeritus (1987); Ph.D., University of California Berkeley, 1970.

Luke A. Calvert, LTC., USA, Strategy Chair (2023), M.B.A. Webster University, 2017. M.A., School of Advanced

Military Studies, 2018.

Anshu Chatterjee, Lecturer (2003); Ph.D., University of California Berkeley, 2003.

Anne L. Clunan, Associate Professor (2002); Ph.D., University of California Berkeley, 2001.

Erik Dahl, CDR, USN (ret.), Associate Professor (2008); Ph.D., Tufts University, 2008.

Christopher Darnton, Associate Professor (2016); Ph.D., Princeton University, 2009.

David Dow, Assistant Professor (2023); Ph.D., University of California, Berkeley, 2018.

Ryan Gingeras, Professor (2010); Ph.D., University of Toronto, 2006.

Mariana Giusti Rodriguez, Assistant Professor (2018); Ph.D., Cornell University, 2018.

Michael Glosny, Lecturer (2010); Ph.D., Massachusetts Institute of Technology, 2012.

Mohammed Hafez, Professor (2008); Ph.D., London School of Economics, 2000.

Carolyn C. Halladay, Senior Lecturer (2010); J.D. Stanford University Law School, 2002; Ph.D., University of California Santa Cruz, 1997.

Wade Lee Huntley, Senior Lecturer (2009); Ph.D., University of California at Berkeley, 1993.

Scott E. Jasper, CAPT, USN (ret.), Senior Lecturer (2002); Ph.D, University of Reading 2018.

Thomas H. Johnson, Research Professor (2003); M.A., University of Southern California, 1976.

S. Paul Kapur, Professor (2008); Ph.D., University of Chicago, 1999.

Feroz Khan, BRIG, Pakistan Army (ret.), Lecturer (2008); M.A., School of Advanced International Studies, The Johns Hopkins University, 1991.

Jeffrey Larsen, Adjunct Professor (2018); Ph.D., Princeton University, 1991.

Letitia Lawson, Senior Lecturer (1996); Ph.D., University of California Davis, 1995.

Robert Edward Looney, Distinguished Professor Emeritus (1979); Ph.D., University of California Davis, 1969.

Tristan Mabry, Senior Lecturer (2009); Ph.D., University of Pennsylvania, 2007.

Michael Malley, Lecturer (2004); Ph.D., University of Wisconsin-Madison, 1999.

Cristiana Matei, Senior Lecturer (2010); Ph.D., King's College, University of London, 2016.

Aleksandar Matovski, Assistant Professor (2020); Ph.D., Cornell University, 2015.

Emily Meierding, Associate Professor (2016); Ph.D. University of Chicago, 2010.

Covell Meyskens, Associate Professor (2015); Ph.D, University of Chicago, 2015.

James Clay Moltz, Professor (2007); Ph.D., University of California Berkeley, 1989.

Daniel Moran, Professor (1994); Ph.D., Stanford University, 1982.

Rodrigo Nieto-Gomez, Assistant Research Professor (2010); Ph.D. University of Paris VIII, 2009.

Edward Allan Olsen, Professor Emeritus (1980); Ph.D., American University, 1974.

Afshon Ostovar, Associate Professor (2016); Ph.D., University of Michigan, 2009.

Michael Owen, CAPT, USN, Information Warfare Chair/Senior Intelligence Officer (2023); M.A., Old Dominion University, 2004, M.A., Regent University, 2015.

Jessica Piombo, Associate Professor (2003); Ph.D., Massachusetts Institute of Technology, 2002.

Douglas Porch, Distinguished Professor Emeritus (1996); Ph.D., Cambridge University, 1972.

Maria Rasmussen, Associate Professor (1993); Ph.D., Yale University, 1990.

James Russell, Associate Professor (2001); Ph.D., King's College, University of London, 2009.

Zachary Shore, Professor (2006); D.Phil., Oxford University, 1999.

Alexandra Sukalo, Assistant Professor (2022); Ph.D., Stanford University, 2021.

Willian D. Swensen, LTC., USA, Foreign Area Officer Advisor (2021), M.A., Naval Postgraduate School, 2017.

Mikhail Tsypkin, Professor Emeritus (1987); Ph.D., Harvard University, 1985.

John Tully, CAPT, USN, Foreign Area Officer and Coalition Warfare Chair (2022); M.A., Naval Postgraduate School, 2001.

Christopher Twomey, Associate Professor (2004); Ph.D., Massachusetts Institute of Technology, 2004.

Robert Weiner, Lecturer (2007), Ph.D., University of California Berkeley, 2003.

James J. Wirtz, Professor (1990); Ph.D., Columbia University, 1989.

David Scott Yost, Distinguished Professor Emeritus (1979); Ph.D., University of Southern California, 1976.

Thomas-Durell Young, Senior Lecturer (2009), Ph.D., University of Geneva (CH), 1988.

Brief Overview

The Department of National Security Affairs (NSA) specializes in the study and teaching of international relations, regional politics and security, international and military history, international political economy, and United States security policy. NSA brings together a faculty comprising historians, political scientists, and economists, with students from all the U.S. armed forces, from various defense agencies, and officers and civilians from dozens of countries around the world.

Requirements for Entry

Applicants for MA programs must have obtained a Bachelor's degree from a regionally accredited academic institution. Graduate Record Examination (GRE) scores are not required for Navy, Marine Corps, or Air Force applicants, but Army and Air Force applicants must include scores from the GRE, taken within five years of the date of application.

International students whose native language, or language of prior instruction, was other than English, are required to have obtained a minimum total score of 90 on the internet-based Test of English as a Foreign Language (TOEFL), or a score of 560 on the written test.

Degrees

NSA offers a Master of Arts in Security Studies and a Master of Science in Strategy. These degrees always entail concentration in a particular regional or topical specialty, which is noted as part of the degree. Specific requirements:

1. Total required credit hours will vary between 48-80 depending on students' length of program.

2. The completion of an approved sequence of graduate courses, including at least three courses at the 4000 level, in one of the following curricula: Strategic Studies (Strategy and Policy; Nuclear Command Control, and Communications; Space Operations), Civil Military Relations, Homeland Security and Defense, Combating Terrorism, or Regional Studies (Middle East, South Asia, and Sub-Saharan Africa; East Asia and the Indo-Pacific; Western Hemisphere; Europe and Eurasia).

3. Successful completion of departmental comprehensive examination or completion of an acceptable thesis.

4. Depending on the curriculum, thesis research may be substituted by a combination of a comprehensive exam and the successful completion of a foreign language program at the Defense Language Institute.

Regional Security Studies

NSA Regional Security Studies curricula meet the high standards set by the U.S. armed forces for Foreign Area Officer education. Students can enroll in one of four curricula:

- Curriculum 681 - Middle East, South Asia, and Sub-Saharan Africa
- Curriculum 682 - East Asia and the Indo-Pacific
- Curriculum 683 - Western Hemisphere
- Curriculum 684 - Europe and Eurasia

International Security Studies

NSA offers a number of degree programs focusing on topics or problems with broad application to international security generally:

- Curriculum 685 - Civil-Military Relations

- Curriculum 688 - Strategic Studies (Strategy and Policy; Nuclear Command Control, and Communications; Space Operations)
- Curriculum 691 - Homeland Security and Defense
- Curriculum 692 - Homeland Defense and Security
- Curriculum 693 - Combating Terrorism: Policy and Strategy

Curricular Structure

All NSA curricula share a common structure, which is designed to provide a firm foundation in the basics of security studies, along with in-depth exposure to a particular regional or topical specialty. This structure varies slightly depending on whether or not a degree program requires a Master's Thesis.

1. **Disciplinary core courses.** All NSA students are expected to complete four disciplinary core courses. These provide a basic familiarity with the underlying academic disciplines that constitute the multidisciplinary field of security studies: history, international relations, and comparative politics. A course in writing and research methods is also required. Because of their foundational purpose, disciplinary core courses should be completed early in a student's time at NPS.

2. **Curricular core courses and elective courses.** All NSA curricula require students to complete at least eight graduate-level courses in their subject of concentration. These are divided between curricular core courses and curricular electives. The ratio of core and elective course varies from one curriculum to the next, but the minimum total is always eight, of which at least three (12 credit hours minimum) must be at the 4000-level.

3. **General Electives.** NSA degree programs usually afford some opportunity for students to take courses in subjects outside their area of specialization. Such courses are called "general" electives, and they may be chosen from among all courses offered at NSA. General electives exist to provide an opportunity for students to take courses relevant to their thesis research, but which may lie outside their particular regional or topical area of concentration. They are not optional. Curricula that provide scope for general electives also require that a certain number must be taken in order to complete the degree. The number of general electives available to students in a given program will vary, depending on sponsor requirements. In some cases such requirements may preempt a student's choice of general electives.

4. **Thesis research.** Students who are required to write a thesis must complete two courses related to the thesis proposal, NS4079 and NS4080, no later than six months prior to graduation. Afterward, they may take NS0810, Thesis Research, up to three times. NS4079 and NS4080 are Pass-Fail courses. They do not count toward the minimum of 12 credit hours of 4000-level course work

described above.

> **4a. Comprehensive examination.** NSA's regional curricula allow successful completion of language training at the Defense Language Institute to serve as a partial substitute for a Master's thesis. In addition to language training students who do not write a thesis must also take a comprehensive examination, for which they prepare by enrolling in NS0811 during their final quarter. NS0811 counts as a regular course, and should not be taken as an overload.

Additional Requirements

1. **Naval Intelligence Requirement.** All Naval Intelligence officers in NSA are required to take NS4159, Seminar on Joint Intelligence Support to Crisis Operations, in lieu of a general elective. This course does not count toward the requirement of three 4000-level courses in a student's area of concentration, unless it is specifically included among the curricular electives of a particular program.

2. **Navy FAO Strategy Requirement.** All Navy Foreign Area Officers in NSA Masters degree programs are required to complete classes on the core strategic topics, including Security Cooperation. Additional information about this requirement is available from the Navy FAO Chair and NSA Department Ed Tech."

3. **JPME.** Students at NPS have the opportunity to complete a sequence of Naval War College courses that convey JPME Phase I Credit. Completion of JPME is not a requirement for any NSA degree, but is available as an option for curriculum sponsors, and for students whose programs afford sufficient time (one additional academic quarter) to complete the work. JPME courses may not be taken as an overload and do not satisfy any curricular requirements in NSA.

> Additional information about NSA academic programs, including an up-to-date schedule of course offerings, can be found on the NSA web site, www.nps.edu/nsa.

National Security Affairs Course Descriptions

FL Courses (p. 381)

NS Courses (p. 448)

Maritime Security Cooperation - Curriculum 241

Academic Associate

Michael Malley, Ph.D.

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Overview

The Certificate Program in Maritime Security Cooperation

is intended to provide U.S. and international students with an introduction to contemporary maritime security threats and the policies, institutions, and mechanisms through which the U.S. cooperates with its allies and partners to counter these threats. The program requires the successful completion of at least four graduate courses and 13 credit hours, including the one-credit hour introduction to Great Power Competition (NS4000) the four-credit hour NS3039 Maritime Security Cooperation and the four-credit hour NS4257 Security Sector Assistance in an Era of Strategic Competition. Students are able to tailor their studies to a specific region by selecting one of the courses listed below. Each student's required course work is developed individually under the direction of the cognizant Academic Associate. Students may begin their course of study in any academic quarter.

Convenes

Fall, Spring

Program Length

3 months

- Identify and describe the range of maritime security threats found throughout the world.
- Identify and describe the principal obstacles to maritime security cooperation and the policies, institutions, and mechanisms that enable countries to overcome those obstacles.
- Apply general knowledge about maritime security cooperation to specific scenarios in regions of interest to each student.

Typical Course of Study

NS4000 Great Power Competition: Current Policy and Strategy (one credit hour)

NS3039 Maritime Security Cooperation (new course) (four credit hours)

NS4257 Security Assistance and Cooperation in an Era Strategic Competition (four credit hours) or NS4580 US Security Cooperation in Latin America and Africa (four credit hours)

and one of the following courses:

Course Number	Title	Lecture Hours	Lab Hours
NS3320	United States Foreign Policy in the Middle East	4	0
NS3321	United States Foreign Policy towards Africa	4	0
NS3520	Latin American International Relations	4	0
NS3621	International Relations of Southeast Asia	4	0
NS4642	Chinese Foreign Policy	4	0
NS4668	Strategy and Security in South Asia and the Indo-Pacific	4	0

Regional Security Studies (Middle East, South Asia, and Sub-Saharan Africa) Certificate - Curriculum 246

Academic Associate

Tristan Mabry, Ph.D.
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Brief Overview

The Academic Certificate Program in Regional Security Studies (Middle East, South Asia, and Sub-Saharan Africa) is designed to provide region-specific knowledge for select senior enlisted and regionally aligned force officers who will benefit from serious engagement with current academic and policy work on their region of specialization. The Certificate requires successful completion of a minimum of three graduate courses focusing on the region (12 credit hours), of which at least one course (4 credit hours) must be at the 4000-level. Each student's required course work is developed individually under the direction of the cognizant Academic Associate, based on the relevant regional courses available during the quarter(s) when the student is in residence. Language maintenance courses at the Defense Language Institute may be taken simultaneously in conjunction with the Certificate Program, but do not count toward the Certificate.

Convenes

Fall, Winter, Spring, Summer

Program Length

9 months

Subspecialty

2101L

Identities, Interests, and Politics: Grasp significant political, economic, historical, cultural, and religious drivers that shape national identities and interests.

Emerging Security Challenges: Know regional sources of political and social instability and understand the roots of ethnic conflict, insurgencies, and terrorism.

U.S. Regional Security Policy: Understand U.S. foreign policy objectives in a given region and be able to explain U.S. political, economic, and military strategy.

Economic Factors: Grasp the importance of underlying economic conditions on regional stability and conflict, as well as the tools of economic statecraft.

Required Courses

Course offerings in NSA vary from year to year. The

following illustrate what a (minimum) acceptable combination of courses might look like. Many other combinations are possible.

Example 1 (Middle East concentration)

Course	Title	Lecture	Lab
NS3320	US Foreign Policy in the Middle East	4	0
NS3330	Comparative Politics of the Middle East	4	0
NS4315	Security and Politics in Iran	4	0

Example 2 (South Asian concentration)

NS3668	Politics and Security in South Asia	4	0
NS4056	Special Topics: South Asia	4	0
NS4667	Political Economy and Security in South Asia	4	0

Example 3 (Sub-Saharan Africa concentration)

NS3301	African History and Cultures	4	0
NS3311	Government and Politics in Sub-Saharan Africa	4	0
NS4328	Government and Security in the Horn of Africa	4	0

Regional Security Studies (East Asia and the Indo-Pacific) Certificate - Curriculum 247

Academic Associate

Covell Meyskens, Ph.D.
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Overview

The Academic Certificate Program in Regional Security Studies (East Asia and the Indo-Pacific) is designed to provide region-specific knowledge for select senior enlisted and regionally-aligned force officers who will benefit from serious engagement with current academic and policy work on their region of specialization. The Certificate requires successful completion of a minimum of three graduate courses focusing on the region (12 credit hours), of which at least one course (4 credit hours) must be at the 4000-level. Each student's required course work is developed individually under the direction of the cognizant Academic Associate, based on the relevant regional courses available during the quarter(s) when the student is in residence. Language maintenance courses at the Defense Language Institute may be taken simultaneously in conjunction with the Certificate Program, but do not count toward the Certificate.

Convenes

Fall, Winter, Spring, Summer

Program Length

9 months

Subspecialty

2102L

Required Courses

Course offerings in NSA vary from year to year. The following illustrate what a (minimum) acceptable combination of courses might look like. Many other combinations are possible.

Example 1 (Northeast Asia concentration)

Course	Title	Lecture	Lab
NS3600	History of Modern East Asia	4	0
NS3662	Government and Security in Japan	4	0

Example 2 (Southeast Asia concentration)

NS3601	History and Cultures of Southeast Asia	4	0
NS3621	International Relations of South East Asia	4	0
NS4641	Political and Ethnic Violence in South East Asia	4	0

Example 3 (China concentration)

NS3661	Politics in China	4	0
NS4642	Chinese Foreign Policy	4	0
NS4024	Political Economy of China	4	0

Regional Security Studies (Western Hemisphere) Certificate - Curriculum 248

Academic Associate

Mariana Giusti Rodriguez, Ph.D.
Code 38, Glasgow Hall, Room 364

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Overview

The Academic Certificate Program in Regional Security Studies (Western Hemisphere) is designed to provide region-specific knowledge for select senior enlisted and regionally-aligned force officers who will benefit from serious engagement with current academic and policy work on their region of specialization. The Certificate requires successful completion of a minimum of three graduate courses focusing on the region (12 credit hours), of which at least one course (4 credit hours) must be at the 4000-level. Each student's required course work is developed individually under the direction of the cognizant Academic Associate, based on the relevant regional courses available during the quarter(s) when the student is in residence. Language maintenance courses at the Defense Language Institute may be taken

simultaneously in conjunction with the Certificate Program, but do not count toward the Certificate.

Convenes

Fall, Winter, Spring, Summer

Program Length

9 months

Subspecialty

2103L

Required Courses

Course offerings in NSA vary from year to year. The following illustrate what a (minimum) acceptable combination of courses might look like. Many other combinations are possible.

Example 1

Course	Title	Lecture	Lab
NS3501	History and Cultures of Latin America	4	0
NS3510	Government and Politics in Latin America	4	0

Example 2

NS3520	Latin American International Relations	4	0
NS3578	Society, Politics, and Security in Contemporary Brazil	4	0
NS4550	Government and Politics in Mexico	4	0

Example 3

NS3501	History and Cultures of Latin America	4	0
NS3520	Latin American International Relations	4	0
NS4501	Politics, Film and Fiction in Latin America	4	0

Regional Security Studies (Europe and Eurasia) Certificate - Curriculum 249

Academic Associate

Aleksandar Matovski, PhD
Glasgow Hall, Room 325
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aleksandar.matovski@nps.edu

Overview

The Academic Certificate Program in Regional Security Studies (Europe and Eurasia) is designed to provide region-specific knowledge for select senior enlisted and regionally aligned force officers who will benefit from serious engagement with current academic and policy work on their region of specialization. The Certificate requires successful completion of a minimum of three graduate courses focusing on the region (12 credit hours),

of which at least one course (4 credit hours) must be at the 4000-level. Each student's required course work is developed individually under the direction of the cognizant Academic Associate, based on the relevant regional courses available during the quarter(s) when the student is in residence. Language maintenance courses at the Defense Language Institute may be taken simultaneously in conjunction with the Certificate Program, but do not count toward the Certificate.

Convenes

Fall, Winter, Spring, Summer

Program Length

9 months

Subspecialty

2104L

Required Courses

Course offerings in NSA vary from year to year. The following illustrate what a (minimum) acceptable combination of courses might look like. Many other combinations are possible.

Example 1 (Europe concentration)

Course	Title	Lecture	Lab
NS3700	History of Modern Europe	4	0
NS3720	European Security Institutions	4	0
NS4037	NATO	4	0

Example 2 (Eurasia concentration)

NS3401	Contemporary Politics of Russia	4	0
NS3412	Government and Security in the Central Asian Republics	4	0
NS4425	Russian Foreign Policy	4	0

Example 3 (Europe concentration)

NS3710	Government and Security in Western Europe	4	0
NS4037	NATO	4	0
NS4722	Special Topics: Europe	4	0

Intelligence Operations Certificate - Curriculum 250

Academic Associate

Michael Owen, CAPT, USN
Code 38, Glasgow Hall, Room 321

(831) 656-2288, DSN 756-2288

michael.owen@nps.edu

Overview

The Intelligence Operations Certificate Program is designed to provide intelligence and non-intelligence officers with an understanding of the complex issues

surrounding operational intelligence today. The Certificate requires successful completion of a minimum of three graduate courses focusing on operational intelligence (12 credit hours), of which at least one course (4 credit hours) must be at the 4000-level. Each student's required course work is developed individually under the direction of the cognizant Academic Associate and the NPS Senior Intelligence Officer, based on the relevant courses available during the quarter(s) when the student is in residence. Each student's course sequence should include at least one course taught by the NPS Senior Intelligence Officer, and two additional courses focused on specific aspects of intelligence collection, analysis, production, writing, briefing, and critical thinking.

Convenes

Fall, Winter, Spring, Summer

Program Length

18 months

Typical Course of Study

Quarter 1

All students must take one of these two courses. Intelligence professionals should take NS4159. Others should take NS3159.

Course	Title	Lecture	Lab
NS4159	Seminar on Joint intelligence support to Crisis Operations -or-	4	0
NS3159	Principles of Joint Operational Intelligence	4	0

Remaining Quarters

All students will take two additional courses, which could include the second course listed above (NS3159 or NS4159) or one of the courses listed below. Note that students may take either NS3160 or DA3260, but not both. The same is true for DA4250 and NS4035, students may take one or the other, but not both.

NS3155	Intelligence and Democracy	4	0
NS4035	Special Topics: Intelligence -or-	4	0
DA4250	Covert Action	4	0
NS4157	Intelligence for Homeland Defense and Security	4	0
NS3160	Human Intelligence -or-	4	0
DA3260	Human Intelligence in Irregular Warfare	4	0

Great Power Competition Certificate - Curriculum 254 (Resident)

Academic Associate

James (Clay) Moltz, Ph.D.
Code 38, Glasgow Hall - Room 394

(831) 656-1039, DSN 756-1039

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Overview

The Certificate Program in Great Power Competition (GPC) will provide students timely academic knowledge on the political and strategic challenges posed for the United States by the emergence of GPC with China and its re-emergence with Russia. Upon completion of the certificate, students will be able to analyze the factors shaping the new era of geopolitical competition among the major powers and potential U.S. responses across all dimensions of power, including diplomacy, economic competition, influence campaigns, and traditional military force.

Students will take three graduate courses (12 credit hours) focusing on GPC, including at least one focusing on China and one on Russia, and also the one-unit introductory GPC lecture series, NS4000. At least one of the courses in addition to NS4000 must be at the 4000-level. The certificate is designed to be earned by currently enrolled master's students. The courses may be taken in any order, depending on when they are offered.

Convenes

Spring

Program Length

12 months

- To understand the nature of great power competition historically and its current manifestations.
- To understand the core motivations behind Chinese and Russian political, economic, and military policies, as well as the challenges they pose to the United States.
- To understand the tools China and Russia use to further their interests in various regions of the world outside their borders and in critical competitive domains, such as cyberspace.
- To understand the range of possible U.S. and allied responses to Chinese and Russian behavior.

Typical course of study--begin any quarter

Quarter 1

Course	Title	Lecture	Lab
NS4000	Great Power Competition: Current Policy and Strategy	0	2
NS3005	Great Power Conflict in Modern History	4	0
NS4315	Security and Politics in Iran	4	0

Course	Title	Lecture	Lab
NS3663	Government and Security in Korea	4	0

NS4000 is <u>required</u>, but may be taken during any quarter it is available. Students will also take one of the following courses:

NS3005 Great Power Conflict in Modern History (for non-NSA students; course is already required for NSA department students), or

NS4315 Security and Politics in Iran (NSA Dept. students only), or

NS3663 Government and Security in Korea (NSA Dept. students only)

Quarter 2

| NS3401 | Contemporary Politics of Russia | 4 | 0 |

If NS3401 is not available, then students will take <u>one</u> of the following courses:

NS3400 History of Russia and Eurasia

NS3450 Military Strategy in Russia, Eastern Europe, and Central Asia

NS4410 Seminar on Security in Russia, Eastern Europe, and Central Asia

NS4425 Russian Foreign Policy

Quarter 3

| NS3661 | Politics in China | 4 | 0 |

If NS3661 is not available, then students will take <u>one</u> of the following courses:

NS4024 Political Economy of China

NS4620 Seminar on the Chinese People's Liberation Army

NS4630 Seminar on Northeast Asian Security

NS4642 Chinese Foreign Policy

NS4643 Science, Technology, and Society in China

Although ESRs are not formally required for certificates, this program supports ESR-4, Great Power Competition:

- Analyze the factors shaping the new era of increasing geopolitical competition among the major powers.
- Understand Chinese and Russian activities and potential U.S. responses across all dimensions of power, including diplomacy, economic competition, influence campaigns, and traditional military force.

Great Power Competition Certificate - Curriculum 255 (DL)

Academic Associate

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Brief Overview

The Certificate Program in Great Power Competition (GPC) will provide students timely academic knowledge on the political and strategic challenges posed for the United States by the emergence of GPC with China and its re-emergence with Russia. Upon completion of the certificate, students will be able to analyze the factors shaping the new era of geopolitical competition among the major powers and potential U.S. responses across all dimensions of power, including diplomacy, economic competition, influence campaigns, and traditional military force.

Students will take one, four-unit course per quarter for three consecutive quarters beginning in the Winter and Summer Quarters. During their first Quarter they will also take a one-unit introductory, GPC lecture series (NS 4000). Although students will normally take a course on Russia in Quarter 2, and on China in Quarter 3, the order of those quarters may be reversed, depending on factors such as faculty availability and the desires of the students' sponsor.

Convenes

Those starting in Winter Quarter will complete the certificate in Summer, those starting in the Summer Quarter will complete the certificate in the Winter.

Program Length

3 quarters.

- To understand the nature of great power competition historically and its current manifestations.
- To understand the core motivations behind Chinese and Russian political, economic, and military policies, as well as the challenges they pose to the United States.
- To understand the tools China and Russia use to further their interests in various regions of the world outside their borders and in critical competitive domains, such as cyberspace.
- To understand the range of possible U.S. and allied responses to Chinese and Russian behavior.

Required Courses

Quarter 1

During Quarter 1, students will take both NS4000 and NS3005.

Course	Title	Lecture	Lab
NS4000	Great Power Competition: Current Policy and Strategy -and-	0	2
NS3005	Great Power Conflict in Modern History	4	0

Quarter 2

Students will take either NS4642 or NS3661.

| NS4642 | Chinese Foreign Policy -or- | 4 | 0 |

NS3661	Politics in China	4	0

Quarter 3

Students will take either NS4425 or NS3401.

NS4425	Russian Foreign Policy	4	0
	-or-		
NS3401	Contemporary Politics of Russia	4	0

Regional Security Studies - Middle East, South Asia, and Sub-Saharan Africa - Curriculum 681

Academic Associate

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Brief Overview

Curriculum 681 studies politics and security in the Middle East, South Asia and Sub-Saharan Africa. Degree requirements vary somewhat depending upon which of these sub-regions is the focus of effort. Separate tracks, with their own sets of requirements, exist for each of these three regions, as indicated in NSA's on-line course schedule. Depending upon sponsor requirements, study at NPS may be preceded or followed by language instruction at the Defense Language Institute, co-located on the Monterey Peninsula. In addition, courses conveying Phase I JPME certification, as well as selected U.S. Marine Corps PME courses, are available to NSA students while in residence at NPS.

Convenes

Students may enter in any quarter. Please refer to the Academic Calendar for quarterly start dates.

Program Length

For thesis students who wish to complete JPME Phase I while in residence, curriculum 681 is a six-quarter (18-month) program. For non-thesis students who wish to complete JPME Phase I in residence, curriculum 681 is a five-quarter (15-month) program. For non-thesis students who do not wish to complete JPME Phase I in residence, curriculum 681 is a four-quarter (12-month) program. For all other students, curriculum 681 is a five-quarter (15-month) program.

Degree

Master of Arts in Security Studies (Middle East, South Asia, and Sub-Saharan Africa).

Subspecialty

Navy P-Codes: 2101P

Typical Subspecialty Jobs

Defense Attaché

Foreign Area Officer

Intelligence Officer

Plans Officer, Staff Planner

Various joint command positions

Service Headquarters - Political / Military officers

Major staff jobs in Combatant Commands and Fleet Commands

Curriculum Requirements

Students in curriculum 681 must complete four (4) disciplinary core courses, as follows:

Course	Title	Lecture	Lab
NS3005	Great Power Conflict in Modern History	4	0
NS3011	Research and Writing for National Security Affairs	4	0
NS3023	Introduction to Comparative Politics	4	0
NS3024	Introduction to International Relations	4	0

In addition, students must complete a minimum of nine (9) curricular core and elective courses in their regional specialization, of which at least three (3) must be at the 4000-level.

Middle East Track must complete (4) curricular core courses, as follows:

NS3300	Islam	4	0
NS3320	US Foreign Policy in the Middle East	4	0
NS3330	Comparative Politics of the Middle East	4	0
	-and-		
NS3315	Modern Arab History	4	0
	-or-		
NS3366	Modern Turkish History	4	0

Sub-Saharan Africa Track must complete (4) curricular core courses, as follows:

NS3301	African History and Cultures	4	0
NS3311	Government and Politics in Sub-Saharan Africa	4	0
NS3321	U.S. Foreign Policy towards Africa	4	0
NS4053	Special Topics: Political Economy	4	0

NS4053 examines the Political Economy of Development.

South Asia Track must complete (3) curricular core courses, as follows:

NS3300	Islam	4	0
NS3668	Politics and Security in South Asia	4	0
NS4667	Political Economy and Security in South Asia	4	0

The additional courses that satisfy these requirements, and the quarters when they are offered, can be found on

the NSA website at https://www.nps.edu/web/nsa/.

Students are also required to take sufficient general electives to maintain a full-time course load (16 hours). The number of general elective slots will vary somewhat depending upon service affiliation and sponsor requirements.

Students who write a thesis must also complete NS4080, Thesis Proposal, no later than six months prior to intended graduation. NS4080 does not count as one of the three 4000-level courses required above. Thereafter thesis students may enroll in NS0810, Thesis Research, up to three times; or they may take additional course work in their area of specialization, with the permission of the Academic Associate.

Students in curriculum 681 who substitute language training plus a comprehensive examination for the thesis must enroll in NS0811, Preparation for Comprehensive Examination, during their final quarter.

Educational Skill Requirements (ESR)

1. **Basic Graduate Level Skills:**
   a. **Conduct Research:** Assemble information from the full range of data sources to understand international political, economic, and military issues.
   b. **Analyze Problems and Demonstrate Critical Thinking:** Frame issues as research questions; logically combine evidence and theory to analyze and explain international political, economic, and military developments; and formulate innovative solutions to strategic problems.
   c. **Communicate Information:** Clearly summarize large quantities of information and persuasively present positions and courses of action using a broad range of verbal and written communications formats, including short oral arguments, visual briefs, policy memos, position papers, and comprehensive student theses.

2. **General Political Science, International Relations, and Security Studies:**
   a. **Great Power Competition:** Analyze the factors shaping the new era of increasing geopolitical competition among the major powers. Understand Chinese and Russian activities and potential U.S. responses across all dimensions of power, including diplomacy, economic competition, influence campaigns, and traditional military force.
   b. **International and Comparative Politics:** Understand international relations theories, including realist, liberal, and cultural paradigms; the conditions and worldviews that shape state interactions in the international system; the history of modern nationalism and the state system; and the roles of domestic politics, non-state actors, and transnational social movements in shaping international politics.
   c. **International Economy:** Understand the economic factors that shape the international security environment, including the economic dimensions of national security policy and the ways in which economic policies and interests affect military strategy and force structure.
   d. **International and Military History:** Grasp the principal causes of war in the modern era, and understand the political, technological, economic, and other influences that have governed its conduct; understand the social, political, economic, and cultural forces that have contributed to periods of stable peace; and analyze relations between states, including negotiations of peace settlements, military alliances, arms limitation agreements, economic arrangements, and human rights accords.
   e. **International Organizations:** Understand the history of international organizations and their role in world politics, including international mediation and negotiations, formal and informal security arrangements, treaty regimes, and the role of international institutions and non-governmental organizations in peacekeeping and humanitarian operations.
   f. **U.S. Security Policy and Strategy:** Understand how U.S. national security policy and strategy are formulated. Understand the roles of nuclear forces in the security policies of the United States and other nuclear powers; U.S. nuclear force acquisition, planning, deterrence policy, and employment concepts from the Second World War to the present; and the role of nuclear weapons in alliance politics and international relations.

3. **Regional Security Studies:**
   a. **Identities, Interests, and Politics:** Grasp the most significant political, economic, historical, cultural, and religious drivers that shape national identities and interests within their region of concentration.
   b. **Emerging Security Challenges:** Know the regional and external great power sources of political and social instability and become familiar with the roots of ethnic conflict, insurgencies, and terrorism, and their effect on regional and U.S. security.
   c. **Regional Conflicts:** Understand the patterns of violent conflicts, the likely sources and character of regional wars in the present and future, and the historical and prospective impact of such wars on the international system.
   d. **Military Forces and Strategic Posture:** Understand the main factors determining the strategic postures of countries in the region, including strategic culture and goals, threat perceptions, military force structures, and influence activities of the outside great powers.
   e. **U.S. Regional Security Policy:** Understand U.S. foreign policy objectives in a given region and be

able to explain U.S. political, economic, and military strategy in the region, including U.S. engagement policy and security assistance programs.

f. **Economic Factors:** Grasp the importance of underlying economic conditions on regional stability and conflict, as well as the tools of economic statecraft that the United States and international organizations may employ to try to influence these conditions and respond to regional economic competition from external great powers.

Regional Security Studies - East Asia and the Indo-Pacific - Curriculum 682

Academic Associate

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Brief Overview

Curriculum 682 studies politics and security in East Asia and the Indo-Pacific. Depending upon sponsor requirements, study at NPS may be preceded or followed by language instruction at the Defense Language Institute, co-located on the Monterey Peninsula.

Convenes

Students may enter in any quarter. Please refer to the Academic Calendar (p. 519) for quarterly start dates.

Program Length

For thesis students who wish to complete JPME Phase I while in residence, curriculum 682 is a six-quarter (18-month) program. For non-thesis students who wish to complete JPME Phase I in residence, curriculum 682 is a five-quarter (15-month) program. For non-thesis student who do not wish to complete JPME Phase I in residence, curriculum 682 is a four-quarter (12-month) program. For all other students, curriculum 682 is a five-quarter (15-month) program.

Degree

Master of Arts in Security Studies (East Asia and the Indo-Pacific)

Subspecialty

Navy P-Codes: 2102P

Typical Subspecialty Jobs

Defense Attaché

Foreign Area Officer

Intelligence Officer

Plans Officer, Staff Planner

Various joint command positions

Service Headquarters - Political / Military officers

Major staff jobs in Combatant Commands and Fleet Commands

Curriculum Requirements

All Students in curriculum 682 must complete Four (4) disciplinary core courses, as follows:

Course	Title	Lecture	Lab
NS3005	Great Power Conflict in Modern History	4	0
NS3011	Research and Writing for National Security Affairs	4	0
NS3023	Introduction to Comparative Politics	4	0
NS3024	Introduction to International Relations	4	0

In addition, students must complete a minimum of nine (9) curricular core and elective courses in their regional specialization, of which at least three (3) must be at the 4000-level.

Northeast Asia Track must complete (4) curricular core courses, as follows:

NS3600	History of Modern East Asia	4	0
NS3620	Survey of Asian Politics	4	0
NS3645	Political Economy of Asia	4	0
NS4630	Seminar on Northeast Asian Security	4	0

Southeast Asia Track must complete (4) curricular core courses, as follows:

NS3601	History and Cultures of Southeast Asia	4	0
NS3620	Survey of Asian Politics	4	0
NS3621	International Relations of South East Asia	4	0
NS3645	Political Economy of Asia	4	0

The additional courses that satisfy these requirements, and the quarters when they are offered, can be found on the NSA website at https://www.nps.edu/web/nsa/.

Students are also required to take sufficient general electives to maintain a full-time course load (16 hours). The number of general elective slots will vary somewhat depending upon service affiliation and sponsor requirements.

Students who write a thesis must also complete NS4080, Thesis Proposal, no later than six months prior to intended graduation. NS4080 does not count as one of the three 4000-level courses required above. Thereafter thesis students may enroll in NS0810, Thesis Research, up to three times; or they may take additional course work in their area of specialization, with the permission of the Academic Associate.

Students in curriculum 682 who substitute language training plus a comprehensive examination for the thesis

must enroll in NS0811, Preparation for Comprehensive Examination, during their final quarter.

Educational Skill Requirements (ESR)

1. **Basic Graduate Level Skills:**
   a. **Conduct Research:** Assemble information from the full range of data sources to understand international political, economic, and military issues.
   b. **Analyze Problems and Demonstrate Critical Thinking:** Frame issues as research questions; logically combine evidence and theory to analyze and explain international political, economic, and military developments; and formulate innovative solutions to strategic problems.
   c. **Communicate Information:** Clearly summarize large quantities of information and persuasively present positions and courses of action using a broad range of verbal and written communications formats, including short oral arguments, visual briefs, policy memos, position papers, and comprehensive student theses.

2. **General Political Science, International Relations, and Security Studies:**
   a. **Great Power Competition:** Analyze the factors shaping the new era of increasing geopolitical competition among the major powers. Understand Chinese and Russian activities and potential U.S. responses across all dimensions of power, including diplomacy, economic competition, influence campaigns, and traditional military force.
   b. **International and Comparative Politics:** Understand international relations theories, including realist, liberal, and cultural paradigms; the conditions and worldviews that shape state interactions in the international system; the history of modern nationalism and the state system; and the roles of domestic politics, non-state actors, and transnational social movements in shaping international politics.
   c. **International Economy:** Understand the economic factors that shape the international security environment, including the economic dimensions of national security policy and the ways in which economic policies and interests affect military strategy and force structure.
   d. **International and Military History:** Grasp the principal causes of war in the modern era, and understand the political, technological, economic, and other influences that have governed its conduct; understand the social, political, economic, and cultural forces that have contributed to periods of stable peace; and analyze relations between states, including negotiations of peace settlements, military alliances, arms limitation agreements, economic arrangements, and human rights accords.
   e. **International Organizations:** Understand the history of international organizations and their role in world politics, including international mediation and negotiations, formal and informal security arrangements, treaty regimes, and the role of international institutions and non-governmental organizations in peacekeeping and humanitarian operations.
   f. **U.S. Security Policy and Strategy:** Understand how U.S. national security policy and strategy are formulated. Understand the roles of nuclear forces in the security policies of the United States and other nuclear powers; U.S. nuclear force acquisition, planning, deterrence policy, and employment concepts from the Second World War to the present; and the role of nuclear weapons in alliance politics and international relations.

3. **Regional Security Studies:**
   a. **Identities, Interests, and Politics:** Grasp the most significant political, economic, historical, cultural, and religious drivers that shape national identities and interests within their region of concentration.
   b. **Emerging Security Challenges:** Know the regional and external great power sources of political and social instability and become familiar with the roots of ethnic conflict, insurgencies, and terrorism, and their effect on regional and U.S. security.
   c. **Regional Conflicts:** Understand the patterns of violent conflicts, the likely sources and character of regional wars in the present and future, and the historical and prospective impact of such wars on the international system.
   d. **Military Forces and Strategic Posture:** Understand the main factors determining the strategic postures of countries in the region, including strategic culture and goals, threat perceptions, military force structures, and influence activities of the outside great powers.
   e. **U.S. Regional Security Policy:** Understand U.S. foreign policy objectives in a given region and be able to explain U.S. political, economic, and military strategy in the region, including U.S. engagement policy and security assistance programs.
   f. **Economic Factors:** Grasp the importance of underlying economic conditions on regional stability and conflict, as well as the tools of economic statecraft that the United States and international organizations may employ to try to influence these conditions and respond to regional economic competition from external great powers.

Regional Security Studies - Western Hemisphere - Curriculum 683

Academic Associate

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Brief Overview

Curriculum 683 studies politics and security in the Western Hemisphere, excluding Canada and the United States. Depending upon sponsor requirements, study at NPS may be preceded or followed by language instruction at the Defense Language Institute, co-located on the Monterey Peninsula. In addition, courses, conveying Phase I JPME certification, as well as selected U.S. Marine Corps PME courses, are available to Regional Security Studies students while in residence at NPS.

Convenes

Students may enter in any quarter. Please refer to the Academic Calendar for quarterly start dates.

Program Length

For thesis students who wish to complete JPME Phase I while in residence, curriculum 683 is a six-quarter (18-month) program. For non-thesis students who wish to complete JPME Phase I in residence, curriculum 683 is a five-quarter (15-month) program. For non-thesis student who do not wish to complete JPME Phase I in residence, curriculum 683 is a four-quarter (12-month) program. For all other students, curriculum 683 is a five-quarter (15-month) program.

Degree

Master of Arts in Security Studies (Western Hemisphere)

Subspecialty

Navy P-Codes: 2103P

Typical Subspecialty Jobs

Defense Attaché

Foreign Area Officer

Intelligence Officer

Plans Officer, Staff Planner

Various joint command positions

Service Headquarters - Political / Military officers

Major staff jobs in Combatant Commands and Fleet Commands

Curriculum Requirements

Students in curriculum 683 must complete four (4) disciplinary core courses, as follows:

Course	Title	Lecture	Lab
NS3005	Great Power Conflict in Modern History	4	0
NS3011	Research and Writing for National Security Affairs	4	0
NS3023	Introduction to Comparative Politics	4	0
NS3024	Introduction to International Relations	4	0

In addition, students must complete a minimum of nine (9) curricular core and elective courses in their regional specialization, of which at least three (3) must be at the 4000-level.

Latin America track must complete (4) curricular core courses, as follows:

NS3501	History and Cultures of Latin America	4	0
NS3510	Government and Politics in Latin America	4	0
NS3520	Latin American International Relations	4	0
NS4053	Special Topics: Political Economy	4	0

NS4053 examines the Political Economy of Development.

The additional courses that satisfy these requirements, and the quarters when they are offered, can be found on the NSA website at https://www.nps.edu/web/nsa/.

Students are also required to take sufficient general electives to maintain a full-time course load (16 hours). The number of general elective slots will vary somewhat depending upon service affiliation and sponsor requirements.

Students who write a thesis must complete NS4080, Thesis Proposal, no later than six months prior to intended graduation. NS4080 does not count as one of the three 4000-level courses required above. Thereafter thesis students may enroll in NS0810, Thesis Research, up to three times; or they may take additional course work in their area of specialization, with the permission of the Academic Associate.

Students in curriculum 683 who substitute language training plus a comprehensive examination for the thesis must enroll in NS0811, Preparation for Comprehensive Examination, during their final quarter.

Educational Skill Requirements (ESR)

1. **Basic Graduate Level Skills**

   a. **Conduct Research:** Assemble information from the full range of data sources to understand international political, economic, and military issues.

   b. **Analyze Problems and Demonstrate Critical Thinking:** Frame issues as research questions; logically combine evidence and theory to analyze and explain international political, economic, and military developments; and formulate innovative solutions to strategic problems.

   c. **Communicate Information:** Clearly summarize large quantities of information and persuasively present positions and courses of action using a broad range of verbal and written communications formats, including short oral arguments, visual briefs, policy memos, position papers, and comprehensive student theses.

2. **General Political Science, International Relations, and Security Studies**
   a. **Great Power Competition:** Analyze the factors shaping the new era of increasing geopolitical competition among the major powers. Understand Chinese and Russian activities and potential U.S. responses across all dimensions of power, including diplomacy, economic competition, influence campaigns, and traditional military force.
   b. **International and Comparative Politics:** Understand international relations theories, including realist, liberal, and cultural paradigms; the conditions and worldviews that shape state interactions in the international system; the history of modern nationalism and the state system; and the roles of domestic politics, non-state actors, and transnational social movements in shaping international politics.
   c. **International Economy:** Understand the economic factors that shape the international security environment, including the economic dimensions of national security policy and the ways in which economic policies and interests affect military strategy and force structure.
   d. **International and Military History:** Grasp the principal causes of war in the modern era, and understand the political, technological, economic, and other influences that have governed its conduct; understand the social, political, economic, and cultural forces that have contributed to periods of stable peace; and analyze relations between states, including negotiations of peace settlements, military alliances, arms limitation agreements, economic arrangements, and human rights accords.
   e. **International Organizations:** Understand the history of international organizations and their role in world politics, including international mediation and negotiations, formal and informal security arrangements, treaty regimes, and the role of international institutions and non-governmental organizations in peacekeeping and humanitarian operations.
   f. **U.S. Security Policy and Strategy:** Understand how U.S. national security policy and strategy are formulated. Understand the roles of nuclear forces in the security policies of the United States and other nuclear powers; U.S. nuclear force acquisition, planning, deterrence policy, and employment concepts from the Second World War to the present; and the role of nuclear weapons in alliance politics and international relations.

3. **Regional Security Studies**
   a. **Identities, Interests, and Politics:** Grasp the most significant political, economic, historical, cultural, and religious drivers that shape national identities and interests within their region of concentration.
   b. **Emerging Security Challenges:** Know the regional and external great power sources of political and social instability and become familiar with the roots of ethnic conflict, insurgencies, and terrorism, and their effect on regional and U.S. security.
   c. **Regional Conflicts:** Understand the patterns of violent conflicts, the likely sources and character of regional wars in the present and future, and the historical and prospective impact of such wars on the international system.
   d. **Military Forces and Strategic Posture:** Understand the main factors determining the strategic postures of countries in the region, including strategic culture and goals, threat perceptions, military force structures, and influence activities of outside great powers.
   e. **U.S. Regional Security Policy:** Understand U.S. foreign policy objectives in a given region and be able to explain U.S. political, economic, and military strategy in the region, including U.S. engagement policy and security assistance programs.
   f. **Economic Factors:** Grasp the importance of underlying economic conditions on regional stability and conflict, as well as the tools of economic statecraft that the United States and international organizations may employ to try to influence these conditions and respond to regional economic competition from external great powers.

Regional Security Studies - Europe and Eurasia - Curriculum 684

Academic Associate

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Brief Overview

Curriculum 684 studies politics and security in Europe and Eurasia. Depending upon sponsor requirements, study at NPS may be preceded or followed by language instruction at the Defense Language Institute, co-located on the Monterey Peninsula.

Curriculum 684 distinguishes between Europe and Eurasia based on the designations used in the Army FAO program as follows:

Europe: United Kingdom, Ireland, France, Norway, Netherlands, Belgium, Sweden, Denmark, Luxembourg, Germany, Austria, Switzerland, Italy, Spain, Portugal, Hungary, Bulgaria, Czech Republic, Slovak Republic, Poland, Albania, Croatia, Bosnia-Herzegovina, Serbia Montenegro, Macedonia, Finland, Romania, Greece, Liechtenstein, Malta, Monaco, Andorra, San Marino, Slovenia, and Iceland.

Eurasia: Russia, Belarus, Ukraine, Moldova, Armenia,

Georgia, Kazakhstan, Uzbekistan, Kyrgyzstan, Turkmenistan, Tajikistan, Azerbaijan, Estonia, Latvia, and Lithuania.

Separate tracks, with their own sets of requirements, exist for these two regions, as indicated in NSA's on-line schedule of classes.

APC

The minimum APC requirement for entry to this program is 265.

Convenes

Students may enter in any quarter. Please refer to the Academic Calendar for quarterly start dates.

Program Length

For thesis students who wish to complete JPME Phase I while in residence, curriculum 684 is a six-quarter (18-month) program. For non-thesis students who will be completing JPME Phase I in residence, curriculum 684 is a five-quarter (15-month) program. For non-thesis student who will not be completing JPME Phase I in residence, curriculum 684 is a four-quarter (12-month) program. for all other students, curriculum 684 is a five-quarter (15-month) program.

Degree

Master of Arts in Security Studies (Europe and Eurasia)

Subspecialty

Navy P-Codes: 2104P

Typical Subspecialty Jobs

Defense Attaché

Foreign Area Officer

Intelligence Officer

Plans Officer, Staff Planner

Various joint command positions

Service Headquarters - Political / Military officers

Major staff jobs in Combatant Commands and Fleet Commands

Curriculum Requirements

Students in curriculum 684 must complete four (4) disciplinary core courses, as follows:

Course	Title	Lecture	Lab
NS3005	Great Power Conflict in Modern History	4	0
NS3011	Research and Writing for National Security Affairs	4	0
NS3023	Introduction to Comparative Politics	4	0
NS3024	Introduction to International Relations	4	0

In addition, students must complete a minimum of nine (9) curricular core and elective courses in their regional specialization, of which at least three (3) must be at the 4000-level.

Europe Track must complete (4) curricular core courses, as follows:

NS3700	History of Modern Europe	4	0
NS3710	Government and Security in Western Europe	4	0
NS3720	European Security Institutions	4	0
NS4710	Eur-Asia in the Global Economic Order	4	0

Eurasia Track must complete (4) curricular core courses, as follows:

NS3400	History of Russia and Eurasia	4	0
NS3401	Contemporary Politics of Russia	4	0
NS3720	European Security Institutions	4	0
NS4710	Eur-Asia in the Global Economic Order	4	0

The additional courses that satisfy these requirements, and the quarters when they are offered, can be found on the NSA website at https://www.nps.edu/web/nsa/.

Students are also required to take sufficient general electives to maintain a full-time course load (16 hours). The number of general elective slots will vary somewhat depending upon service affiliation and sponsor requirements.

Students who write a thesis must complete NS4080, Thesis Proposal, no later than six months prior to intended graduation. NS4080 does not count as one of the three 4000-level courses required above. Thereafter thesis students may enroll in NS0810, Thesis Research, up to three times; or they may take additional course work in their area of specialization, with the permission of the Academic Associate.

Students in curriculum 684 who substitute language training plus a comprehensive examination for the thesis must enroll in NS0811, Preparation for Comprehensive Examination, during their final quarter.

Educational Skill Requirements (ESR)

1. **Basic Graduate Level Skills**

   a. **Conduct Research:** Assemble information from the full range of data sources to understand international political, economic, and military issues.

   b. **Analyze Problems and Demonstrate Critical Thinking:** Frame issues as research questions; logically combine evidence and theory to analyze and explain international political, economic, and military developments; and formulate innovative solutions to strategic problems.

   c. **Communicate Information:** Clearly summarize large quantities of information and persuasively present positions and courses of action using a broad range

of verbal and written communications formats, including short oral arguments, visual briefs, policy memos, position papers, and comprehensive student theses.

2. **General Political Science, International Relations, and Security Studies**

   a. **Great Power Competition:** Analyze the factors shaping the new era of increasing geopolitical competition among the major powers. Understand Chinese and Russian activities and potential U.S. responses across all dimensions of power, including diplomacy, economic competition, influence campaigns, and traditional military force.

   b. **International and Comparative Politics:** Understand international relations theories, including realist, liberal, and cultural paradigms; the conditions and world views that shape state interactions in the international system; the history of modern nationalism and the state system; and the roles of domestic politics, non-state actors, and transnational social movements in shaping international politics.

   c. **International Economy:** Understand the economic factors that shape the international security environment, including the economic dimensions of national security policy and the ways in which economic policies and interests affect military strategy and force structure.

   d. **International and Military History:** Grasp the principal causes of war in the modern era, and understand the political, technological, economic, and other influences that have governed its conduct; understand the social, political, economic, and cultural forces that have contributed to periods of stable peace; and analyze relations between states, including negotiations of peace settlements, military alliances, arms limitation agreements, economic arrangements, and human rights accords.

   e. **International Organizations:** Understand the history of international organizations and their role in world politics, including international mediation and negotiations, formal and informal security arrangements, treaty regimes, and the role of international institutions and non-governmental organizations in peacekeeping and humanitarian operations.

   f. **U.S. Security Policy and Strategy:** Understand how U.S. national security policy and strategy are formulated. Understand the roles of nuclear forces in the security policies of the United States and other nuclear powers; U.S. nuclear force acquisition, planning, deterrence policy, and employment concepts from the Second World War to the present; and the role of nuclear weapons in alliance politics and international relations.

3. **Regional Security Studies**

   a. **Identities, Interests, and Politics:** Grasp the most significant political, economic, historical, cultural, and religious drivers that shape national identities and interests within their region of concentration.

   b. **Emerging Security Challenges:** Know the regional and external great power sources of political and social instability and become familiar with the roots of ethnic conflict, insurgencies, and terrorism, and their effect on regional and U.S. security.

   c. **Regional Conflicts:** Understand the patterns of violent conflicts, the likely sources and character of regional wars in the present and future, and the historical and prospective impact of such wars on the international system.

   d. **Military Forces and Strategic Posture:** Understand the main factors determining the strategic postures of countries in the region, including strategic culture and goals, threat perceptions, military force structures, and influence activities of outside great powers.

   e. **U.S. Regional Security Policy:** Understand U.S. foreign policy objectives in a given region and be able to explain U.S. political, economic, and military strategy in the region, including U.S. engagement policy and security assistance programs.

   f. **Economic Factors:** Grasp the importance of underlying economic conditions on regional stability and conflict, as well as the tools of economic statecraft that the United States and international organizations may employ to try to influence these conditions and respond to regional economic competition from external great powers.

Civil-Military Relations - Curriculum 685

Academic Associate

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Brief Overview

The Civil-Military Relations curriculum is an interdisciplinary program tailored to the needs of international officers and civilians. It is open to members of the U.S. armed services and eligible U.S. Federal Government Civilians. The program is designed to meet three related requirements. First, it gives international students the skills needed to resolve the security problems confronting new and emerging democracies. Second, the program offers an in-depth understanding of civil-military relations. Finally, the program prepares students to resolve the civil-military issues raised by participation in U.N. peacekeeping operations, membership in the Partnership for Peace and other alliances, and security cooperation between other nations and the United States.

APC

The minimum APC requirement for entry to this program is 265.

Convenes

Students may enter in any quarter. Please refer to the Academic Calendar (p. 519) for quarterly start dates.

Program Length

For students who wish to complete JPME Phase I while in residence, curriculum 685 is a six-quarter (18-month) program. For all other students, curriculum 685 is a five-quarter (15-month) program.

Degree

Master of Arts in Security Studies (Civil-Military Relations)

Subspecialty

Navy P-Codes: None

Curriculum Requirements

Students in curriculum 685 must complete four (4) disciplinary core courses, as follows:

Course	Title	Lecture	Lab
NS3005	Great Power Conflict in Modern History	4	0
NS3011	Research and Writing for National Security Affairs	4	0
NS3023	Introduction to Comparative Politics	4	0
NS3024	Introduction to International Relations	4	0

In addition, students must complete a minimum of nine (9) curricular core and elective courses in their regional specialization, of which at least three (3) must be at the 4000-level.

685 students must complete (3) curricular core courses, as follows:

NS3021	Defense Capability Development	4	0
NS3025	Introduction to Civil-Military Relations	4	0
NS4225	Civil-Military Relations and Transitions to Democracy	4	0

The additional courses needed to satisfy these requirements, and the quarters when they are offered, can be found on the NSA website at https://www.nps.edu/web/nsa/. 685 students have the option of substituting four (4) courses in a single region for four of the curricular electives that would otherwise be required. At least one of the regional courses must be at the 4000-level.

Students are also required to take sufficient general electives to maintain a full-time course load (16 hours). The number of general elective slots will vary somewhat depending upon service affiliation and sponsor

requirements.

Students in curriculum 685 must complete NS4080, Thesis Proposal, no later than six months prior to intended graduation. Thereafter students may enroll in NS0810, Thesis Research, up to three times; or they may take additional course work in their area of specialization, with the permission of the Academic Associate.

Educational Skill Requirements (ESR)

1. **Basic Graduate Level Skills**
   a. **Conduct Research:** Assemble information from the full range of data sources to understand international political, economic, and military issues.
   b. **Analyze Problems and Demonstrate Critical Thinking:** Frame issues as research questions; logically combine evidence and theory to analyze and explain international political, economic, and military developments; and formulate innovative solutions to strategic problems.
   c. **Communicate Information:** Clearly summarize large quantities of information and persuasively present positions and courses of action using a broad range of verbal and written communications formats, including short oral arguments, visual briefs, policy memos, position papers, and comprehensive student theses.

2. **General Political Science, International Relations, and Security Studies**
   a. **Great Power Competition:** Analyze the factors shaping the new era of increasing geopolitical competition among the major powers. Understand Chinese and Russian activities and potential U.S. responses across all dimensions of power, including diplomacy, economic competition, influence campaigns, and traditional military force.
   b. **International and Comparative Politics:** Understand international relations theories, including realist, liberal, and cultural paradigms; the conditions and world views that shape state interactions in the international system; the history of modern nationalism and the state system; and the roles of domestic politics, non-state actors, and transnational social movements in shaping international politics.
   c. **International Economy:** Understand the economic factors that shape the international security environment, including the economic dimensions of national security policy and the ways in which economic policies and interests affect military strategy and force structure.
   d. **International and Military History:** Grasp the principal causes of war in the modern era, and understand the political, technological, economic, and other influences that have governed its conduct; understand the social, political, economic,

and cultural forces that have contributed to periods of stable peace; and analyze relations between states, including negotiations of peace settlements, military alliances, arms limitation agreements, economic arrangements, and human rights accords.

e. **International Organizations:** Understand the history of international organizations and their role in world politics, including international mediation and negotiations, formal and informal security arrangements, treaty regimes, and the role of international institutions and non-governmental organizations in peacekeeping and humanitarian operations.

f. **U.S. Security Policy and Strategy:** Understand how U.S. national security policy and strategy are formulated. Understand the roles of nuclear forces in the security policies of the United States and other nuclear powers; U.S. nuclear force acquisition, planning, deterrence policy, and employment concepts from the Second World War to the present; and the role of nuclear weapons in alliance politics and international relations.

Strategic Studies - Curriculum 688

Curriculum 688 studies strategic issues that are critical to the US national security and defense policy. Degree requirements vary depending upon which functional issue is the focus of effort. Separate programs, with their own sets of requirements, exist for three functional issues:

Master of Arts in Security Studies (Strategy and Policy) - Curriculum 688

Academic Associate

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Brief Overview

Strategy is concerned with the use of force to further the political ends. The aim of this degree is to produce students with a thorough understanding of this relationship, and of the relationship of force to other instruments by which the ends of policy may be pursued. Graduates will possess a comprehensive knowledge of US national security and defense policy and military strategy. They will have the ability to develop and coordinate national and military strategy; to develop concepts and plans to employ military forces at the national and theater levels; to write strategic- and operational-level vision and guidance documents; and to formulate, articulate, and coordinate the employment of all dimensions of military power to support the ends of American national security policy.

Strategy and Policy is a multi-disciplinary degree grounded in the fields of history, international relations, comparative politics, and political economy, and requires completion of a Master's thesis as the capstone degree requirement. Satisfactory completion of the four-course Naval War College JPME sequence is required for Navy officers. Students who do not need or desire to complete JPME are expected to develop a coherent four-course elective sequence in its place.

APC

The minimum APC requirement for entry to this program is 265.

Convenes

Any Quarter

Program Length

The program of study lasts five-quarters (15-months) and students may begin in any academic quarter. Please refer to the Academic Calendar (p. 519) for quarterly start dates.

Degree

Master of Arts in Security Studies (Strategy and Policy)

Subspecialty

Navy P-Codes: 2301

Curriculum Requirements

Students in Security Studies must complete the following:

Course	Title	Lecture	Lab
NS3005	Great Power Conflict in Modern History	4	0
NS3011	Research and Writing for National Security Affairs	4	0
NS3023	Introduction to Comparative Politics	4	0
NS3024	Introduction to International Relations	4	0

Four JPME courses taught by the Naval War College satellite program:

These courses must be taken one per quarter and in the sequence indicated below (Strategy & War, Theatre Security Decision Making, Joint Maritime Operations - Part 1, Joint Maritime Operations - Part 2).

Also, there should be no gap or intervening academic term between Part 1 & 2 of Joint Maritime Operations, and it is highly recommended that there are no gaps between any of the JPME courses.

NW3230	Strategy & War	4	2
NW3285	Theater Security Decision Making	4	0
NW3275	Joint Maritime Operations - part 1	4	0
NW3276	Joint Maritime Operations - part 2	2	2

Curricular Courses - Required

NS3030	American National Security Policy	4	0
NS3230	Innovation and Adaptation in the Military	4	0
NS4990	Seminar in Strategic Studies	4	0
NS4256	Maritime Strategy	4	0

Four (4) electives from courses approved by the sponsor.

Three of the eight curricular courses must be at the 4000 level.

Students in the Security Studies degree program must complete NS4080, Thesis Proposal, no later than six months prior to intended graduation. Thereafter students may enroll in NS0810, Thesis Research, up to three times; or they may take additional course work in their area of specialization, with the permission of the Academic Associate.

Educational Skill Requirements (ESR)

1. **Basic Graduate Level Skills**

   a. **Conduct Research:** Assemble information from the full range of data sources to understand international political, economic, and military issues.

   b. **Analyze Problems and Demonstrate Critical Thinking:** Frame issues as research questions; logically combine evidence and theory to analyze and explain international political, economic, and military developments; and formulate innovative solutions to strategic problems.

   c. **Communicate Information:** Clearly summarize large quantities of information and persuasively present positions and courses of action using a broad range of verbal and written communications formats, including short oral arguments, visual briefs, policy memos, position papers, and comprehensive student theses.

2. **General Political Science, International Relations, and Security Studies**

   a. **Great Power Competition:** Analyze the factors shaping the new era of increasing geopolitical competition among the major powers. Understand Chinese and Russian activities and potential U.S. responses across all dimensions of power, including diplomacy, economic competition, influence campaigns, and traditional military force.

   b. **International and Comparative Politics:** Understand international relations theories, including realist, liberal, and cultural paradigms; the conditions and world views that shape state interactions in the international system; the history of modern nationalism and the state system; and the roles of domestic politics, non-state actors, and transnational social movements in shaping international politics.

   c. **International Economy:** Understand the economic factors that shape the international security environment, including the economic dimensions of national security policy and the ways in which economic policies and interests affect military strategy and force structure.

   d. **International and Military History:** Grasp the principal causes of war in the modern era, and understand the political, technological, economic, and other influences that have governed its conduct; understand the social, political, economic, and cultural forces that have contributed to periods of stable peace; and analyze relations between states, including negotiations of peace settlements, military alliances, arms limitation agreements, economic arrangements, and human rights accords.

   e. **International Organizations:** Understand the history of international organizations and their role in world politics, including international mediation and negotiations, formal and informal security arrangements, treaty regimes, and the role of international institutions and non-governmental organizations in peacekeeping and humanitarian operations.

   f. **U.S. Security Policy and Strategy:** Understand how U.S. national security policy and strategy are formulated. Understand the roles of nuclear forces in the security policies of the United States and other nuclear powers; U.S. nuclear force acquisition, planning, deterrence policy, and employment concepts from the Second World War to the present; and the role of nuclear weapons in alliance politics and international relations.

3. **U.S. National Security, Defense, and Military Strategy**

   a. **U.S. National Security Policy:** Demonstrate a comprehensive knowledge of US national security policy, military history, and defense, military, and naval strategy.

   b. **International Environment:** Assess the international strategic environment, analyze the factors shaping increasing great power competition, have knowledge of politico-military affairs, and understand the inner workings of the highest levels of government. Draw policy-relevant conclusions and formulate actionable recommendations.

   c. **Strategic plans and policy:** Demonstrate ability to write strategic-to-operational-level vision and guidance documents calculated to relate the ends of policy to the ways and means of strategic action. Understand the relationship of DIME elements to naval power and joint and maritime strategy. Differentiate and define Service, COCOM, and Naval

theater levels.

d. **Strategic Theory and Concepts:** Demonstrate ability to evolve concepts and strategy to employ forces at the national and theater levels. Understand how joint and maritime forces may influence the future global security environment. Develop strategic- and theater-level concepts of operations based on higher-level policies and strategies.

e. **Coalitions and Alliance Politics:** Analyze the principal alliances and international organizations that shape the current security environment, including their role in U.S. national strategy, coalition building, and military missions from peace operations to major wars.

f. **Regional Security:** Understand the basic security dynamics of at least two major world regions.

g. **Joint Professional Military Education:** Satisfactory completion of JPME Phase I.

Master of Science in Strategy (Nuclear Command, Control, and Communications) - Curriculum 688

Academic Associate

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Brief Overview

This inter-disciplinary degree of curriculum 688 provides officers with expertise in nuclear strategy and international security combined with technical knowledge in nuclear command, control, and communications (NC3). The MS in Strategy (Nuclear Command, Control, and Communications) is pedagogically innovative, focusing on the Navy's S&T objectives and on Great Power Competition. The degree is for U.S. military students with Secret-level or higher clearance only.

APC

The minimum APC requirement for entry to this degree program is 244.

Convenes
Fall, Spring

Program Length
12 months

Degree
Master of Science in Strategy (Nuclear Command, Control, and Communications)

Subspecialty
Navy P-Codes: 2301P

Curriculum Requirements

Students in curriculum 695 must complete the following:

Course	Title	Lecture	Lab
NS3005	Great Power Conflict in Modern History	4	0
NS3011	Research and Writing for National Security Affairs	4	0
NS3024	Introduction to International Relations	4	0
NS3280	Nuclear Weapons and National Strategies	4	0
NS4000	Great Power Competition: Current Policy and Strategy	0	2
NS4253	Seminar on Technology and Strategic Planning	4	0
NS4990	Seminar in Strategic Studies	4	0
SS3011	Space Technology and Applications	3	0
SS3613	Military Satellite Communications	3	0
SS3740/AE3740	Nuclear Command, Control, and Communications Systems - Part I	3	0
SS3741/AE3741	Nuclear Command, Control, and Communications Systems - Part II	3	0

Three electives from courses approved by the sponsor.

Three courses associated with the degree must be at the 4000 level.

Thesis-Related Courses - Required

NS4080	Thesis Proposal	0	8
NS0810	Thesis Research	0	8
NS0810	Thesis Research	0	8

NS0810 must be taken twice.

Four JPME courses taught by the Naval War College satellite program maybe be added with a 5th quarter:

NW3230	Strategy & War	4	2
NW3275	Joint Maritime Operations - part 1	4	0
NW3276	Joint Maritime Operations - part 2	2	2
NW3285	Theater Security Decision Making	4	0

Educational Skill Requirements (ESR)

1. Understand the critical technical systems involved in the U.S. NC3 system.
2. Understand the factors involved in the operation of highly reliable systems, including methods used to protect and secure these systems in extremely adverse environments.
3. Demonstrate a knowledge of the state of nuclear weapons worldwide and an ability to understand and examine potential vulnerabilities.
4. Understand the basic physics of orbital mechanics and the space environment as they relate to national systems involved in NC3.
5. Demonstrate an ability to examine the design of orbits and constellations and explain how spacecraft maneuver and transfer to other orbits in support of NC3 missions.
6. Understand the history of NC3 technologies and the political, strategic, and budgetary factors that have affected their development over time.
7. Demonstrate a knowledge of nuclear strategy in both historical and comparative (international) contexts.
8. Demonstrate a knowledge of the fundamental principles and theories of international relations.
9. Understand the history and current dynamics of Great Power Competition and its linkages to U.S. national strategy.
10. Understand the interaction between technology and strategic planning, as well as adaptation in military organizations, as related to nuclear weapons.
11. Demonstrate a knowledge of future challenges to the U.S. NC3 system from the perspective of emerging technical and geo-strategic threats.

Master of Science in Strategy (Space Operations) - Curriculum 688

Academic Associate

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Overview

This inter-disciplinary degree of curriculum 688 provides officers with social science expertise in policy and strategy combined with technical knowledge in space science and military space applications. The MS in Strategy (Space Operations) is pedagogically innovative, focusing on the Navy's S&T objectives and on Great Power Competition. The degree is available for U.S. military students as well as for international students and U.S. civilians.

APC

The minimum APC requirement for entry to this degree program is 244.

Convenes

Fall

Program Length

12 months

Degree

Master of Science in Strategy (Space Operations)

Subspecialty

Navy P-Codes: 2301

Curriculum Requirements

U.S. Military students (with secret-level or higher clearance only) must complete the following:

Course	Title	Lecture	Lab
NS3005	Great Power Conflict in Modern History	4	0
NS3011	Research and Writing for National Security Affairs	4	0
NS3024	Introduction to International Relations	4	0
NS4000	Great Power Competition: Current Policy and Strategy	0	2
NS4253	Seminar on Technology and Strategic Planning	4	0
NS4677	Space and International Security	4	0
NS4990	Seminar in Strategic Studies	4	0
SS3011	Space Technology and Applications	3	0
SS3051	Military Applications of DoD and Commercial Space Systems	3	2
SS3613	Military Satellite Communications	3	0
PH3052	Physics of Space and Airborne Sensor Systems	4	0

Three electives from courses approved by the sponsor.

Three courses associated with the degree must be at the 4000 level.

Thesis-Related Courses - Required

NS4080	Thesis Proposal	0	8
NS0810	Thesis Research	0	8
NS0810	Thesis Research	0	8

NS0810 must be taken twice.

Four JPME courses taught by the Naval War College satellite program may be added with a 5th quarter

NW3230	Strategy & War	4	2
NW3275	Joint Maritime Operations - part 1	4	0
NW3276	Joint Maritime Operations - part 2	2	2

NW3285	Theater Security Decision Making	4	0

International and US civilian students must complete the following:

NS3005	Great Power Conflict in Modern History	4	0
NS3011	Research and Writing for National Security Affairs	4	0
NS3024	Introduction to International Relations	4	0
NS4253	Seminar on Technology and Strategic Planning	4	0
NS4677	Space and International Security	4	0
NS4990	Seminar in Strategic Studies	4	0
SS3011	Space Technology and Applications	3	0
SS3610	Space Communications Systems: Fundamentals and Analysis	4	2
PH2514	Introduction to the Space Environment	4	0
PH3052	Physics of Space and Airborne Sensor Systems	4	0

Three electives from courses approved by the sponsor.

Three courses associated with the degree must be at the 4000 level.

Thesis-Related Courses - Required

NS4080	Thesis Proposal	0	8
NS0810	Thesis Research	0	8
NS0810	Thesis Research	0	8

NS0810 must be taken twice.

Educational Skill Requirements (ESR)

1. Understand the basic physics of orbital mechanics and the space environment.
2. Demonstrate an ability to examine the design of orbits and constellations and explain how spacecraft maneuver and transfer to other orbits.
3. Understand critical space technologies and the military uses of space, as well as the role of commercial space systems.
4. Demonstrate a knowledge of military satellite communications, systems design, and applications, including terminal design, telemetry control, and IO/IW implications.
5. Understand joint space doctrine and the role of space in force enhancement, including for intelligence, surveillance, reconnaissance, missile tracking, launch detection, environmental monitoring, and position, navigation, and timing.
6. Demonstrate a knowledge of the fundamental principles and theories of international relations.
7. Understand the history and current dynamics of Great Power Competition and its linkages to U.S. national strategy.
8. Demonstrate an ability to analyze national security space challenges as affected by international space politics, law, and treaties.
9. Understand the interaction between technology and strategic planning, as well as adaptation in military organizations.

Homeland Security and Defense - Curriculum 691

Academic Associate

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Brief Overview

Homeland Security and Defense provides military officers with a theoretical and practical understanding of unconventional threats within the framework of the U.S. domestic security environment, and organizational strategies to deal with such threats. It explores the Department of Defense's primary role in deterring and preventing attacks on the territory of the United States and in consequence management should such attacks occur. The strategic interests and objectives of the United States; the roles missions, structures, and effectiveness of U.S. Homeland Security organizations and intelligence organizations, as well as potential threats to U.S. domestic security are examined.

Convenes

Students may enter in any quarter. Please refer to the Academic Calendar (p. 519) for quarterly start dates.

Program Length

For U.S. Navy students who wish to complete JPME Phase I while in residence, curriculum 691 is a six-quarter (18-month) program. For all other students, curriculum 691 is a five-quarter (15-month) program.

APC

The minimum APC requirement for entry to this program is 265.

Degree

Master of Arts in Security Studies (Homeland Security and Defense)

Subspecialty

Navy P-Codes: 2600P

Typical Subspecialty Jobs

Intelligence Officer
Plans Officer, Staff Planner
Various Joint Command Positions
Service Headquarters-Homeland Defense/Critical Infrastructure Protection

Major Staff Jobs in Combatant Commands and Fleet Commands

Curriculum Requirements

Students in curriculum 691 must complete four (4) disciplinary core courses, as follows:

Course	Title	Lecture	Lab
NS3005	Great Power Conflict in Modern History	4	0
NS3011	Research and Writing for National Security Affairs	4	0
NS3023	Introduction to Comparative Politics	4	0
NS3024	Introduction to International Relations	4	0

In addition, students must complete a minimum of nine (9) curricular core and elective courses in their regional specialization, of which at least three (3) must be at the 4000-level.

Homeland Security and Defense students must complete (5) curricular core courses, as follows:

NS3181	Introduction to Homeland Defense and Security	4	0
NS3802	Counter-terrorism Policy in Comparative Perspective	4	0
NS4157	Intelligence for Homeland Defense and Security	4	0
NS4941	National Security Law for Homeland Security and Defense	4	0
NS4721/OS4621	Critical Infrastructure Analysis and Defense	4	0

The additional courses needed to satisfy these requirements, and the quarters when they are offered, can be found on the NSA website at https://www.nps.edu/web/nsa/.

Students are also required to take sufficient general electives to maintain a full-time course load (16 hours). The number of general elective slots will vary somewhat depending upon service affiliation and sponsor requirements.

Students in curriculum 691 must complete NS4080, Thesis Proposal, no later than six months prior to intended graduation. Thereafter students may enroll in NS0810, Thesis Research, up to three times; or they may take additional course work in their area of specialization, with the permission of the Academic Associate.

Educational Skill Requirements (ESR)

1. **Basic Graduate Level Skills**

   a. **Conduct Research:** Assemble information from the full range of data sources to understand international political, economic, and military issues.

   b. **Analyze Problems and Demonstrate Critical Thinking:** Frame issues as research questions; logically combine evidence and theory to analyze and explain international political, economic, and military developments; and formulate innovative solutions to strategic problems.

   c. **Communicate Information:** Clearly summarize large quantities of information and persuasively present positions and courses of action using a broad range of verbal and written communications formats, including short oral arguments, visual briefs, policy memos, position papers, and comprehensive student theses.

2. **General Political Science, International Relations, and Security Studies**

   a. **Great Power Competition:** Analyze the factors shaping the new era of increasing geopolitical competition among the major powers. Understand Chinese and Russian activities and potential U.S. responses across all dimensions of power, including diplomacy, economic competition, influence campaigns, and traditional military force.

   b. **International and Comparative Politics:** Understand international relations theories, including realist, liberal, and cultural paradigms; the conditions and world views that shape state interactions in the international system; the history of modern nationalism and the state system; and the roles of domestic politics, non-state actors, and transnational social movements in shaping international politics.

   c. **International Economy:** Understand the economic factors that shape the international security environment, including the economic dimensions of national security policy and the ways in which economic policies and interests affect military strategy and force structure.

   d. **International and Military History:** Grasp the principal causes of war in the modern era, and understand the political, technological, economic, and other influences that have governed its conduct; understand the social, political, economic, and cultural forces that have contributed to periods of stable peace; and analyze relations between states, including negotiations of peace settlements, military alliances, arms limitation agreements, economic arrangements, and human rights accords.

   e. **International Organizations:** Understand the history of international organizations and their role in world politics, including international mediation and negotiations, formal and informal security arrangements, treaty regimes, and the role of

international institutions and non-governmental organizations in peacekeeping and humanitarian operations.

    f. **U.S. Security Policy and Strategy:** Understand how U.S. national security policy and strategy are formulated. Understand the roles of nuclear forces in the security policies of the United States and other nuclear powers; U.S. nuclear force acquisition, planning, deterrence policy, and employment concepts from the Second World War to the present; and the role of nuclear weapons in alliance politics and international relations.

3. **Homeland Security and Defense**

    a. **Analytical Skills:** Graduates will be able to logically combine data and theory to analyze and explain political, economic, and military events in the context of the Department of Homeland Security. Students will demonstrate writing, briefing, and computer skills in preparing and presenting their findings.

    b. **National Security Issues:** Graduates will be aware of the economic, political, social, and military characteristics of homeland security, homeland defense, and national security issues. These issues include: intelligence gathering and information sharing, posse comitatus, the interaction of law enforcement with military command, and the increasing significance of great power competition for homeland defense.

    c. **Critical Infrastructure Vulnerability:** Graduates will be familiar with the full range of critical infrastructure sectors within the United States. They will know what their vulnerabilities are, and how to "harden" the critical nodes in each sector. Particular emphasis will be placed on networked infrastructure and the protection of critical nodes.

    d. **Threat Analysis:** Graduates will learn about domestic and international terrorism as they pertain to homeland security, as well as plans and capabilities to respond to such threats at the state, local, and federal levels.

    e. **Civil-Military Relations:** Graduates will understand the field of civil-military relations as it applies to homeland security within the framework of the U.S. Constitution and the history of American civil-military relations. Students will be able to identify key players in homeland security at the various levels of government within and beyond the DoD, including the Department of Homeland Security, Northern Command, FBI, CIA, etc.

    f. **Law Enforcement and the Judicial System:** Graduates will understand the interface between domestic law enforcement, state and local police, emergency response teams, military support of civilians, and investigations by various agencies such as the U.S. Postal Service, etc. Graduates will know the roles and responsibilities of various law enforcement agencies. Finally, graduates will understand how the judicial system interfaces with the military, at the state and local levels.

    g. **Intelligence in Homeland Security:** Graduates will understand the role of intelligence in defense of the homeland, including the restraints imposed upon intelligence-gathering within the United States. Graduates will recognize what can be learned from military intelligence and applied to homeland security. Graduates will understand the complexities of information gathering, analysis, and sharing in the context of homeland security.

Curriculum Sponsor and ESR Approval Authority

Deputy Chief of Naval Operations (Plans, Policy and Operations) (N3/N5)

Center for Homeland Defense and Security - Curriculum 692 (DL and Res)

Academic Associate

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Interim Director

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This 18-month program is offered at no cost to eligible senior and fast-track local, state, tribal and federal officials and NORTHCOM-sponsored officers with significant homeland security responsibilities. **Participants:** U.S. students only.

Program: Designed to accommodate busy officials, the Master of Arts degree program requires participants to be in residence (at the Naval Postgraduate School in Monterey, California or at an educational facility in the National Capital Region [NCR]) two weeks each quarter (for a total of 12 weeks). Participants complete the remainder of their coursework via network-based distance learning methods. The curriculum and research are focused on current policy, strategy and organizational design challenges. Participants complete research papers and a thesis on policy development issues confronting their city, state, or sponsoring organization.

The program graduated its first class in June 2004 and graduates approximately 30 officials three times a year. A military variant of the program, including classified courses, is available through the Department of National Security Affairs.

Requirements for Entry

Applicants eligible for sponsorship must be full-time state, local, tribal or federal DHS officials or U.S. Navy and Marine Corps officers. All others, including other military branches and NORTHCOM, are eligible to apply but must obtain financial sponsorship from their command. A baccalaureate degree or its equivalent is required. A minimum grade point average of 3.0 or its equivalent is required. A complete application and eligibility details are available online at http://www.chds.us.

Convenes

This is an 18-month program with entry dates in spring and fall for Monterey cohorts; NCR cohorts start in the summer.

The program requires 12 weeks of in-residence attendance, with the balance of coursework conducted online.

Degree

Master of Arts in Security Studies (Homeland Defense and Security)

Typical Subspecialty Jobs (Executive Level)

Homeland Security

Emergency Management

Public Health

Public Safety (Law, Fire Enforcement)

Public Policy

Subspecialty Code

Navy P-Code: 2600P

Website: www.chds.us

A CHDS master's program graduate will be able to:

1) Serve and lead in public sector organizations with insight, ethics, and an awareness of the cultural, political, legal, fiscal, technological, and strategic context for the purpose of advancing the homeland security enterprise

2) Make informed contributions to procedural discussions and policy development efforts at various levels of government in support of U.S. and allied homeland security missions, objectives, and goals

3) Use a variety of analytical frameworks to assess and deploy human capital and material resources to meet current and emerging homeland security threats, challenges, and opportunities

4) Conduct research and create timely and relevant work, to include papers, theses, presentations, and analyses on homeland security topics

Required Course of Study

Quarter 1

Course	Title	Lecture	Lab
NS3180	Introduction to Homeland Security	4	0

Course	Title	Lecture	Lab
NS3210	The Unconventional Threat to HLS	4	0

Quarter 2

Course	Title	Lecture	Lab
IS4010	Technology in Homeland Security	4	0
NS4156	Intelligence for Homeland Security: Organizational and Policy Challenges	4	0
NS3014	Research and Writing for Homeland Security	2	0

Quarter 3

Course	Title	Lecture	Lab
CS3660	Critical Infrastructure Protection	4	0
NS4081	Research Colloquium	2	0
NS4755	Strategic Planning and Budgeting for Homeland Security	4	0

Quarter 4

Course	Title	Lecture	Lab
NS4881	Multi-Discipline Approaches to Homeland Security	4	0
NS3028	Comparative Government for Homeland Security	4	0

Quarter 5

Course	Title	Lecture	Lab
NS4910	Internet, Society, and Cyberconflict	4	0
NS4239	Special Topics in American Government for Homeland Security	4	0

Quarter 6

Course	Title	Lecture	Lab
NS4232	Knowledge into Practice: A Homeland Security Capstone Course	3	0
NS0810	Thesis Research	0	8

Educational Skill Requirements (ESRs)

Strategic Praxis: Students will build on their existing knowledge of—and experiences with—the homeland security enterprise (HSE) by critically examining HSE strategies and policies; analyzing the historical, political, economic, and legal factors that underpin homeland defense and security at all levels of government; and evaluating challenges, opportunities, and threats, both contemporary and future. Students will consider institutional roles and missions as they critically assess risks, consequences, and mitigation options for a wide range of homeland security challenges; create assessments to identify near-term and long-term threats; and effectively communicate their findings to support the creation of plans and policies for community resilience, including protection, preparedness, response, and recovery.

Enterprise Praxis: Drawing from an interdisciplinary range

of methods, sources, ideas, and practice, students will apply creativity and critical thinking skills to analyze and evaluate the institutions that make up the homeland security enterprise by assessing the missions, capabilities, interests, equities, and limitations of components of the HSE. Students will identify and evaluate HSE objectives and stakeholders at every level of government and develop the capacity to advance interagency and inter-government collaboration. Students will also consider the role of capacity-building partnerships with external organizations, including non-government actors, to address homeland security and defense challenges under preparatory and crisis conditions.

Cultural Praxis: Students will consider how historical, political, social, and ethical factors can affect HSE practitioners' ability to effectively respond to the needs of policymakers and the public. Students will assess how communities are formed, evolve, and may emerge as vulnerable or adversarial populations; assess institutional and interpersonal dynamics by evaluating the actions, motivations, and incentives of both HSE components and known and potential adversaries; consider models of interpersonal and bureaucratic leadership and followership that have applicability in departmental, interagency, and inter-government settings; and develop the skills to communicate effectively with diverse constituencies within and outside the HSE.

Analytical Praxis: Students will build on their existing research and writing skills as they learn and apply a portfolio of qualitative and quantitative research methods to ask critical questions about the HSE and examine options to address homeland defense and security challenges. Students will refine their abilities to identify, evaluate, and integrate source materials; assess and address their own analytical biases; effectively communicate with diverse audiences using a variety of media formats; and analyze how complexity and change define and shape the homeland defense and security discourse. Students will create knowledge that has academic and/or practical value, informing policy discussions and enriching the literature on homeland security.

Innovation Praxis: Students will develop innovative approaches to improving the effectiveness and efficiency of the homeland security enterprise by using a variety of methodologies to frame challenges and threats in new ways; understand different frames of reference, to include individual and organizational expectations, to assess the practicality and utility of new techniques and capabilities to implement HSE goals and objectives; and discover new methods for gathering and deploying data and information in support of HSE requirements. Students will study and assess new concepts and ideas – drawn from a range of disciplinary sources – in order to prompt informed discussions among homeland security and defense policymakers and professionals about strategy, policy, resource management, and operational

constraints. Students will consider how historical, political, social, and ethical factors can affect HSE practitioners' ability to effectively respond to the needs of policymakers and the public. Students will assess how communities are formed, evolve, and may emerge as vulnerable or adversarial populations; assess institutional and interpersonal dynamics by evaluating the actions, motivations, and incentives of both HSE components and known and potential adversaries; consider models of interpersonal and bureaucratic leadership and followership that have applicability in departmental, interagency, and inter-government settings; and develop the skills to communicate effectively with diverse constituencies within and outside the HSE.

Combating Terrorism -- Policy and Strategy - Curriculum 693

Academic Associate

Carolyn C. Halladay, Ph.D.
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cchallad@nps.edu

Brief Overview

This curriculum provides an understanding of the nature and dynamics of terrorist organizations, and the domestic and international variables involved in the formulation of counter-terrorist policy. The curriculum allows the students to combine a regional focus with comparative courses that discuss terrorist organizations and operations, the financing of terror, legal and policing developments in counter-terrorism, intelligence, and the military role in homeland defense.

The NSA department is a unique environment in which to pursue this course of studies since its student body is inherently joint and combined, providing students with both a stimulating intellectual environment and an opportunity to establish networks and life-long working relationships with fellow officers from other services and countries.

APC

The minimum APC requirement for entry to this program is 265.

Convenes

For students who wish to complete JPME Phase I while in residence, curriculum 693 is a six-quarter (18 month) program. For all other students, curriculum 693 is a five-quarter (15-month) program. Students may enter in any quarter. Please refer to the Academic Calendar (p. 519) for quarterly start dates.

Degree

Master of Arts in Security Studies (Combating Terrorism Policy and Strategy)

Subspecialty

Navy P Codes: None

Course Requirements

Students in curriculum 693 must complete four (4) disciplinary core courses, as follows:

Course	Title	Lecture	Lab
NS3005	Great Power Conflict in Modern History	4	0
NS3011	Research and Writing for National Security Affairs	4	0
NS3023	Introduction to Comparative Politics	4	0
NS3024	Introduction to International Relations	4	0

In addition, students must complete a minimum of nine (9) curricular core and elective courses in their regional specialization, of which at least three (3) must be at the 4000-level.

Combating Terrorism - Policy and Strategy students must complete (4) curricular core courses, as follows:

NS3802	Counter-terrorism Policy in Comparative Perspective	4	0
NS3900	International Law and Organizations	4	0
NS4801	Seminar on Terrorism	4	0
NS3155	Intelligence and Democracy -or-	4	0
NS4157	Intelligence for Homeland Defense and Security	4	0

The additional courses needed to satisfy these requirements, and the quarters when they are offered, can be found on the NSA website at https://www.nps.edu/web/nsa/.

Students are also required to take sufficient general electives to maintain a full-time course load (16 hours). The number of general elective slots will vary somewhat depending upon service affiliation and sponsor requirements.

Students in curriculum 693 must complete NS4080, Thesis Proposal, no later than six months prior to intended graduation. Thereafter students may enroll in NS0810, Thesis Research, up to three times; or they may take additional course work in their area of specialization, with the permission of the Academic Associate.

Educational Skill Requirements (ESR)

1. **Basic Graduate Level Skills:**
   a. **Conduct Research:** Assemble information from the full range of data sources to understand international political, economic, and military issues.
   b. **Analyze Problems and Demonstrate Critical Thinking:** Frame issues as research questions; logically combine evidence and theory to analyze and explain international political, economic, and military developments; and formulate innovative solutions to strategic problems.
   c. **Communicate Information:** Clearly summarize large quantities of information and persuasively present positions and courses of action using a broad range of verbal and written communications formats, including short oral arguments, visual briefs, policy memos, position papers, and comprehensive student theses.
2. **General Political Science, International Relations, and Security Studies:**
   a. **Great Power Competition:** Analyze the factors shaping the new era of increasing geopolitical competition among the major powers. Understand Chinese and Russian activities and potential U.S. responses across all dimensions of power, including diplomacy, economic competition, influence campaigns, and traditional military force.
   b. **International and Comparative Politics:** Understand international relations theories, including realist, liberal, and cultural paradigms; the conditions and world views that shape state interactions in the international system; the history of modern nationalism and the state system; and the roles of domestic politics, non-state actors, and transnational social movements in shaping international politics.
   c. **International Economy:** Understand the economic factors that shape the international security environment, including the economic dimensions of national security policy and the ways in which economic policies and interests affect military strategy and force structure.
   d. **International and Military History:** Grasp the principal causes of war in the modern era, and understand the political, technological, economic, and other influences that have governed its conduct; understand the social, political, economic, and cultural forces that have contributed to periods of stable peace; and analyze relations between states, including negotiations of peace settlements, military alliances, arms limitation agreements, economic arrangements, and human rights accords.
   e. **International Organizations:** Understand the history of international organizations and their role in world politics, including international mediation and negotiations, formal and informal security arrangements, treaty regimes, and the role of international institutions and non-governmental

organizations in peacekeeping and humanitarian operations.

f. **U.S. Security Policy and Strategy:** Understand how U.S. national security policy and strategy are formulated. Understand the roles of nuclear forces in the security policies of the United States and other nuclear powers; U.S. nuclear force acquisition, planning, deterrence policy, and employment concepts from the Second World War to the present; and the role of nuclear weapons in alliance politics and international relations.

Doctor of Philosophy in Security Studies - Curriculum 694

Doctoral Committee Chair

Daniel Moran, Ph.D.
Code 38, Glasgow Hall, Room 316
(831)656-2059, DSN 756-2059
djmoran@nps.edu

Brief Overview

Security Studies is a multidisciplinary field based on the traditional academic disciplines of Political Science, History, and Economics. The doctoral program in Security Studies seeks to equip students with the skills and knowledge required to do work of the highest professional quality in these areas, with emphasis on understanding the challenges and characteristics of modern security and defense policy.

The PhD in Security Studies requires three years in-residence, beginning with one year of course work beyond the Master's degree, followed by two years conducting research and writing the dissertation.

Requirements for Entry

Admission to the Ph.D. program in Security Studies is available to officers of all the U.S. armed services, civilian federal employees with agency sponsorship, and to individuals sponsored by selected allied nations. Applicants must possess a Master's Degree in Security Studies or a closely-allied field (Political Science, History, Economics, etc.) by the time doctoral instruction begins.

Admissions decisions are made on a rolling basis, once a complete application has been received. The following materials are required:

- A completed online application, which may be accessed at http://www.nps.edu/Academics/Admissions/ApplyOnline/ApplyNow.html.
- A cover letter specifying research interest and purpose for seeking a doctoral degree, especially in relation to the candidate's previous academic and professional experiences.
- Certified transcripts of prior graduate and undergraduate work. Transcripts of work completed at NPS are not necessary.

- Scores from the Graduate Record Examination, taken within the last five years.
- At least two (2) letters of recommendation, either from former professors or from others in a position to judge the candidate's academic potential.
- Attestation by the student's sponsoring agency or nation that it is committed to provide tuition and salary support during the student's residence at NPS.
- A sample of expository writing (e.g. a paper written for a graduate seminar, a Master's thesis, an article published in an academic or service journal) chosen by the applicant to demonstrate his or her ability to do advanced academic work.
- International applicants who are not currently enrolled at NPS, and whose native language or language of prior instruction is other than English, must submit current results of the Test of English as a Foreign Language (TOEFL) and the Test of Written English.

    Domestic applicants should forward the materials just described, to the NPS Director of Admissions. International students should forward their materials to the International Graduate Programs Office.

Convenes

Once a student has been admitted, doctoral study may begin in any subsequent quarter during the following twelve months.

Degree

Doctor of Philosophy in Security Studies.

Curriculum Requirements

General Degree Requirements: The NSA doctoral program requires one year of course work beyond the Master's degree. Courses and directed studies are tailored to develop the candidate's analytical and methodological foundations in three functional, regional, or disciplinary sub-fields of security studies, to prepare students to take required written qualifying examinations, and to identify a dissertation topic and write a dissertation proposal.

A student is expected to have completed comprehensive examinations, and secured approval of the dissertation proposal by the committee that will supervise its completion, by the end of the fifth and sixth quarters, in residence, respectively.

Degree Candidacy and Dissertation Research: Doctoral students are admitted to candidacy for the Ph.D. following successful completion of written and oral qualifying examinations, and the submission of a satisfactory dissertation proposal. Students admitted to candidacy for the degree are thereafter expected to be engaged full-time in dissertation research and writing. Once a completed dissertation has been submitted the student must defend it before the dissertation committee. A representative of the Academic Council and other interested observers will also be present for the defense.

Curriculum Sponsor and ESR Approval Authority

Deputy Chief of Naval Operations (Plans, Policy and Operations) (N3/5).

Subspecialty

2000D

Department of Oceanography

Chair

Peter C. Chu, Ph.D.
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(831) 656-2673, DSN 756-2673
pcchu@nps.edu

Associate Chair, Instruction

James MacMahan, Ph.D.
Spanagel Hall, Room 327C
(831) 656-2379, DSN 756-2379
chiu@nps.edu

Associate Chair, Research

Timour Radko, Ph.D.
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tradko@nps.edu

Peter C. Chu, Distinguished Professor and Chair(1986); Ph.D., University of Chicago, 1985.

Jacqueline L Clement-Kinny, Research Assistant Professor(2002); Ph.D., Naval Postgraduate School, 2011.

John A. Colosi, Professor (2005); Ph.D., University of California, Santa Cruz, 1993.

Joel W. Feldmeier, Military Faculty (2017); Ph.D. Naval Postgraduate School, 2013.

Arlene A. Guest, Senior Lecturer, (1999); M.S., Florida State University, 1981.

Leonid Ivanov, Research Associate Professor (2012); Ph.D., Marine Hydrophysical Institute of the Ukrain Academy of Sciences, 1983.

James MacMahan, Associate Professor and Associate Chair (2007), Ph.D., University of Florida, 2003.

Wieslaw Maslowski, Research Professor (1994); Ph.D., University of Alaska-Fairbanks, 1994.

Jeffrey Dean Paduan, Professor (1991); Ph.D., Oregon State University, 1987.

Timour Radko, Associate Professor (2004); Ph.D., Florida State University, 1997.

D. Benjamin Reeder , Associate Research Professor (2011); Ph.D., Massachusetts Institute of Technology/Woods Hole Oceanographic Institution Joint Program, 2002.

Andrew F. Roberts, Associate Research Professor (2011); Ph.D., University of Tasmania, 2005.

William J. Shaw, Research Assistant Professor (2005); Ph.D., Woods Hole Oceanographic Institution, 2000.

Robin T. Tokmakian, Research Associate Professor (1997); Ph.D., Naval Postgraduate School, 1997.

Research Associates And Assistants:

John E. Joseph, Faculty Associate Research (AD5) (2005); M.S., Naval Postgraduate School, 1991

Tetyana Margolina, Research Associate (2011); Ph.D. Marine Hydrophysical Institute of the Ukraine Academy of Sciences, 2001.

Christopher W. Miller, Research Associate (1992); M.S., Naval Postgraduate School, 1998.

Professors Emeriti:

Robert Hathaway Bourke, Professor Emeritus (1971); Ph.D., Oregon State University, 1972.

Curtis Allan Collins, Professor Emeritus (1987); Ph.D., Oregon State University, 1967.

Roland William Garwood, Professor Emeritus, (1976); Ph.D., University of Washington, 1976.

Thomas H. C. Herbers, Professor Emeritus, (1993) PhD. University of California, San Diego, 1990.

Glenn Harold Jung, Professor Emeritus (1958); Ph.D., Texas A & M University, 1955, 1950.

Albert Julius Semtner, Jr., Professor Emeritus(1986); Ph.D., Princeton University, 1973

Timothy P. Stanton, Research Professor Emeritus (1978); M.S., University of Aukland, 1977.

Eugene Dewees Traganza, Professor Emeritus (1970); Ph.D., University of Miami, 1966.

Joseph John von Schwind, Professor Emeritus (1967); Ph.D., Texas A & M University, 1968.

Distinguished Professor Emeritus:

Ching-Sang Chiu, Distinguished Professor Emeritus (1988); Ph.D., MIT/Woods Hole Oceanographic Institution, 1985.

Edward Bennett Thornton, Distinguished Professor Emeritus , (1969); Ph.D., University of Florida, 1970.

* The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

Brief Overview

Founded as a separate department in 1968, the Oceanography Department supports curricula sponsored by the Oceanographer of the Navy: #372 Meteorology #373 Air-Ocean Science, #374 Operational Oceanography, #440 Oceanography. The department also offers the MS in Physical Oceanography to Undersea Warfare curricula #525 (USN) and #526 (international).

The department focuses primarily on Physical Oceanography, Ocean Acoustics and Acoustical Oceanography, Numerical Modeling, Air-Sea Interactions, and Nearshore and Coastal/Littoral Oceanography, and has strong interests in remote sensing and geospatial information systems.

Topics include ocean dynamics, numerical ocean prediction and simulation, satellite remote sensing of the ocean, air-sea interaction, polar oceanography, upper ocean dynamics and thermodynamics, near-shore processes, wave and surf forecasting, mesoscale dynamics, coastal ocean circulation, tactical oceanography and environmental acoustics. The department also provides core courses for Undersea Warfare and the Space Systems curricula.

Degree

A student is able to earn an academic degree listed below while enrolled in Meteorology and Oceanography (Curriculum 373), Operational Oceanography (Curriculum 374), Oceanography (Curriculum 440), and Undersea Warfare (Curriculum 525).

Master of Science in Physical Oceanography

Entrance to a program leading to the Master of Science in Physical Oceanography degree requires a baccalaureate degree. Minimal requirements include mathematics through differential and integral calculus and one year of calculus-based physics.

The Master of Science in Physical Oceanography degree requires:

1. Completion of at least eight physical oceanography graduate courses with at least four courses in the OC4000 series. The sequence of core courses in physical oceanography encompasses the fields of dynamic, acoustical, and coastal/littoral oceanography. The entire sequence of courses selected must be approved by the Department of Oceanography. Significant experience in the field using instruments is required for the degree. (OC3570 satisfies this requirement).
2. At least 32 credit hours of approved graduate study, of which must include at least eight physical oceanography courses totaling 28 credit hours, and of the 28 credit hours at least 13.5 credit hours must be at the 4000 level in courses other than directed study. Four credit hours of directed study or additional OC elective courses would count for the remainder of the degree requirements.
3. Completion of an acceptable thesis on a topic approved by the Department of Oceanography.

Master of Science in Meteorology and Physical Oceanography

Direct entrance to a program leading to the Master of Science in Meteorology and Physical Oceanography degree requires a baccalaureate degree in one of the physical sciences, mathematics, or engineering. This normally permits the validation of a number of required undergraduate courses such as physics, differential equations, linear algebra, vector analysis and various courses in meteorology and/or oceanography, which are prerequisites to the graduate program. These prerequisites may be taken at the Naval Postgraduate School; however, in that event, the program may be lengthened by one or more quarters.

The Master of Science in Meteorology and Physical Oceanography degree requires:

1. Necessary prerequisite courses in mathematics (through partial differential equations), meteorology and physical oceanography.
2. The sequence of core courses in meteorology and oceanography in the fields of dynamical, numerical and physical and synoptic meteorology and oceanography.
3. An approved selection of graduate elective courses in oceanography and meteorology.
4. Significant experience in the field using instruments.
5. An acceptable thesis on a topic approved by either department.

The total number of quarter-hours in (2) and (3) above must be at least 48. These 48 hours must include 20 hours at the 4000 level in courses other than directed study and they should show an approximate balance between the disciplines of Meteorology and Physical Oceanography.

Dual Degree in Meteorology and Physical Oceanography

The Meteorology and Oceanography Departments have adopted a policy to not recommend its award of dual master's degrees in Meteorology and Physical Oceanography

Doctor of Philosophy

Department of Oceanography admission requirements for the Doctor of Philosophy degree include:

A bachelor's degree with a high QPR or a highly successful first graduate year in a master's program, with clear evidence of research ability.

A master's degree may be required before admission to candidacy.

The Ph.D. program is in Physical Oceanography, including areas of study in ocean circulation theory, air-sea interaction, ocean acoustics, nearshore, and coastal/littoral oceanography among others. An applicant to the Ph.D. program who is not already at NPS should submit transcripts of previous academic and professional work, plus results of a current Graduate Record Examination (GRE) general test, to the Director of Admissions, Code 01C3, Naval Postgraduate School, Monterey, California 93943-5100.

Oceanographic Laboratories

NPS is a member of CENCAL (Central California Cooperative), UCAR (University Corporation for Atmosphere Research), MBCORC (Monterey Bay Crescent Ocean Research Consortium), CeNCOOS (Central and Northern California Ocean Observing Systems and CORE (Consortium for Oceanographic Research and Education). In 2007, CORE Joined with JOI (Joint Oceanographic Institutions) to become CoOL (Consortium for Ocean Leadership). UNOLS operates the nation's academic oceanographic research fleet, while CENCAL promotes

and coordinates research vessel operations between several academic institutions in central California.

The Rapid Environmental Assessment Laboratory (REAL) consists of moored-equipment in Monterey Bay, and provides for instruction in the practical design, deployment and collection of state-of-the-art oceanographic data. Real-time observations of currents, temperature, salinity and sound speed structure in a variety of oceanic regimes are analyzed and modeled, applying theoretical and mathematical techniques learned in the classroom to Naval Oceanography problems.

The Oceanography Department operates a graphics laboratory that is equipped with networked workstations for the analysis of numerical model output, geospatial information system (GIS) exercises, satellite imagery, acoustical data and other digital fields from REAL. Smart classrooms enable data to be brought into the classroom in real time to demonstrate signal processing, rapid environmental assessment and other state-of-the-art oceanographic and tactical decision aids.

The department is organized around thematic laboratories, each containing faculty, staff and student offices, computing facilities and special laboratory equipment. Thematic laboratories exist for Oceanic Planetary, Polar, Nearshore, Acoustics, Coastal /Littoral Modeling, Global and Polar Ocean/Sea Ice Modeling, GI&S, Naval Ocean Analysis and Prediction, Ocean Turbulence, Ocean Waves, Radar and Drifter, and Tactical Environmental Support.

Oceanography Course Descriptions

OC Courses (p. 478)

Meteorology and Oceanography (METOC) - Curriculum 373 (OC)

Meteorology and Oceanography (METOC under Dept. of Oceanography)

Program Officer

CDR Pamela Tellado
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Academic Associates

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James MacMahan, Ph.D. (Oceanography)
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Brief Overview

This program in meteorology and oceanography involves approximately 109 quarter-hours of classroom lectures, supplemented by an additional 42 quarter-hours of laboratory exercises. This program is designed to provide the student with:

- A thorough understanding of the principles governing the physical and dynamic properties of the oceans and atmosphere.
- The ability to observe, assimilate, analyze, interpret, and predict oceanic and atmospheric parameters and conditions using field experimentation, direct and remote sensing observational techniques, statistical analyses, and numerical models.
- A thorough understanding of the effects of oceanic and atmospheric properties and conditions on weapon, sensor and platform performance while conducting and supporting naval warfare, with particular emphasis on ocean acoustics and electromagnetic/optical propagation.
- An oceanographic or meteorological research experience germane to naval warfare culminating in a thesis of professional quality.
- A knowledge of Joint Strategy and Policy.
- Thesis with multi-authors is not allowed.

This education will enhance performance in all duties throughout a career, including operational billets, technical management assignments and policy making positions. Students will develop graduate-level technical ability based upon scientific principles, acquire diverse professional knowledge, and develop analytical ability for practical problem solving.

Requirements for Entry

This program is open to METOC (1800) Officers, officers from other services, International Officers and DoD civilians.

A baccalaureate degree in the physical sciences, mathematics or engineering is required. Completion of mathematics through differential and integral calculus and one year of calculus-based college physics are required. An APC of 233 is required for direct entry.

Convenes

The METOC program is normally a ten-quarter course of study with entry dates in January and July. If further information is needed, contact the Program Officer. Academic questions may be referred directly to either of the Academic Associates.

Program Length

30 months

Subspecialty

Completion of this program qualifies an officer as a METOC Subspecialist with a subspecialty code of 6401P. The Curriculum Sponsor is the Oceanographer of the Navy (CNO N2/N6E).

Typical Subspecialty Jobs

METOC Officer aboard CV(N)/LHD

Submarine Group Staff
Numbered Fleet Staff
CARSRTKGRU Staff
OIC Naval Meteorology and Oceanography Command
Detachment
NAVMETOCCOM Mobile Warfare Teams
National Geospatial Agency
Office of Naval Research

Typical Course of Study - Summer Start

Quarter 1

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 2

OC3230	Descriptive Physical Oceanography	3	1
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
MA2121	Differential Equations	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 3

MR3480	Atmospheric Thermodynamics and Radiative Processes	4	1
MR2020	Computer Computations in Air-Ocean Sciences	2	2
	-or-		
OC2020	Computer Computations in Air-Ocean Sciences	2	2
MA3132	Partial Differential Equations and Integral Transforms	4	0
MR3140	Probability and Statistics for Air-Ocean Science	3	2
	-or-		
OC3140	Probability and Statistics for Air-Ocean Science	3	2
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 4

MR3222	Meteorological Analysis/Laboratory	4	3

MR3150	Analysis of Air/Ocean Time Series	3	2
	-or-		
OC3150	Analysis of Air Ocean Time Series	3	2
OC3260	Fundamentals of Ocean Acoustics	4	1
MR3321	Air-Ocean Fluid Dynamics	4	0
	-or-		
OC3321	Air-Ocean Fluid Dynamics	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 5

MR4322	Dynamic Meteorology	4	0
MR4413/OC4413	Air-Sea Interaction	4	0
	-or-		
OC4413/MR4413	Air/Sea Interaction	4	0
MR3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
	-or-		
OC3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
OC3240	Ocean Circulation Analysis	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 6

MR4323	Air and Ocean Numerical Prediction Systems	4	2
	-or-		
OC4323	Air and Ocean Numerical Prediction Systems	4	2
MR3234	Tropospheric and Stratospheric Meteorology/Laboratory	4	4
OC4800	Advanced Courses in Oceanography	V	0
OC3212	Polar Meteorology/Oceanography	4	0
OC4211	Ocean Dynamics II	4	0
MR4900	Directed Study in Meteorology	V	0
	-or-		

		Lecture	Lab
OC4900	Directed Study in Oceanography	V	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 7

MR3252	Tropical Meteorology/Laboratory	3	4
MR4800	Advanced Topics in Meteorology	V	0
	-or-		
OC4800	Advanced Courses in Oceanography	V	0
NW3230	Strategy & War	4	2
OC3212	Polar Meteorology/Oceanography	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 8

MR4240	Coastal Meteorology	3	1
OC4335	Naval Ocean Analysis and Prediction	3	2
OC4210	Littoral Field Studies	2	4
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 9

MR4416	Atmospheric Factors in Electromagnetic and Optical Propagation	3	0
OC4270	Tactical Oceanography	3	4
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 10

MR3262	Operational Atmospheric Prediction/Laboratory	3	5
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0999	Seminar in Meteorology	2	0
	-or-		
OC0999	Thesis Seminars	2	0

Typical Course of Study-Winter Start

Quarter 1

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 2

OC3230	Descriptive Physical Oceanography	3	1
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
MA2121	Differential Equations	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Quarter 3

MR3480	Atmospheric Thermodynamics and Radiative Processes	4	1
MR2020	Computer Computations in Air-Ocean Sciences	2	2
	-or-		
OC2020	Computer Computations in Air-Ocean Sciences	2	2
MA3132	Partial Differential Equations and Integral Transforms	4	0

Course	Title		
MR3140	Probability and Statistics for Air-Ocean Science	3	2
	-or-		
OC3140	Probability and Statistics for Air-Ocean Science	3	2
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1
Quarter 4			
MR3222	Meteorological Analysis/Laboratory	4	3
MR3150	Analysis of Air/Ocean Time Series	3	2
	-or-		
OC3150	Analysis of Air Ocean Time Series	3	2
OC3260	Fundamentals of Ocean Acoustics	4	1
MR3321	Air-Ocean Fluid Dynamics	4	0
	-or-		
OC3321	Air-Ocean Fluid Dynamics	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1
Quarter 5			
MR4322	Dynamic Meteorology	4	0
MR4413/OC4413	Air-Sea Interaction	4	0
	-or-		
OC4413/MR4413	Air/Sea Interaction	4	0
MR3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
	-or-		
OC3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
OC3240	Ocean Circulation Analysis	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1
Quarter 6			
MR4323	Air and Ocean Numerical Prediction Systems	4	2
	-or-		
OC4323	Air and Ocean Numerical Prediction Systems	4	2
MR3234	Tropospheric and Stratospheric Meteorology/Laboratory	4	4
OC4800	Advanced Courses in Oceanography	V	0
MR4900	Directed Study in Meteorology	V	0
	-or-		
OC4900	Directed Study in Oceanography	V	0
OC4211	Ocean Dynamics II	4	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1
Quarter 7			
MR3252	Tropical Meteorology/Laboratory	3	4
MR4800	Advanced Topics in Meteorology	V	0
	-or-		
OC4800	Advanced Courses in Oceanography	V	0
MR4416	Atmospheric Factors in Electromagnetic and Optical Propagation	3	0
NW3230	Strategy & War	4	2
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1
Quarter 8			
MR3262	Operational Atmospheric Prediction/Laboratory	3	5
MR4325	METOC for Warfighter Decision Making	3	2
OC4210	Littoral Field Studies	2	4
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1
Quarter 9			
OC4270	Tactical Oceanography	3	4

OC3212	Polar Meteorology/Oceanography	4	0
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1
Quarter 10			
MR4240	Coastal Meteorology	3	1
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0810	Thesis Research	0	8
	-or-		
OC0810	Oceanography Thesis Research	0	8
MR0999	Seminar in Meteorology	2	0
	-or-		
OC0999	Thesis Seminars	2	0
MR0001	METOC Colloquium	0	1
	-or-		
OC0001	METOC Colloquium	0	1

Educational Skill Requirements (ESR)
Meteorology & Oceanography (METOC) - Curriculum 373
Subspecialty Code: 6401P

1. **Weapon & Sensor Performance:** The officer must have an understanding of the effects of open-ocean and near-shore ocean and atmospheric properties on weapons, sensors, and platform performance. The officer must have the ability to translate this knowledge into warfighter decision recommendations based on sound decision theory, taking into account available courses of action, assessments of vulnerability, uncertainty, and risk as indicated on performance surfaces.

2. **Integration of Oceanic & Atmospheric Parameters:** The officer must be able to observe, assimilate, analyze, and predict oceanic and littoral water conditions, and atmospheric conditions using direct and remote sensing observation techniques, statistical analysis, and numerical models. The officer will have a sound understanding of polar, mid-latitude and tropical atmospheric and oceanographic dynamics, including the impact of regional conditions on military operations

and systems.

3. **Numerical Processing:** The officer will have a thorough understanding of numerical modeling/processing as it applies to the physics and dynamics of the ocean and the atmosphere. This understanding should include a broad understanding of the modeling process itself to include strengths, weaknesses, and vulnerabilities; the state of current models and techniques; and appropriate applications of deterministic and stochastic techniques.

4. **Ocean/Atmosphere Problem Solving:** The officer must develop critical thinking skills and conduct independent analyses to solve environmentally challenging problems in the fields of Physical Oceanography and/or Meteorology as they apply to Naval/Joint operations, using modern scientific research techniques, field experience, tools, and equipment. The officer should understand the concept of developing and producing a performance surface.

5. **Other NPS Requirements:** The officer must successfully complete all NPS requirements for the Master's Degree in Meteorology and Physical Oceanography.

Operational Oceanography

Program Officer

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Academic Associate

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Brief Overview

This flexible oceanography program involves approximately 100 quarter-hours of classroom lectures, supplemented by an additional 20 quarter-hours of laboratory exercises. This program is designed to provide the student with:

- A thorough understanding of the principles governing the physical and dynamic properties of the oceans.
- An understanding of the analysis and prediction of oceanic and atmospheric parameters and conditions using direct and remote sensing observational techniques, statistical analyses, and numerical models.
- An understanding of the effects of oceanic and atmospheric properties and conditions on weapon, sensor, and platform performance, while conducting and supporting naval warfare with particular emphasis on ocean acoustics.
- An educationally significant oceanographic experience at sea.
- An oceanographic research experience germane to

naval warfare culminating in a thesis of professional quality.

- A knowledge of Joint Maritime Strategic Planning.
- Thesis with multi-authors is not allowed.

This program is designed to allow the student to meet all of the requirements for Navy PME (as established by the Chief of Naval Operations) and for Joint PME (as established by the Chairman, Joint Chiefs of Staff) for Intermediate Level Professional Military Education.

The Operational Oceanography program has a physical oceanography and ocean acoustics base. It is a very flexible program allowing students to examine oceanographic topics relevant to their warfare specialization areas, such as antisubmarine warfare, amphibious warfare, mine warfare, anti-air warfare, strike warfare and special warfare. This program is open to Information Dominance Corps (18xx) Unrestricted Line Officers (1110, 1120, 1310, 1320), officers from other services, International Officers and DoD civilians.

Requirements for Entry

A baccalaureate degree in the physical sciences, mathematics or engineering is desirable. Completion of mathematics through differential and integral calculus and one year of calculus-based college physics are required. An APC of 323 is required for direct entry. A refresher quarter is available for candidates who do not meet all admission requirements for direct entry and is offered in the Spring or Fall quarter prior to enrollment.

Convenes

Operational Oceanography is an eight-quarter course of study with entry dates in January and July. If further information is needed, contact the Academic Associate or the Program Officer for this program.

Program Length

24 months

Subspecialty

Completion of this program qualifies an officer as an Operational Oceanography Subspecialist with a subspecialty code of 6402P. The program sponsor is the Oceanographer of the Navy (CNO N2/N6E).

Typical Subspecialty Jobs

CV ASW Module
ASW Operations Center
Navy Laboratories
Office of Naval Research
Naval Academy Instructor
NIMA
Naval Oceanographic Office

Typical Course of Study - Fall Start

Quarter 1

Course	Title	Lecture	Lab
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
MA2121	Differential Equations	4	0
OC3230	Descriptive Physical Oceanography	3	1

MA1115: 1st 6wks

MA1116: 2nd 6wks

Quarter 2

Course	Title	Lecture	Lab
MA3132	Partial Differential Equations and Integral Transforms	4	0
MR2020	Computer Computations in Air-Ocean Sciences -or-	2	2
OC2020	Computer Computations in Air-Ocean Sciences	2	2
NW3230	Strategy & War	4	2
MR3140	Probability and Statistics for Air-Ocean Science -or-	3	2
OC3140	Probability and Statistics for Air-Ocean Science	3	2

Quarter 3

Course	Title	Lecture	Lab
OC3150	Analysis of Air Ocean Time Series	3	2
MR3321	Air-Ocean Fluid Dynamics -or-	4	0
OC3321	Air-Ocean Fluid Dynamics	4	0
NW3275	Joint Maritime Operations - part 1	4	0
OC3260	Fundamentals of Ocean Acoustics	4	1

Quarter 4

Course	Title	Lecture	Lab
OC4210	Littoral Field Studies	2	4
MR4413/OC4413	Air-Sea Interaction -or-	4	0
OC4413/MR4413	Air/Sea Interaction	4	0
OC3240	Ocean Circulation Analysis	4	0
NW3276	Joint Maritime Operations - part 2	2	2

Quarter 5

Course	Title	Lecture	Lab
OC4267	Ocean Acoustic Variability and Uncertainty	4	0
MR4323	Air and Ocean Numerical Prediction Systems	4	2

-or-

Course	Title	Lecture	Lab
OC4323	Air and Ocean Numerical Prediction Systems	4	2
OC4211	Ocean Dynamics II	4	0
OC4900	Directed Study in Oceanography	V	0

Quarter 6

Course	Title	Lecture	Lab
OC4270	Tactical Oceanography	3	4
OC3212	Polar Meteorology/Oceanography	4	0
OC4800	Advanced Courses in Oceanography	V	0
OC0810	Oceanography Thesis Research	0	8

Quarter 7

Course	Title	Lecture	Lab
OC4325	METOC for Warfighter Decision Making	3	2
OC4800	Advanced Courses in Oceanography	V	0
OC0810	Oceanography Thesis Research	0	8
OC0810	Oceanography Thesis Research	0	8

Quarter

Course	Title	Lecture	Lab
NW3285	Theater Security Decision Making	4	0
OC0810	Oceanography Thesis Research	0	8
OC0810	Oceanography Thesis Research	0	8
OC0999	Thesis Seminars	2	0

Typical Course of Study - Spring Start

Quarter 1

Course	Title	Lecture	Lab
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
MA2121	Differential Equations	4	0
OC3230	Descriptive Physical Oceanography	3	1

MA1115: 1st 6wks

MA1116: 2nd 6wks

Quarter 2

Course	Title	Lecture	Lab
MA3132	Partial Differential Equations and Integral Transforms	4	0
MR2020	Computer Computations in Air-Ocean Sciences	2	2
OC2020	Computer Computations in Air-Ocean Sciences	2	2
NW3230	Strategy & War	4	2

Course	Title	Lecture	Lab
MR3140	Probability and Statistics for Air-Ocean Science	3	2
OC3140	Probability and Statistics for Air-Ocean Science	3	2

Quarter 3

Course	Title	Lecture	Lab
OC3150	Analysis of Air Ocean Time Series	3	2
MR3321	Air-Ocean Fluid Dynamics	4	0
OC3321	Air-Ocean Fluid Dynamics	4	0
NW3275	Joint Maritime Operations - part 1	4	0
OC3260	Fundamentals of Ocean Acoustics	4	1

Quarter 4

Course	Title	Lecture	Lab
OC4210	Littoral Field Studies	2	4
MR4413/OC4413	Air-Sea Interaction	4	0
OC4413/MR4413	Air/Sea Interaction	4	0
OC3240	Ocean Circulation Analysis	4	0
NW3276	Joint Maritime Operations - part 2	2	2

Quarter 5

Course	Title	Lecture	Lab
OC4325	METOC for Warfighter Decision Making	3	2
OC4800	Advanced Courses in Oceanography	V	0
OC4211	Ocean Dynamics II	4	0
OC4900	Directed Study in Oceanography	V	0

Quarter 6

Course	Title	Lecture	Lab
OC4270	Tactical Oceanography	3	4
OC4800	Advanced Courses in Oceanography	V	0
MR4413/OC4413	Air-Sea Interaction	4	0
OC4413/MR4413	Air/Sea Interaction	4	0
OC0810	Oceanography Thesis Research	0	8

Quarter 7

Course	Title	Lecture	Lab
OC4267	Ocean Acoustic Variability and Uncertainty	4	0
MR4323	Air and Ocean Numerical Prediction Systems	4	2

Course	Title	Lecture	Lab
	-or-		
OC4323	Air and Ocean Numerical Prediction Systems	4	2
OC0810	Oceanography Thesis Research	0	8
OC0810	Oceanography Thesis Research	0	8
Quarter 8			
NW3285	Theater Security Decision Making	4	0
OC0810	Oceanography Thesis Research	0	8
OC0810	Oceanography Thesis Research	0	8
OC0999	Thesis Seminars	2	0

Educational Skill Requirements (ESR)
Operational Oceanography Program
Subspecialty Code: 6402P

1. **Weapon & Sensor Performance:** The officer must have an understanding of the effects of open-ocean and near-shore ocean on weapons, sensors, and platform performance. The officer must have the ability to translate this knowledge into warfighter decision recommendations, taking into account available courses of action, assessments of vulnerability, uncertainty, and risk.
2. **Integration of Oceanic Parameters:** The officer must be able to observe, assimilate, analyze, and predict oceanic and littoral water conditions using direct and remote sensing observation techniques, statistical analysis, and numerical models. The officer will have a sound understanding of polar, mid-latitude oceanographic dynamics, including the impact of regional conditions on military operations and systems.
3. **Numerical Processing:** The officer will have a thorough understanding of numerical modeling/processing as it applies to the physics and dynamics of the ocean. This understanding should include a broad understanding of the modeling process itself to include strengths, weaknesses, and vulnerabilities; the state of current models and techniques; and appropriate applications of deterministic and stochastic techniques.
4. **Ocean Problem Solving:** The officer must develop critical thinking skills and conduct independent analyses to solve environmentally challenging problems in the field of Physical Oceanography as it applies to Naval/Joint operations, using modern scientific research techniques, field experience, tools, and equipment.
5. **Other NPS Requirements:** The officer must successfully complete all NPS requirements for the Master's Degree in Physical Oceanography.

Oceanography
Program Officer

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Brief Overview

The Oceanography program provides students with a sound understanding of the science of oceanography. The student develops the technical expertise to provide and use oceanographic and acoustical data and models in support of all aspects of at-sea operations. The graduate will be able to:

- Interpret and predict oceanic and air-ocean interface conditions.
- Operate modern oceanographic data management, archival and communications systems.
- Plan, conduct, interpret and present results of research activities.
- Thesis with multi-authors is not allowed.

This education further enhances performance in operational billets, technical management assignments and policy-making positions. Students will develop a sound, graduate-level, technical ability based on scientific principles.

Requirements for Entry

This program is open to International Officers, officers from other services and DoD civilians. It is open to METOC (1800) officers as a Ph.D. program.

A baccalaureate degree in the physical sciences, mathematics or engineering is required. Completion of mathematics through differential and integral calculus and one year of calculus-based college physics are required. An APC of 233 is required for direct entry. A refresher quarter is available for candidates who do not meet all admission requirements for direct entry, and is offered in the Spring or Fall quarter prior to enrollment.

Convenes

Oceanography is a 6-8 quarter course of study with entry dates in September and April. If further information is needed, contact the Program Officer for this program. Academic questions may be referred directly to the Academic Associate.

Program Length

24 months

Typical Course of Study - Fall

Quarter 1 (Fall)

Course	Title	Lecture	Lab
MR2020	Computer Computations in Air-Ocean Sciences	2	2
	-or-		

Course	Title	Lecture	Lab
OC2020	Computer Computations in Air-Ocean Sciences	2	2
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
MA2121	Differential Equations	4	0
OC3230	Descriptive Physical Oceanography	3	1

MA1115: 1st 6wks

MA1116: 2nd 6wks

Quarter 2 (Winter)

MA3132	Partial Differential Equations and Integral Transforms	4	0
MR3321	Air-Ocean Fluid Dynamics	4	0
	-or-		
OC3321	Air-Ocean Fluid Dynamics	4	0
OC3902	Fundamentals of Mapping, Charting and Geodesy	3	2
MR3480	Atmospheric Thermodynamics and Radiative Processes	4	1

OC3902: or Elective

Quarter 3 (Spring)

MR3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
	-or-		
OC3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
MR3140	Probability and Statistics for Air-Ocean Science	3	2
	-or-		
OC3140	Probability and Statistics for Air-Ocean Science	3	2
OC3260	Fundamentals of Ocean Acoustics	4	1
OC3240	Ocean Circulation Analysis	4	0

Quarter 4 (Summer)

OC4211	Ocean Dynamics II	4	0
MR3150	Analysis of Air/Ocean Time Series	3	2
	-or-		
OC3150	Analysis of Air Ocean Time Series	3	2

IT1600	Communication Skills for International Officers	3	0
IT1700	Academic Writing for International Officers	3	0

IT1600, IT1700: or Elective

Quarter 5 (Fall)

OC4900	Directed Study in Oceanography	V	0
MR3570	Operational Oceanography and Meteorology	2	4
	-or-		
OC3570	Operational Oceanography and Meteorology	2	4
OC4267	Ocean Acoustic Variability and Uncertainty	4	0
OC4610	Wave and Surf Forecasting	2	2

Quarter 6 (Winter)

MR4323	Air and Ocean Numerical Prediction Systems	4	2
	-or-		
OC4323	Air and Ocean Numerical Prediction Systems	4	2
OC0810	Oceanography Thesis Research	0	8
OC4220	Coastal Circulation	4	1
OC4213	Nearshore and Wave Processes	3	1

Quarter 7 (Spring)

OC4271	Topics in Tactical Oceanography	3	0
MR4413/OC4413	Air-Sea Interaction	4	0
	-or-		
OC4413/MR4413	Air/Sea Interaction	4	0
OC0810	Oceanography Thesis Research	0	8
OC0810	Oceanography Thesis Research	0	8

Quarter 8 (Summer)

OC4331	Ocean Variability	4	0
OC0810	Oceanography Thesis Research	0	8
OC0999	Thesis Seminars	2	0
ELECT	Elective OCXXXX		

Typical Course of Study - Spring

Quarter 1 (Spring)

Course	Title	Lecture	Lab
MR2020	Computer Computations in Air-Ocean Sciences	2	2
	-or-		
OC2020	Computer Computations in Air-Ocean Sciences	2	2
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
MA2121	Differential Equations	4	0
OC3230	Descriptive Physical Oceanography	3	1

MA1115: 1st 6wks

MA1116: 2nd 6wks

Quarter 2 (Summer)

MA3132	Partial Differential Equations and Integral Transforms	4	0
MR3321	Air-Ocean Fluid Dynamics	4	0
	-or-		
OC3321	Air-Ocean Fluid Dynamics	4	0
OC3902	Fundamentals of Mapping, Charting and Geodesy	3	2
MR3480	Atmospheric Thermodynamics and Radiative Processes	4	1

OC3902: or Elective

Quarter 3 (Fall)

MR3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
	-or-		
OC3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
MR3140	Probability and Statistics for Air-Ocean Science	3	2
	-or-		
OC3140	Probability and Statistics for Air-Ocean Science	3	2
OC3260	Fundamentals of Ocean Acoustics	4	1
OC3240	Ocean Circulation Analysis	4	0

Quarter 4 (Winter)

OC4211	Ocean Dynamics II	4	0
MR3150	Analysis of Air/Ocean Time Series	3	2
	-or-		
OC3150	Analysis of Air Ocean Time Series	3	2
OC4220	Coastal Circulation	4	1
IT1600	Communication Skills for International Officers	3	0

IT1600: or Elective

Quarter 5 (Spring)

MR4413/OC4413	Air-Sea Interaction	4	0
	-or-		
OC4413/MR4413	Air/Sea Interaction	4	0
OC4900	Directed Study in Oceanography	V	0
OC4267	Ocean Acoustic Variability and Uncertainty	4	0
IT1700	Academic Writing for International Officers	3	0

IT1700: or Elective

Quarter 6 (Summer)

MR4323	Air and Ocean Numerical Prediction Systems	4	2
	-or-		
OC4323	Air and Ocean Numerical Prediction Systems	4	2
OC0810	Oceanography Thesis Research	0	8
OC4331	Ocean Variability	4	0
ELECT	Elective OCXXXX		

Quarter 7 (Fall)

OC0810	Oceanography Thesis Research	0	8
OC4271	Topics in Tactical Oceanography	3	0
OC3570	Operational Oceanography and Meteorology	2	4
OC4610	Wave and Surf Forecasting	2	2

Quarter 8 (Winter)

OC4213	Nearshore and Wave Processes	3	1
OC0810	Oceanography Thesis Research	0	8
OC0810	Oceanography Thesis Research	0	8
OC0999	Thesis Seminars	2	0

Educational Skill Requirements (ESR) Oceanography (Masters) Program

Subspecialty Code: Not Applicable for MS Degree

Note - there is no p-code associated with this program, thus there are no official ESRs. This list describes the skills that this program will provide students upon successful completion of the program.

This program provides students with a sound understanding of the science of oceanography. The student develops the technical expertise to provide and use oceanographic and acoustical data and models in support of all aspects of at-sea operations. The graduate will be able to:

1. Interpret and predict oceanic and air-ocean interface conditions.

2. Operate modern oceanographic data management, archival and communications systems.

3. Plan, conduct, interpret and present results of research activities.

This education further enhances performance in operational billets, technical management assignments and policy-making positions. Students will develop a sound, graduate-level, technical ability based on scientific principles.

Oceanography PhD - Curriculum 443

Program Officer

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Brief Overview

The Ph.D. program is in Physical Oceanography, including areas of study in ocean circulation theory, air-sea interaction, ocean acoustics, nearshore, and coastal/littoral oceanography among others.

Department of Oceanography admission requirements for the Doctor of Philosophy degree include:

A bachelor's degree with a high QPR or a highly successful first graduate year in a master's program, with clear evidence of research ability. A master's degree may be required before admission to candidacy. The minimum APC requirement for entry to this program is 233. An applicant to the Ph.D. program who is not already at NPS should submit transcripts of previous academic and professional work, plus results of a current Graduate Record Examination (GRE) general test, to the Director of Admissions, Code 01C3, Naval Postgraduate School, Monterey, California 93943-5100.

Convenes
Fall, Spring

Program Length
36 months

Subspecialty
6402D

Educational Skill Requirements (ESR)
The officer will have a thorough theoretical and functional knowledge (obtained at the doctorate level) of the principles of oceanography and its effects on naval warfare and weapons systems.

Department of Operations Research

Chair

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Associate Chair, Distributed Programs

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* The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

David L. Alderson, Professor (2006); Ph.D., Stanford University, 2003.

Jeffrey Appleget, Senior Lecturer (2009); Ph.D., Naval Postgraduate School, 1999.

Michael Atkinson, Associate Professor (2009); Ph.D.,

Stanford University, 2009.

Robert Bassett, Assistant Professor (2018); Ph.D., University of California Davis, 2018.

Samuel E. Buttrey, Associate Professor (1996); Ph.D., University of California at Berkeley, 1996.

W. Matthew Carlyle, Professor (2002); Ph.D., Stanford University, 1997.

Louis Chen, Assistant Professor (2019); Ph.D., Massachusetts Institute of Technology, 2019.

Quinn Kennedy Cortez, Senior Lecturer (2007); Ph.D., Stanford, 2002.

Emily Craparo, Associate Professor (2010); Ph.D., Massachusetts Institute of Technology, 2008.

Daniel Eisenberg, Research Assistant Professor (2018); Ph.D., Arizona State University, 2018.

Paul Lee Ewing, Research Associate Professor (2010); Ph.D., Colorado School of Mines, 2002.

Robert Froberg, Major, U. S. Army, Military Assistant Professor (2023); Ph.D. North Dakota State University, 2019.

Thomas E. Halwachs, Senior Lecturer (1988); M.S., Naval Postgraduate School, 1976.

Thomas A. Hamrick, Lecturer (2006); M.S., Naval Postgraduate School, 1997.

Jefferson Huang, Assistant Professor (2018); Ph.D., Stony Book University, 2016.

Patricia A. Jacobs, Distinguished Professor (1978); Ph.D., Northwestern University, 1973.

Meghan Quinn Kennedy Cortez, Research Associate Professor (2007); Ph.D., Stanford, 2002.

Jeffrey E. Kline, Professor of Practice (2005); M.S., Naval Postgraduate School, 1991.

Robert A. Koyak, Associate Professor (1998); Ph.D., University of California at Berkeley, 1985.

Moshe Kress, Distinguished Professor (2003); Ph.D., University of Texas at Austin, 1981.

Darian Lawrence-Sidebottom, Research Associate (2021); Ph.D., Washington State University, 2020.

Kyle Y. Lin, Professor (2004); University of California at Berkeley, 2000.

Thomas W. Lucas, Professor (1998); Ph.D., University of California at Riverside, 1991.

Kevin J. Maher, Lecturer (1997); M.S., Naval Postgraduate School, 1993.

Mary McDonald, Research Associate (2008); M.S., Naval Postgraduate School, 1997.

Gregory K. Mislick, Senior Lecturer (2005); M.S., Naval Postgraduate School, 1988.

Karen Richey Mislick, Senior Lecturer (2019); Master of Cost Estimating and Analysis, Naval Postgraduate School, 2016.

Claire M. Modica, LCDR, MSC, USN, Military Assistant Professor (2023); Ph.D., University at Buffalo, 2016.

Peter Nesbitt, LTC, USA, Military Assistant Professor (2020); Ph.D., Colorado School of Mines, 2020.

Matthew Cody Nicholson, Lecturer (2020); Master of Human Systems Integration, Naval Postgraduate School, 2019.

Michael O'Neil, Lecturer (2019); M.S., Naval Postgraduate School, 2014.

Douglas E. Otte, Senior Lecturer (2007); M.S., Naval Postgraduate School, 1989.

Steven E. Pilnick, Senior Lecturer (1999); Ph.D., Naval Postgraduate School, 1989.

Johannes O. Royset, Professor (2003); Ph.D., University of California at Berkeley 2002.

Anton Rowe, Research Associate (1999); M.S., Stanford University, 1997.

Javier Salmeron, Professor (2000); Ph.D., Universidad Politécnica de Madrid, 1998.

Susan M. Sanchez, Professor (2000); Ph.D., Cornell University, 1986.

Ross Schuchard, Lt. Col., U.S. Army, Military Assistant Professor (2019); Ph.D., George Mason University, 2019.

Nita Lewis Shattuck, Professor (2000); Ph.D., University of Texas, 1982.

Dashi Singham, Research Associate Professor (2010); Ph.D., University of California at Berkeley, 2010.

Roberto Szechtman, Professor (2003); Ph.D., Stanford University, 2001.

Stephen Upton, Research Associate (2007); Applied Scientist, George Washington University, 2005.

Ruriko (Rudy) Yoshida, Associate Professor (2016); Ph.D., University of California at Davis, 2004.

Adrian Zavala, Research Associate (2020); B.S., U.S. Merchant Marine Academy, 2006.

Emeritus Professors

Gordon H. Bradley, Professor Emeritus (1973); Ph.D., Northwestern University, 1967.

Gerald G. Brown, Distinguished Professor Emeritus (1973); Ph.D., University of California at Los Angeles, 1974.

James N. Eagle, Professor Emeritus (1982); Ph.D., Stanford University, 1975.

Peter Purdue, Professor Emeritus (1986); Ph.D., Purdue University, 1972.

Susan M. Sanchez, Distinguished Professor Emeritus (2000); Ph.D., Cornell University, 1986.

David A. Schrady, Distinguished Professor Emeritus (1965); Ph.D., Case Institute of Technology, 1965.

Michael G. Sovereign, Professor Emeritus (1970); Ph.D., Purdue University, 1965.

Alan R. Washburn, Distinguished Professor Emeritus

(1970); Ph.D., Carnegie Institute of Technology, 1965.

Lyn R. Whitaker, Professor Emeritus (1988); Ph.D., University of California at Davis, 1985.

R. Kevin Wood, Distinguished Professor Emeritus(1982); Ph.D., University of California at Berkeley, 1982.

Brief Overview

Operations Research (OR) originated during World War II as a response to tactical problems relating to the effective and efficient operation of weapon systems, and to operational problems relating to the deployment and employment of military forces. Since then, OR has evolved into a full-scale, scientific discipline that is practiced widely by analysts in industry, government, and the military.

OR is the science of helping people and organizations make better decisions. More formally, it is the development and application of mathematical models, statistical analyses, simulations, analytical reasoning, and common sense to the understanding and improvement of real-world operations. Improvement can be measured by the minimization of cost, maximization of efficiency, or optimization of other relevant measures of effectiveness.

The military uses OR at the strategic, operational, and tactical levels. OR improves decision making and facilitates insights into the phenomena of combat. OR applications cover the gamut of military activities including: national policy analysis, resource allocation, force composition and modernization, logistics, human resources (recruiting, retention, promotion, training, and personnel assignment), battle planning, flight operations scheduling, intelligence, command and control, weapon selection (weapon system effectiveness, cost, compatibility, and operability), engagement tactics (fire control, maneuver, target selection, and battle damage assessment), maintenance and replenishment, and search and rescue.

The Naval Postgraduate School's Operations Research Department offers M.S. and Ph.D. degrees. In 2021, it celebrated the 70th anniversary of its curriculum, which was the first educational program in OR in the United States. It is one of the oldest, largest, and highest-ranking OR departments in the country. It is without peer in terms of the extent to which graduate education is integrated with a commitment to solving real military problems. Our students and faculty use the latest mathematical modeling ideas and computing technology to penetrate deeply into the analysis of important real-world problems. Analysis is a key word; NPS operations researchers frequently influence decisions and serve as agents for change.

For further information, see the OR Department Website: https://nps.edu/web/or.

Degree

Master of Science in Operations Research

Master of Science in Applied Science (Operations Research)

Doctor of Philosophy in Operations Research

Master of Science in Human Systems Integration

Master of Operational Analysis (Warfare)

Master of Operational Modeling and Analysis

Master of Systems Analysis

Master of Cost Estimation and Analysis

Master of Human Systems Integration

Certificates

Cost Estimation and Analysis Certificate

Human Systems Integration Certificate

Systems Analysis Certificate

Data Science (joint with Department of Computer Science)

Operational Data Science and Statistical Machine Learning

Operations Research Course Descriptions

OA Courses (p. 469)

OS Courses (p. 483)

Human Systems Integration Certificate - Curriculum 262

Program Manager

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Brief Overview

The Human Systems Integration Certificate program is a distance learning, graduate-level, non-degree program designed to enable acquisition professionals, program managers, engineers and scientists of the DoD to effectively implement Human Systems Integration (HSI) as required by the DoD.

Students will learn the fundamentals in applying usability assessments, modeling, optimization, and decision making to demonstrate cost-benefit trade-offs for technical, cost, and schedule modifications in systems acquisition.

The program consists of four online courses taken over a 12-month period. The course content and projects address problems of interest to the DoD.

Requirements for Entry

Completion of DAU ACQ 101 and ACQ 201A.

Convenes

Fall

Program Length

Four quarters.

Subspecialty Code

4600L

The goal of the Human Systems Integration Certificate Program is to acquaint HSI practitioners, HSI domain practitioners, Program Managers, Systems Engineers, Logisticians, and other Acquisition Professionals in the policies and processes for conducting HSI in DoN, DoD, and other Federal Agencies.

Graduate Certificate Requirements

Requirements for the certificate are met by successful completion of OA3411, OA3412, OA3413, and OA4414, in succession.

Alternatively, the HSI Certificate Program capstone experience of OA4414 can be met by completing SE3211 (Systems Engineering Management Capstone I) and SE3212 (Systems Engineering Management Capstone II).

Required Courses

Course	Title	Lecture	Lab
OA3411	Introduction to Human Systems Integration	3	0
OA3412	Human Systems Integration in the DoD Acquisition Lifecycle	3	0
OA3413	Human Systems Integration Tools, Tradeoffs, and Processes	3	1
OA4414	Human Systems Integration Case Studies and Applications -or-	4	0
SE3211	Systems Engineering Management Capstone I -and-	2	4
SE3212	Systems Engineering Management Capstone II	2	4

Data Science Certificate -- Curriculum 268 (CS/OR)

(Joint DL certificate program of the Department of Computer Science and Department of Operations Research)

This curriculum is described in the Department of Computer Science section (p. 35) of this Catalog. The Department of Operations Research supports this curriculum with courses and faculty.

Operational Data Science and Statistical Machine Learning - Curriculum 269

Program Officer

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Academic Associate

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Brief Overview

The Academic Certificate in Operational Data Science and Statistical Machine Learning provides education in the computational thinking and practical skills necessary to plan, execute, and manage the day-to-day operations for applied data science, with a particular emphasis on rapidly evolving Machine Learning techniques. Data Science and Machine Learning have emerged as critical to the mission of the Navy and the Department of Defense because of the central role they play in intelligence, surveillance, and reconnaissance, talent management, cyber-security, and logistics functional areas. However, practitioners in the military and civilian workforce need not only the ability "think computationally" but also to "do computationally". This includes the ability to work directly in the languages of data science (e.g., R, Python) and not just third-party tools. The emphasis throughout the program is on making military analysts more effective at addressing real-world problems through the use of data science and advanced computation.

Upon successful completion of the course work, students will be awarded an Academic Certificate in keeping with standard practices of the Naval Postgraduate School.

Experience with higher level programming language and background in statistics as evidenced by transcripts or work history is required for enrollment.

Convenes

Winter, Summer

Program Length

12 months

1. Understand fundamental tradeoffs in representing and manipulating data on different computing platforms (e.g., local computer, computing cluster, cloud-based services) and how these affect the outcome of any numerical analysis.

2. Develop the ability to import, clean, and manage large data sets in various formats on these platforms.

3. Develop the ability to generate static and interactive data visualizations that support decision-making.

4. Understand the capabilities and limitations of advanced data science and machine learning techniques for solving applied military problems.

5. Demonstrate proficiency in the development and review of these advanced computer tools in practical applications with DoD sponsors.

Certificate Requirements

Required Courses

Course	Title	Lecture	Lab
OA3801	Computational Methods for Operations Research II	3	1
OA3802	Computational Methods for Data Analytics	4	0
OA4106	Advanced Data Analysis	3	1
OA4118	Statistical and Machine Learning	4	0
OA4820	Case Studies in Applied Defense Analytics	3	1

This certificate is intended for in-resident students who are already admitted to another curriculum.

Certificate in Systems Analysis - Curriculum 281 (DL)

Program Officer

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Academic Associate & Program Director

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Brief Overview

The Systems Analysis Certificate program is a distance learning, graduate-level, nondegree program designed to meet the needs of the Navy and other services in the Department of Defense (DoD) for nondegree technical education in systems analysis as a basis for aiding key decisions on force requirements, weapon systems, and other defense matters. Students learn and apply modeling, optimization, simulation, and decision making under risk and uncertainty.

The Certificate Program consists of four courses delivered entirely online over a one-year period. The course content and projects will challenge the student academically and address problems of
interest to the Department of Defense. The courses are paced week-to-week by the instructors, but the students have great flexibility to do their course work at times of their choosing during each
week.

Requirements for Entry

A baccalaureate degree is required. Completion of mathematics through single variable differential and integral calculus is considered minimal preparation. The minimum APC requirement for entry to this program is

335.

Convenes

Fall, Spring

Program Length

12 months

Subspecialty

3211L

Graduate Certificate Requirements

Requirements for the graduate certificate in Systems Analysis are met by successful completion of all four courses.

At the completion of the certificate program, the student should be able to:

• Demonstrate proficiency in the fundamental for systems analysis, including selected applications of probability and statistics.

• Demonstrate proficiency in the modeling and simulation of combat systems.

• Demonstrate proficiency in Naval tactical analysis.

• Demonstrate proficiency in Naval systems analysis.

• Demonstrate proficiency in appropriate presentation of technical material.

Required Courses

Quarter 1

Course	Title	Lecture	Lab
OS2080	Probability and Statistics I	3	0

OS3180 Probability and Statistics for Systems Engineering may be substituted for OS2080. In the case of recent college graduates who have completed calculus-based Probability and Statistics within 3 years of starting the Systems Analysis Certificate, OS3080, OS3211, OS4011, or OA4702 may be substituted for OS2080.

Quarter 2

Course	Title	Lecture	Lab
OS3380	Combat Systems Simulation	3	1

Quarter 3

Course	Title	Lecture	Lab
OS3680	Naval Tactical Analysis	4	0

In the case of a student completing both the Systems Analysis Certificate and the ASW Certificate, each of which require OS3680, an approved substitute for OS3680 to count towards the Systems Analysis Certificate is OS3211 Systems Optimization, or OS4011 Risk Benefit Analysis.

Quarter 4

Course	Title	Lecture	Lab
OS4680	Naval Systems Analysis	4	0

Cost Estimating and Analysis Certificate (DL) - Curriculum 289

Program Officer

Kevin Maher

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Program Manager

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Brief Overview

The Cost Estimating and Analysis certificate program is a distance learning, graduate-level, non-degree program designed to provide cost estimating and analysis training to Navy and other DoD personnel. The program consists of four courses delivered one per quarter via distance learning over a one-year period.

Requirements for Entry

A baccalaureate degree is required. Recent completion (within five years) of mathematics through single variable differential and integral calculus is considered minimal preparation. Prior course work in probability and statistics, including regression is essential for successful completion of the certificate.

Convenes

Summer

Program Length

12 months

Subspecialty

5300 L

Graduate Certificate Requirements

Requirements for the graduate-level certificate in Cost Estimating and Analysis are met by successful completion of all four required courses.

Required Courses

Course	Title	Lecture	Lab
OS3701	Cost Estimation I: Methods and Techniques -or-	3	0
OA4702	Cost Estimation	4	0
OS4702	Cost Estimation II: Advanced Concepts in Cost Estimating	3	0
OS4013	Cost Estimation VI: Decision Analysis for Cost Estimators	3	0
OS4012	Cost Estimation III: Risk and Uncertainty Analysis	3	0

Educational Skills Requirements

Cost Analysis: The graduate will understand the methods and practice of cost analysis including various cost models, with particular emphasis in the relationship of effectiveness models and measures to cost, and applications in cost-benefit analysis.

Rates Development: The graduate will be able to construct a rate-set for direct labor, overhead, general and administrative costs, and inflation. The graduate will also be able to construct costs for various contract types, such as cost-plus, fixed-fee plus incentive, etc.

Cost-Benefit Analysis: The graduate will be able to apply the principles of probabilistic cost assessment in the context of resource allocation problems. This includes a framework for balancing costs and benefits, and analysis under conditions of large financial and technological uncertainties.

Software Cost Estimation: The graduate will understand software cost estimation, and be able to distinguish between development paradigms (e.g., waterfall, agile, incremental). The graduate will also be able to develop software cost estimates for both development and maintenance efforts

Scheduling: The graduate will understand how schedule networks rely on logic and the critical path method as well as other top-level schedule methods. The graduate will also learn Schedule Risk Analysis and how to update and baseline a schedule using industry best practices.

Data Analytics: The graduate will understand how to obtain, normalize, analyze and then visualize data using various methods. The graduate will know how to assess the data to determine its reliability and applicability to cost estimating to support informed decision making.

Systems Engineering Analysis Program - Curriculum 308

This curriculum is described under the Systems Engineering Analysis Curriculum and Program section (p. 261) of this Catalog. The Department of Operations Research supports this curriculum with courses, faculty and project advisors.

Operational Warfare Analysis (OWA) - Curriculum 355

Program Officer

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Academic Associate

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Brief Overview

The Operational Warfare Analysis (OWA) curriculum 355 is tailored for U. S. Navy Unrestricted Line Officers whose

career paths do not permit attendance in the traditional Operations Analysis (OA) curriculum 360.

The Operations Analysis (OA) curriculum was founded by the Navy in 1951 to retain, develop, and promulgate the methods of Operations Research (OR) that were used so successfully in World War II. OR is the science of helping people and organizations make better decisions. More formally, it is the development and application of mathematical models, statistical analyses, simulations, analytical reasoning, and common sense to the understanding and improvement of real-world operations. Improvement can be measured by the minimization of cost, maximization of efficiency, or optimization of other relevant measures of effectiveness. Practitioners are called on to advise military and civilian decision makers on the allocation of scarce resources, the selection of new equipment and processes, and the optimal deployment of given resources to achieve required missions.

Mathematics, probability, statistics, and optimization supply the theoretical background for analyzing alternative choices in tactical and strategic warfare, and in planning, budgeting, and procurement of systems and forces. The student learns computational methods and develops skills to identify relevant information, formulate decision criteria, and select alternatives. This education enhances performance in all duties throughout a military career including operational billets, technical management assignments, and policy-making positions.

Requirements for Entry

The Operational Warfare Analysis (OWA) curriculum is open to Navy Unrestricted Line Officers only.

A baccalaureate degree with above-average grades is required. Completion of mathematics through single variable differential and integral calculus with above-average grades is considered minimal preparation. Students without these quantitative prerequisites will be accepted in cases where their undergraduate records indicate that they are exceptional students and there are other indicators of potential. An academic profile code (APC) of 325 is required.

Convenes

Fall, Spring

Subspecialty

Completion of this curriculum qualifies an officer as an Operations Research Analysis subspecialist with a subspecialty code of 3211P. The community manager for the Operations Research Analysis subspecialty is the Office of the Chief of Naval Operations, Assessment Division (OPNAV N81).

Typical Subspecialty Jobs

OPNAV Analyst
Fleet Commander Analyst
Numbered Fleet Analyst
Air, Surface, or Submarine TYCOM Analyst

Master of Operational Modeling and Analysis

The Master of Operational Modeling and Analysis degree requires:
• Completion of a minimum of 40 quarter-hours of graduate-level courses with:
• At least 20 quarter-hours of 4000-level courses, of which at least 16 are OA.
• An operational modeling and analysis sequence approved by the Chairman,
Department of Operations Research.
• Completion of an acceptable capstone project on a subject previously approved by the Chairman, Department of Operations Research.

Fall or Spring start

Quarter 1 (spring/fall)

Course	Title	Lecture	Lab
MA1118	Multivariable Calculus for Operations Research	4	0
MA3042	Linear Algebra	4	0
OA2801	Computational Methods for Operations Research	4	1
OA3101	Probability	4	1

Quarter 2 (summer/winter)

OA3102	Statistics	4	2
OA3201	Linear Programming	4	0
OA3301	Stochastic Models I	4	0
OA3801	Computational Methods for Operations Research II	3	1

Quarter 3 (spring/fall)

OA3103	Data Analysis	4	1
OA3302	Simulation-Modeling	4	0
OA4202	Network Flows and Graphs	4	0
OS3680	Naval Tactical Analysis	4	0
OA3900	Workshop in Operations Research/Systems Analysis	V	0

Quarter 4 (summer/winter)

OA4106	Advanced Data Analysis	3	1
OA4333	Simulation Analysis	4	0
OS3081	Systems Analysis Cases I	3	0
NW3230	Strategy & War	4	2

Quarter 5 (spring/fall)

OA4801	Spreadsheet Modeling for Military Operations Research	3	2
OS3082	Systems Analysis Cases II	3	0
NW3275	Joint Maritime Operations - part 1	4	0
NW3285	Theater Security Decision Making	4	0

Quarter 6 (summer/winter)

| OA3304 | Decision Theory | 4 | 0 |

OS4083	Systems Analysis Cases III	3	4
OA4702	Cost Estimation	4	0
NW3276	Joint Maritime Operations - part 2	2	2

Educational Skill Requirements (ESRs)
Operational Warfare Analysis - Curriculum 355
Subspecialty Code: 3211P

1. BASIC: The graduate will possess the mathematical and advanced computer programming skills required to support graduate study in operations research and have the ability to use computers to aid in analysis.

2. UNCERTAINTY AND DATA ANALYTICS: The graduate will be well versed in uncertainty fundamentals for systems analysis, including applications of probability, statistics, data analysis, modeling uncertainty and specialized models in advanced data analysis and statistical and machine learning.

3. SIMULATION: The graduate will be able to construct and utilize Monte Carlo simulations of combat and other processes that evolve in time, will be able to deal with statistical issues associated with the need for replication; and be able to use advanced methods of simulation outcome analysis.

4. TACTICAL ANALYSIS: The graduate will be able to apply operations analysis methods to tactical and operational problems including tactical decision analysis.

5. COST ANALYSIS: The graduate will understand the methods and practice of cost analysis including various cost models, with particular emphasis in the relationship of effectiveness models and measures to cost, and applications in cost-benefit analysis.

6. RISK-BENEFIT ANALYSIS: The graduate will be able to apply the principles of probabilistic risk assessment in the context of systems analysis decision problems. This includes a framework for balancing risks and benefits, and analysis under conditions of large financial and technological uncertainties.

7. OPTIMIZATION: The graduate will be able to formulate and solve a wide variety of optimization problems with particular emphasis on applications in optimum allocation of scarce resources, multi-year capital budgeting, and network analysis.

8. PRACTICE: The graduate will have gained experience in all aspects of analytical studies, including review and critique the work of others, as well as participation in the conduct of an analytical study. Review and critique to include the ability to highlight critical assumptions, recognize strengths and weaknesses of applied analytical methodologies, and evaluate study recommendations. Practice in the design and conduct of an analytical study includes the skills to formulate problems, use the analytical process to define study requirements, and apply appropriate analytical methodologies. Practice also includes demonstrating proficiency in presenting results both orally and in writing.

Curriculum Sponsor and ESR Approval Authority
The Major Area Sponsor (MAS) for the Operations Research Analysis subspecialty is Deputy Chief of Naval Operations, Integration of Capabilities and Resources (OPNAV N8). The designated Subject Matter Expert (SME) for the Operations Analysis curriculum is Director, Assessment Division, Office of the Chief of Naval Operations (OPNAV N81). The Curriculum and ESR approval authority is Deputy Chief of Naval Operations for Warfighting Development (OPNAV N7).

Operations Analysis - Curriculum 360

Program Officer

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Brief Overview

The Operations Analysis (OA) curriculum was founded by the Navy in 1951, to retain, develop, and promulgate the methods of Operations Research (OR) that were used so successfully in World War II. OR is the science of helping people and organizations make better decisions. More formally, it is the development and application of mathematical models, statistical analyses, simulations, analytical reasoning, and common sense to the understanding and improvement of real-world operations. Improvement can be measured by the minimization of cost, maximization of efficiency, or optimization of other relevant measures of effectiveness. Practitioners are called on to advise military and civilian decision makers on the allocation of scarce resources, the selection of new equipment and processes, and the optimal deployment of given resources to achieve required missions.

Mathematics, probability, statistics, and optimization supply the theoretical background for analyzing alternative choices in tactical and strategic warfare, and in planning, budgeting, and procurement of systems and forces. The student learns computational methods and develops skills to identify relevant information, formulate decision criteria, and select alternatives. This education enhances performance in all duties throughout a military career including operational billets, technical management assignments, and policy-making positions.

Requirements for Entry

A baccalaureate degree with above-average grades is

required. Completion of mathematics through single variable differential and integral calculus with above-average grades is considered minimal preparation. Students without these quantitative prerequisites will be accepted in cases where their undergraduate records indicate that they are exceptional students and there are other indicators of potential. An academic profile code (APC) of 325 is required. Waivers may be obtained with a one-quarter refresher.

Convenes

Fall, Spring

Degree

Requirements for the Master of Science degree are met en route to satisfy the Educational Skill Requirements of the curricular program as well as Service Intermediate-level PME and Phase I Joint PME credit.

Master of Science in Applied Science (Operations Research)

Students with acceptable academic backgrounds may enter a program leading to a degree in Applied Science with a major in Operations Research. The program of each student seeking this degree must contain a minimum of 20 quarter-hours in operations research at the graduate level, including work at the 4000 level. Additionally, a sequence of at least 12 hours of graduate level courses representing a specialization in some area other than that of the major. A total minimum of 12 quarter-hours at the 4000 level, plus an acceptable thesis, is required. This program provides depth and diversity through specially arranged course sequences to meet the needs of the Navy and the interests of the individual. The Department Chairman's approval is required for all programs leading to this degree. Applications to include this degree in dual master's programs will not be approved.

Master of Science in Operations Research

The Master of Science in Operations Research degree requires:

- Completion of a minimum of 40 quarter-hours of graduate-level courses with:
  - At least 20 quarter-hours of 4000-level courses, of which at least 16 are OA.
  - An elective sequence approved by the Chairman, Department of Operations Research.
- Submission of an acceptable thesis on a subject previously approved by the Chairman, Department of Operations Research.

Subspecialty

Completion of this curriculum qualifies an officer as an Operations Analysis Subspecialist with a subspecialty code of 3211P and JPME Phase I education certification for students whose orders include the extra quarter for JPME. The community manager for the OA subspecialty is the Office of the Chief of Naval Operations, Assessment Division (OPNAV N81).

U.S. Marine Corps officers completing this curriculum fulfill the requirements for MOS 8850.

Typical Subspecialty Jobs

Defense Resources Management OPNAV Analyst
JCS Analyst Director, OPS Research: SACLANT
Assistant Staff OPS and PLANS: COMCARGRU Staff OPS and PLANS: COMTHIRDFLT
BUPERS OSD Analyst
OPS Analyst: Naval War College Instructor: NPS
Cost Analyst Warfare Analyst

Typical Course of Study (Naval Warfare Option)

Quarter 1

Course	Title	Lecture	Lab
MA1118	Multivariable Calculus for Operations Research	4	0
MA3042	Linear Algebra	4	0
OA2801	Computational Methods for Operations Research	4	1
OA3101	Probability	4	1

Quarter 2

OA3102	Statistics	4	2
OA3201	Linear Programming	4	0
OA3301	Stochastic Models I	4	0
OA3801	Computational Methods for Operations Research II	3	1

Quarter 3

OA3103	Data Analysis	4	1
OA3302	Simulation-Modeling	4	0
OA4202	Network Flows and Graphs	4	0
OA4301	Stochastic Models II	4	0

Quarter 4

OA4201	Nonlinear Programming.	4	0
OA4106	Advanced Data Analysis	3	1
OA4333	Simulation Analysis	4	0
OA4702	Cost Estimation	4	0

Quarter 5 (First eight weeks)

OA3602	Search Theory and Detection	4	0
OA4655	Introduction to Joint Combat Modeling	4	0
OA4801	Spreadsheet Modeling for Military Operations Research (Last three weeks) Experience Tour/Thesis Research	3	2

Quarter 6

ELECT	Elective OAXXXX		
OA4602	Joint Campaign Analysis	4	0
OA3304	Decision Theory	4	0

OA0810	Thesis Research for Operations Analysis Students	0	8

Quarter 7

ELECT	Elective OAXXXX		
OA4604	Wargaming Applications	3	2
NW3230	Strategy & War	4	2
OA0810	Thesis Research for Operations Analysis Students	0	8

Educational Skill Requirements (ESR)
Operations Analysis - Curriculum 360
Subspecialty Code: 3211P

1. **Basics:** The graduate will possess the mathematical and advanced computer programming skills required to support graduate study in operations research and have the ability to use computers as a tool to aid in analysis.
2. **Probability, Statistics, and Data Analysis:** The graduate will be well-versed in applications of probability, statistics, data analysis, and machine learning to the modeling and analysis of a broad range of military decision problems.
3. **Optimization:** The graduate will be able to formulate and understand state-of-the-art algorithms used to solve linear, nonlinear, network, dynamic, and integer programs.
4. **Stochastic Modeling:** The graduate will be able to formulate a wide variety of stochastic models, calculate measures of performance for them, and be well-versed in a broad range of advanced applications of continuous- and discrete-time Markov chains, homogenous and non-homogenous Poisson processes, queueing theory, and renewal processes.
5. **Simulation:** The graduate will be able to employ simulation methods to model situations of interest to the defense community, be able to formulate, implement, explore, and analyze simulations using state-of-the-art design-of-experiments techniques to efficiently explore high-dimensional spaces, and make informed recommendations.
6. **Analysis of Military Operations:** The graduate will have significant exposure to and be able to model and analyze military operations using operations analysis techniques, and support concept development, tactics, and operations.
7. **Systems Analysis:** The graduate will be able to apply systems analysis concepts as a basis for making key decisions on force requirements, weapon systems, and other defense problems with particular emphasis in risk-benefit and cost-benefit analysis.
8. **Practice:** The graduate will have gained experience working on all aspects of an analytical study, and will demonstrate the ability to conduct independent analytical studies and proficiency in presenting the results both orally and in writing.

Curriculum Sponsor and ESR Approval Authority

The Major Area Sponsor (MAS) for the Operations Research Analysis subspecialty is Deputy Chief of Naval Operations, Integration of Capabilities and Resources (OPNAV N8). The designated Subject Matter Expert (SME) for the Operations Analysis curriculum is Director, Assessment Division, Office of the Chief of Naval Operations (OPNAV N81). The Curriculum and ESR approval authority is Deputy Chief of Naval Operations, Warfighting Development (OPNAV N7). (OA Curriculum Review conducted 4 April 2022.)

Operations Research - Logistics Analysis - Curriculum 361

Program Officer

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Brief Overview

This program provides education in mathematics and computation, probability and statistics, data analysis, simulation, optimization as foundation for logistics operations analysis.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of mathematics through single variable differential and integral calculus with above-average grades is considered minimal preparation. Students without these quantitative prerequisites will be accepted in cases where their undergraduate records indicate that they are exceptional students and there are other indicators of potential. An academic profile code (APC) of 325 is required. Waivers may be obtained with a one-quarter refresher.

Convenes

Fall, Spring

Degree

Requirements for the Master of Science in Operations Research degree are met en route to satisfy the Educational Skill Requirements of the curriculum.

Alternatively, the Master of Operational Analysis (Warfare) degree may be awarded in lieu of the Master of Science in Operations Research. The Department Chair's

approval is required for all programs leading to this degree. Applications to include the Master of Operational Analysis (Warfare) degree in dual master's programs will not be approved.

Subspecialty

Completion of this curriculum qualifies an officer as an Operations Research Logistics Analysis (ORLA) Subspecialist with a subspecialty code of 3212P. The community manager for this subspecialty is BUPERS-316, the Director of Supply Corps Officer Community Management.

Typical Subspecialty Jobs

Joint Chiefs of Staff: Joint Logistics Planning, Mobility Analyst
OPNAV: Operational Logistics Analyst, Logistics Assessment
Fleet Forces Command: Readiness Analyst
Naval Supply Systems Command, Weapons Systems Support: Operations Research Director, Analyst
Defense Logistics Agency: Operations Research Analyst
TRANSCOM: Operations and Plans Officer, Sealift Analyst
Afloat Staffs: Logistics Planning Officer

Typical Course of Study (with JPME)

Quarter 0 (Refresher, if needed)

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
MA1025	Introduction to Mathematical Reasoning	4	0
OA1600	Introduction of Operations Analysis I	2	2

Quarter 1

MA1118	Multivariable Calculus for Operations Research	4	0
MA3042	Linear Algebra	4	0
OA2801	Computational Methods for Operations Research	4	1
OA3101	Probability	4	1

Quarter 2

OA3102	Statistics	4	2
OA3201	Linear Programming	4	0
OA3301	Stochastic Models I	4	0
OA3801	Computational Methods for Operations Research II	3	1

Quarter 3

OA3103	Data Analysis	4	1
OA4202	Network Flows and Graphs	4	0
OA4301	Stochastic Models II	4	0
OA3302	Simulation-Modeling	4	0

Quarter 4

OA4106	Advanced Data Analysis	3	1

OA4333	Simulation Analysis	4	0
OA3501	Inventory I	4	0
OA4201	Nonlinear Programming.	4	0

Quarter 5 (First eight weeks)

OA3802	Computational Methods for Data Analytics	4	0
OA4655	Introduction to Joint Combat Modeling	4	0
OA4801	Spreadsheet Modeling for Military Operations Research	3	2
OA3900	Workshop in Operations Research/Systems Analysis (Last three weeks) Experience Tour/Thesis Research	V	0

Quarter 6

OA3611	Principles of Operational Logistics	4	0
OA4702	Cost Estimation	4	0
NW3230	Strategy & War	4	2
OA0810	Thesis Research for Operations Analysis Students	0	8

Quarter 7

OA4613	Energy Logistics in Warfare Operations	4	0
NW3285	Theater Security Decision Making	4	0
NW3275	Joint Maritime Operations - part 1	4	0
OA0810	Thesis Research for Operations Analysis Students	0	8

Quarter 8

OA4602	Joint Campaign Analysis	4	0
OA3304	Decision Theory	4	0
NW3276	Joint Maritime Operations - part 2	2	2
OA0810	Thesis Research for Operations Analysis Students	0	8

Educational Skill Requirements (ESR)
Operations Research Logistics Analysis - Curriculum 361 Subspecialty Code 3212P

1. **Basics:** The graduate will possess the mathematical and computing skills to support quantitative analysis.

2. **Modeling Uncertainty:** The graduate will be well-versed in applications of probability and, statistics, and their applications to Operations Research (OR) problems.

3. **Optimization:** The graduate will be able to formulate and solve a wide variety of optimization problems and also be conversant with the major uses of such models

in DoD and the private sector.

4. **Stochastic Modeling:** The graduate will be able to formulate and solve problems involving stochastic processes (processes with uncertainty over time) and be familiar with major applications of such models.

5. **Simulation:** The graduate will be able to construct and utilize Discrete Event and Monte Carlo simulations of combat and other processes, particularly logistics themed, evolving in time, and will be able to deal with statistical issues associated with the need for replication.

6. **Analysis of Military Operations:** The graduate will be familiar with US, Allied and potential enemy capabilities, and will be able to model and analyze joint military operations using OR techniques. The graduate will also be able to develop and evaluate new tactical and logistics concepts for the range of operations from humanitarian assistance/disaster relief to combat.

7. **Joint Logistics Analysis:** The graduate will understand naval supply systems and joint operational logistics, and will be able to use quantitative analysis techniques in all aspects of logistics support.

8. **Systems Analysis:** The graduate will understand the principles and applications of be able to apply systems analysis concepts as a basis for making key decisions on force requirements, weapon systems, and other defense problems.

9. **Practice:** The graduate will have gained experience working on all aspects of an analytical study, to include completing a formal thesis as a demonstration of their independent analytical capability and proficiency in presenting results both via briefings and in writing.

Curriculum Sponsor and ESR Approval Authority

The Major Area Sponsor (MAS) for the Operations Research Logistics Analysis subspecialty is Deputy Chief of Naval Operations, Fleet Readiness and Logistics (N4). The designated Subject Matter Expert (SME) for the Operations Research Logistics Analysis curriculum is Commander, Naval Supply Systems Command. The Curriculum and ESR approval authority is Deputy Chief of Naval Operations, Warfighting Development (OPNAV N7). (ORLA Curriculum Review conducted 14 November 2022.)

Human Systems Integration - Curriculum 359 (DL), Curriculum 362 (RES)

Program Officer and Academic Associate

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Brief Overview

Human Systems Integration (HSI) is an interdisciplinary program that emphasizes human considerations as a priority in systems design and acquisition, to reduce life cycle costs, and improve total system performance. HSI has been divided into several distinct domains that include human factors engineering, manpower, personnel, training, human survivability, health hazards, system safety, and habitability. HSI is based on the understanding that people (operators, maintainers, and support personnel) are critical elements of the system and that a human-centered design perspective promotes system effectiveness, safety, and cost savings. This degree will provide students with the knowledge, skills, and abilities to be effective leaders in the assessment, design, testing, and management of a total human machine system throughout its life cycle.

Requirements for Entry

A baccalaureate degree with above-average grades is required. Students without these quantitative prerequisites will be accepted in cases where their undergraduate records indicate that they are exceptional students and there are other indicators of potential. An academic profile code (APC) of 335 is required for the resident program, and 345 for the distance learning program.

Convenes

Fall

Degree

Master of Human Systems Integration

The degree of Master of Human Systems Integration (HSI) requires:

1. Completion of a minimum of 40 quarter-hours of graduate-level courses with:
   a. At least 20 quarter-hours of 4000-level courses, and
   b. Human Systems Integration core courses and a series of supporting courses, including coursework in HSI domains, Systems Engineering, Defense Acquisition, Cost Estimation, and Probability and Statistics, all of which are set in a matrix approved by the Chairman, Department of Operations Research.

2. Students are required to demonstrate mastery of Human Systems Integration practice through satisfactory completion of a two-quarter capstone project approved by the Chairman, Department of Operations Research. The quarter-hours earned in the Capstone project are applied towards satisfying the minimum graduate level quarter-hours for the degree.

Master of Science in Human Systems Integration

The degree of Master of Science in Human Systems Integration requires:

1. Completion of a minimum of 40 quarter-hours of graduate-level courses with:
   a. At least 20 quarter-hours of 4000 level courses.
   b. An elective sequence approved by the Chairman, Department of Operations Research.

2. Submission of an acceptable thesis on a subject previously approved by the Chairman, Department of Operations Research.

Subspecialty (RES)

4600P

Typical Course of Study- Curriculum 359 (DL)

(Distance Learning)

Quarter 1

Course	Title	Lecture	Lab
OA3411	Introduction to Human Systems Integration	3	0
MN3301	Acquisition of Defense Systems	4	0

Quarter 2

OA3412	Human Systems Integration in the DoD Acquisition Lifecycle	3	0
SE3100	Fundamentals of Systems Engineering	3	2

Quarter 3

OA3413	Human Systems Integration Tools, Tradeoffs, and Processes	3	1
OA3401/OS3401	Human Factors in System Design	3	1

Quarter 4

OA4414	Human Systems Integration Case Studies and Applications	4	0
OS3111	Probability and Statistics for HSI and MOVES	4	0

Quarter 5

OA4401	Individual Performance & Personnel Considerations	3	1
OS3112	Statistics and Design of Experiments	4	2

Quarter 6

OA4406	Survivability, Habitability, Environmental Safety and Occupational Health	4	0
OA4408	Macroergonomics and Organizational Behavior in Human Systems Integration	3	1

Quarter 7

OA4402	Training and Simulation	3	1
OA4702	Cost Estimation	4	0

OS3701 can be substituted for OA4702 upon approval of the HSI Academic Associate.

Quarter 8

OA4603	Test and Evaluation	4	0
OA4415	HSI Case Studies and Applications (Capstone II)	4	0

OA4415: Capstone Part 2

Typical Course of Study- Curriculum 362 (RES)

(Navy, Marine Corps)

Summer Refresher

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
GB3012	Communication for Managers	3	0
NW3230	Strategy & War	4	2

Quarter 1

OA3411	Introduction to Human Systems Integration	3	0
OS3111	Probability and Statistics for HSI and MOVES	4	0
OA3401/OS3401	Human Factors in System Design	3	1
SE3100	Fundamentals of Systems Engineering	3	2

Quarter 2

OA3402	Research Methods for Performance Assessment	3	1
OS3113	Data Analysis for HSI and MOVES	4	1
MN3331	Principles of Acquisition and Program Management	5	1
SI3400	Fundamentals of Engineering Project Management	3	2

Quarter 3

OA3412	Human Systems Integration in the DoD Acquisition Lifecycle	3	0
OS3112	Statistics and Design of Experiments	4	2
OA4407	Human Anthropometry- and Biomechanics	3	1
SE3302	System Suitability	3	2

Quarter 4

OA4406	Survivability, Habitability, Environmental Safety and Occupational Health	4	0
OA4603	Test and Evaluation	4	0
OA4109	Survey Research Methods	4	2
SE3303	System Assessment	3	2

NW3230	Strategy & War	4	2

NW3230: if the Summer refresher is not taken

Quarter 5

OA3413	Human Systems Integration Tools, Tradeoffs, and Processes	3	1
MN4115	Foundations of Education and Learning in DoD Organizations	3	0
OA4401	Individual Performance & Personnel Considerations	3	1
NW3285	Theater Security Decision Making	4	0

Quarter 6

OS4701	Manpower and Personnel Models	4	0
OA4702	Cost Estimation	4	0
OA4408	Macroergonomics and Organizational Behavior in Human Systems Integration	3	1
MV4002	Simulation and Training	4	1

OS3701 can be substituted for OA4702 upon approval of the HSI Academic Associate.

Quarter 7

MN3111	Analysis of Human Resource Management	4	0
OA0810	Thesis Research for Operations Analysis Students	0	8
NW3275	Joint Maritime Operations - part 1	4	0
OA0810	Thesis Research for Operations Analysis Students	0	8

Quarter 8

OA0810	Thesis Research for Operations Analysis Students	0	8
OA0810	Thesis Research for Operations Analysis Students	0	8
OA4414	Human Systems Integration Case Studies and Applications	4	0
NW3276	Joint Maritime Operations - part 2	2	2

Typical Course of Study

(Army, International, Civilians, Air Force)

Summer Refresher

Course	Title	Lecture	Lab
MA1113	Single Variable Calculus I	4	0

Course	Title	Lecture	Lab
MA1114	Single Variable Calculus II with Matrix Algebra	4	0
GB3012	Communication for Managers	3	0

Quarter 1

OA3411	Introduction to Human Systems Integration	3	0
OS3111	Probability and Statistics for HSI and MOVES	4	0
OA3401/OS3401	Human Factors in System Design	3	1
SE3100	Fundamentals of Systems Engineering	3	2

Quarter 2

OA3402	Research Methods for Performance Assessment	3	1
OS3113	Data Analysis for HSI and MOVES	4	1
MN3331	Principles of Acquisition and Program Management	5	1
SI3400	Fundamentals of Engineering Project Management	3	2

Quarter 3

OA3412	Human Systems Integration in the DoD Acquisition Lifecycle	3	0
OS3112	Statistics and Design of Experiments	4	2
OA4407	Human Anthropometry- and Biomechanics	3	1
SE3302	System Suitability	3	2

Quarter 4

OA4406	Survivability, Habitability, Environmental Safety and Occupational Health	4	0
OA4603	Test and Evaluation	4	0
OA4109	Survey Research Methods	4	2
SE3303	System Assessment	3	2

Quarter 5

OA3413	Human Systems Integration Tools, Tradeoffs, and Processes	3	1
MN4115	Foundations of Education and Learning in DoD Organizations	3	0
OA4401	Individual Performance & Personnel Considerations	3	1

Quarter 6

OS4701	Manpower and Personnel Models	4	0
OA4702	Cost Estimation	4	0
OA4408	Macroergonomics and Organizational Behavior in Human Systems Integration	3	1
MV4002	Simulation and Training	4	1

Quarter 7

MN3111	Analysis of Human Resource Management	4	0
OA0810	Thesis Research for Operations Analysis Students	0	8
OA0810	Thesis Research for Operations Analysis Students	0	8

Quarter 8

OA0810	Thesis Research for Operations Analysis Students	0	8
OA0810	Thesis Research for Operations Analysis Students	0	8
OA4414	Human Systems Integration Case Studies and Applications	4	0

Provisional Learning Outcomes

Human Systems Integration - Curriculum 359 (DL)

The goal of the distance learning program is to educate eligible personnel within the federal government and defense contractor organizations in the discipline of Human Systems Integration (HSI). Graduates of this program will possess the skills necessary to function as practitioners of HSI.

1. SYSTEMS APPROACH: Graduates will be able to positively influence the activities the Program Management (PM), Systems Engineering (SE), and Test & Evaluation (T&E) communities as they function within the Department of Defense (DoD) Acquisition Lifecycle.

2. HSI DOMAIN KNOWLEDGE: Graduates will demonstrate a basic knowledge of all HSI domains: Human Factors Engineering, Manpower, Personnel, Training, Environmental Safety and Occupational Health, Survivability, and Habitability. Graduates will be familiar with the primary approaches and techniques used by each HSI domain.

3. HUMAN PERFORMANCE: Graduates will be able to apply their knowledge of the cognitive and physiological capabilities and constraints on human performance in operational settings. Graduates will be able to assess factors that affect human performance such as attention, memory, workload, situation awareness, stress, fatigue, and human error.

4. IMPLEMENTING HSI TRADEOFFS: Graduates will be able to conduct elementary tradeoffs across HSI domains, as well as tradeoffs involving engineering, acquisition, and T&E disciplines. They will be able to articulate the impacts and risks associated with those tradeoffs to technical and non-technical audiences.

5. ANALYTICAL TECHNIQUES: Graduates will be able to conduct fundamental quantitative and qualitative research in both field and laboratory settings within the context of the defense acquisition process.

6. MODELING and SIMULATION: Graduates will be familiar with basic modeling and simulation (M&S) techniques to explore tradeoffs across HSI domains and tradeoffs involving engineering, acquisition, and T&E disciplines.

Provisional Educational Skill Requirements (ESR)
Human Systems Integration - Curriculum 362 (RES)

The goal of this curriculum is to educate Naval Officers of the United States Navy in Human Systems Integration. The delivery method is an in-resident course at the Naval Postgraduate School. Human Systems Integration (HSI) acknowledges that the human is a critical component in any complex system. It is an interdisciplinary approach that makes explicit the underlying tradeoffs across the HSI domains, and other engineering disciplines, logistics, acquisition, and T&E, optimizing total system performance while minimizing total ownership costs. The graduate of this program will possess the skills necessary to function as a practitioner in HSI.

HSI DOMAIN KNOWLEDGE: Graduates will possess a thorough background in all HSI domains: Human Factors Engineering, Manpower, Personnel, Training, Environment, Safety, and Occupational Health, Survivability, and Habitability. Graduates will understand the basis for the decisions made by individual domain specialists and will be familiar with the primary approaches and techniques used by each of the HSI domains.

1. ANALYTICAL TECHNIQUES: Graduates will be able to perform tradeoff analysis across domains and other engineering disciplines, logistics, acquisition, and T&E, and to conduct empirical analysis within the domains of human systems integration. They will be able to apply, at the right place and at the right time, these analytical methods and tools in both field and laboratory settings within the context of the defense acquisition process.

2. MODELING and SIMULATION: Graduates will be able to apply Modeling and Simulation (M&S) techniques to explore HSI domain tradeoffs and tradeoffs within other engineering disciplines, logistics, acquisition, and T&E. They will demonstrate the ability to apply M&S techniques within and across the HSI domains to facilitate the development, T&E, operations, and sustainment of military systems.

3. HUMAN PERFORMANCE: HSI maintains that the human is a critical component in any complex system. Graduates will understand the basis of both individual

and team performance in military settings including human information processing, perception, cognition, decision making, and motor control. Graduates will understand current theory and practice in assessing cognitive factors that affect human performance such as attention, memory, situation awareness, stress, fatigue, and motivation. Graduates will understand current scientific knowledge of factors affecting human performance and human error.

4. SYSTEMS APPROACH: Graduates will comprehend the principles and practices of the fields of PM, SE, and logistics, and T&E as related to the DoD Acquisition Lifecycle. Knowledge of HSI influences on PM, SE, and logistics, and T&E will enable graduates to positively influence the DoD Acquisition Lifecycle at appropriate times and in the right manner.

5. IMPLEMENTING HSI TRADEOFFS: Graduates will learn techniques to develop domain level trades, trades within other engineering disciplines, logistics, acquisition, and T&E, impacts, and risk assessments, and the ability to negotiate and communicate to both technical and non-technical audiences. Graduates will understand the political, organizational, social, and economic issues associated with integrating human-machine systems into organizational cultures and environments.

6. JOINT PROFESSIONAL MILITARY EDUCATION: Students will be encouraged to complete the Joint Professional Military Education (JPME) program. This sequence of courses develops an understanding of warfighting within the context of operational art. Topics include: national military capabilities and command structure, joint and service doctrine, joint planning and execution, and joint multinational forces and integration at the operational level of war. JPME includes coursework in wargaming designed to develop an appreciation of the art of war.

Curriculum Sponsor and ESR Approval Authority

Approved as l ESRs; N15 letter "REPORT OF CURRICULUM REVIEW OF MASTER OF SCIENCE IN HUMAN SYSTEMS INTEGRATION (362) AND CERTIFICATE IN HUMAN SYSTEMS INTEGRATION (262)."

Master of Systems Analysis - (DL) - Curriculum 363

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Brief Overview

The Master of Systems Analysis (MSA) program is a distance learning, graduate degree program, designed to meet the needs of the Navy and other services in the Department of Defense (DoD) for technical graduate education in systems analysis as a basis for aiding key decisions on force requirements, weapon systems, and other defense matters. Students acquire foundation skills and hands-on experience in all aspects of analytical studies, which includes the skills to formulate problems, use the analytical process to design study requirements, highlight critical assumptions, recognize strengths and weaknesses of applied analytical methodologies, and evaluate study recommendations.

This program is especially tailored to students whose career pattern will not allow them to get away for a full-time, graduate education program. The entire degree program can be completed at the student's current duty station. This program consists of a blend of approximately 50% web-based, asynchronous online instruction, and 50% synchronous distance learning with scheduled class video meetings. The web-based instruction is paced week-to-week by the instructors, but the students have great flexibility to do their course work at times of their choosing during each week. The synchronous classes meet at a scheduled time, once per week, during the workday, with the agreement of the student's current command.

Requirements for Entry

A baccalaureate degree is required. Completion of mathematics through single variable differential and integral calculus is considered minimal preparation. An academic profile code (APC) of 335 is required.

Convenes

Fall, Spring

Degree

Master of Systems Analysis

The Master of Systems Analysis degree requires:

- Completion of a minimum of 32 quarter-hours of graduate-level courses with:
  - At least 16 quarter-hours of 4000-level courses.
  - Systems analysis core courses and a Systems Analysis context sequence approved by the Chairman, Department of Operations Research.
- Students are required to demonstrate mastery of Systems Analysis practice through satisfactory completion of the thesis-equivalent three-course sequence in Systems Analysis Cases culminating in a final project approved by the Chairman, Department of Operations Research. The quarter-hours earned in the Systems Analysis Cases courses are applied towards satisfying the minimum graduate-level quarter-hours for the degree.

Program Description

The MSA program is a 24-month, part-time program. Students take two courses per quarter, for eight quarters. The curriculum consists of four blocks. Two of the blocks comprise stand-alone, web-based sequences. One is a four-course sequence leading to a Certificate in Systems Analysis, the second online sequence is a track approved by the student's service sponsor in a particular defense systems area in which systems analysis may be applied. The other two blocks round out the master's program with additional systems analysis core courses and a sequence of systems analysis case studies and projects that are an approved equivalent of a master's thesis. All students who successfully complete the distance-learning course of study will receive:

- A Certificate in Systems Analysis awarded after completion of the first four quarters.
- A Master of Systems Analysis degree awarded upon completion of the two-year program.
- The approved systems analysis context track for Navy Unrestricted Line Officer students is a four-course sequence in Defense Resources Management (DRM). The student's service sponsor may approve another track based on course availability and needs of the sponsor and student.

Subspecialty

Completion of this curriculum is designed to qualify an officer as an Operations Research Analysis Subspecialist with a subspecialty code of 3211P. The curriculum sponsor is Director, Assessment Division (N81), Office of the Chief of Naval Operations.

Typical Subspecialty Jobs

OPNAV staff
JCS staff
Fleet staff
Type Commander staff
Battle Group staff
OSD staff

Typical Course of Study (Navy URL Track)

Quarter 1, Spring/Fall

Course	Title	Lecture	Lab
OS2080	Probability and Statistics I	3	0
MO1180	Topics in Mathematics for Systems Analysis	3	2

Quarter 2, Summer/Winter

OS3380	Combat Systems Simulation	3	1
OS3080	Data Analysis and Probability Models	3	0

Quarter 3, Fall/Spring

OS3680	Naval Tactical Analysis	4	0
OA4702	Cost Estimation	4	0

Quarter 4, Winter/Summer

OS4680	Naval Systems Analysis	4	0
OS3211	Systems Optimization	4	0

Quarter 5, Spring/Fall

OS4011	Risk Benefit Analysis	3	2
MN4053/GE4053	Defense Budget and Financial Management Policy	4	0

Quarter 6, Summer/Winter

OS3081	Systems Analysis Cases I	3	0
MN3510	Defense Financial Management Practice	3	0

Quarter 7, Fall/Spring

OS3082	Systems Analysis Cases II	3	0
MN3221	Principles of Acquisition and Program Management I	3	0

Quarter 8, Winter/Summer

OS4083	Systems Analysis Cases III	3	4
MN3222	Principles of Acquisition and Program Management II	3	0

Educational Skill Requirements (ESR)
Master of Systems Analysis (MSA) - Curriculum 363
Subspecialty Code: 3211P

1. **Systems Analysis:** The graduate of this curriculum will understand and be able to apply the basic principles of systems analysis as a basis for aiding key decisions on force requirements, weapon systems, and other defense matters. The following specific Educational Skill Requirements support this high-level objective.
2. **Basics:** The graduate will possess the mathematical skills required to support graduate study in operational analysis and have the ability to use computers to aid in analysis.
3. **Uncertainty Fundamentals:** The graduate will be well versed in uncertainty fundamentals for systems analysis, including applications of probability, statistics, data analysis, and modeling uncertainty.
4. **Simulation:** The graduate will be able to construct and utilize Monte Carlo simulations of combat and other processes that evolve in time and will be able to deal with statistical issues associated with the need for replication.
5. **Tactical Analysis:** The graduate will be able to apply operations analysis methods to tactical and operational problems, including tactical decision analysis.

6. **Cost Analysis:** The graduate will understand the methods and practice of cost analysis including various cost models, with particular emphasis in the relationship of effectiveness models and measures to cost, and applications in cost-benefit analysis.

7. **Risk-Benefit Analysis:** The graduate will be able to apply the principles of probabilistic risk assessment in the context of systems analysis decision problems. This includes a framework for balancing risks and benefits, and analysis under conditions of large financial and technological uncertainties.

8. **Optimization:** The graduate will be able to formulate and solve a wide variety of optimization problems with particular emphasis on applications in optimum allocation of scarce resources and multi-year capital budgeting.

9. **Practice:** The graduate will have gained experience in all aspects of analytical studies, including review, critique, and oversight of the work of others, as well as participation in the conduct of an analytical study. Review, critique, and oversight include the ability to highlight critical assumptions, recognize strengths and weaknesses of applied analytical methodologies, and evaluate study recommendations. Practice in the design and conduct of an analytical study includes the skills to formulate problems, use the analytical process to define study requirements, and apply appropriate analytical methodologies. Practice also includes demonstrating proficiency in presenting results both orally and in writing.

10. **Systems Analysis Context:** The graduate will have completed an approved option sequence in Defense Resource Management, or another approved option sequence in a particular defense systems area in which systems analysis may be applied.

Curriculum Sponsor and ESR Approval Authority

The Major Area Sponsor (MAS) for the Systems Analysis subspecialty is Deputy Chief of Naval Operations, Integration of Capabilities and Resources (OPNAV N8). The designated Subject Matter Expert (SME) for the Master of Systems Analysis curriculum is Director, Assessment Division, Office of the Chief of Naval Operations (OPNAV N81). The Curriculum and ESR approval authority is Deputy Chief of Naval Operations, Warfighting Development (OPNAV N7). (MSA Curriculum Review conducted 14 April 2022.)

Master of Cost Estimating and Analysis (MCEA) - (Distance Learning) - Curriculum 379

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Brief Overview

The Master of Cost Estimating and Analysis (MCEA) is a 24-month, distance learning graduate degree program designed to increase the accuracy and proficiency of DoD cost estimates and cost estimators. This curriculum is sponsored by Naval Sea Systems Command. Students will learn cost estimating techniques commonly used in both DoD and industry, and acquire foundational skills and hands-on experience in all aspects of cost estimation, including shipbuilding, aircraft, software, and many other areas. Students enroll in two courses per quarter for eight quarters. Case studies and a two-quarter capstone project will complete the program. This program blends web-based with online instruction, and is especially tailored to students whose careers will not allow them to get away for a full-time graduate education program. Web-based courses (asynchronous) are paced week-to-week by the instructors, where students have the flexibility to complete their coursework at times of their choosing during each week. The "live" classes are delivered during a three-hour period each week at a pre-determined time throughout the program via ZoomForGov or Microsoft Teams. These courses are scheduled on Wednesdays from 2:00 PM to 5:00 PM eastern time (for odd-numbered cohorts) or Thursdays from 2:00 PM to 5:00 PM eastern time (for even-numbered cohorts).

Requirements for Entry

A baccalaureate degree is required. Recent completion (within five years) of mathematics through single variable differential and integral calculus is considered minimal preparation. An academic profile code (APC) of 235 is required. For applicants with an undergraduate GPA below 2.7, a waiver will be considered depending on work experience.

Convenes

Spring

Degree

The Master of Cost Estimating and Analysis is a professional degree awarded for completing a curriculum focused on the practice of the profession rather than the more general arts or sciences behind the profession. It is analogous to the professional focus of an MBA (Master of Business Administration) compared to the more academic focus of an MS (Master of Science) in Management Science.

The Master of Cost Estimating and Analysis degree requires:

1. Completion of a minimum of 40 quarter-hours of graduate-level courses with:
   a. At least 15 quarter-hours of 4000-level courses.
   b. Cost Estimating and Analysis core courses and a series of supporting courses in Probability, Statistics, Defense Acquisition, Financial Management, and Systems Engineering, all of which are set in a matrix approved by the Chairman, Department of Operations Research.
2. Students are required to demonstrate mastery of Cost Estimating and Analysis practice through satisfactory completion of a Capstone Project approved by the Chairman, Department of Operations Research. The quarter-hours earned in the Capstone project are applied towards satisfying the minimum graduate level quarter-hours for the degree.

Required Courses

Quarter 1, Spring

Course	Title	Lecture	Lab
OS2080	Probability and Statistics I	3	0
MN3301	Acquisition of Defense Systems	4	0

Quarter 2, Summer

OS3080	Data Analysis and Probability Models	3	0
OS3701	Cost Estimation I: Methods and Techniques	3	0

Quarter 3, Fall

OS3006	Operations Research for Cost Analysts	3	0
OS4702	Cost Estimation II: Advanced Concepts in Cost Estimating	3	0

Quarter 4, Winter

OS4013	Cost Estimation VI: Decision Analysis for Cost Estimators	3	0
GE4053	DoD Mission and Resource Determination	4	0

Quarter 5, Spring

OS4012	Cost Estimation III: Risk and Uncertainty Analysis	3	0
OS4080	Cost Estimation V: Cost Estimating and Analysis Cases	3	0

Quarter 6, Summer

OS4703	Cost Estimation IV: Applied Cost Analysis	3	0
SE3100	Fundamentals of Systems Engineering	3	2

Quarter 7, Fall

OS4081	Cost Estimating and Analysis Capstone I	3	4
OS3605	Introduction to Data Analytics for Cost Estimators	3	0

(OS4081: MCEA Thesis Equivalent)

Quarter 8, Winter

OS4082	Cost Estimating and Analysis Capstone II	3	4
MN3510	Defense Financial Management Practice	3	0

(OS4082: MCEA Thesis Equivalent)

Educational Skill Requirements (ESR)
Master of Cost Estimating and Analysis (MCEA) - Curriculum 379

1. **BASIC MATHEMATICS:** The graduate will possess the mathematical skills required to support graduate study in Cost Analysis/Cost Estimating.
2. **PROBABILITY AND STATISTICS:** The graduate will have a firm understanding of probability analysis and statistics and be able to apply that knowledge in the development of cost estimating relationships. The graduate will also be able to correctly interpret statistical measures of any data set.
3. **UNCERTAINTY FUNDAMENTALS:** The graduate will be well versed in uncertainty fundamentals for cost analysis, including applications of probability, statistics, data analysis, and modeling uncertainty.
4. **OPTIMIZATION:** The graduate will be able to formulate and solve basic optimization problems with emphasis on allocating scarce resources and multi-year capital budgeting.
5. **SIMULATION:** The graduate will be able to develop Monte Carlo simulations of cost estimating scenarios, incorporating cost and schedule drivers; and the graduate will be able to assess statistical issues associated with estimating costs of programs with limited financial resources.
6. **COST ANALYSIS:** The graduate will understand and be able to apply the data, methods, and tools required to conduct cost analysis.
7. **RATES DEVELOPMENT:** The graduate will be able to construct a fully burdened wrap rate (e.g., direct labor, overhead, general and administrative costs, and inflation/escalation) utilizing Forward Pricing Rates (FPRs).
   the one
   - The graduate will understand how business base forecasts, competition, and economic changes impact FPRs
   - The graduate will also be able to understand various contract types (cost-plus, fixed-price plus incentive, etc.) and the impacts they have of cost

sharing ratios, contract geometries, and ceiling prices.

8. **COST BENEFIT ANALYSIS:** The graduate will be able to apply the principles of probabilistic cost assessment in the context of resource allocation problems. This includes a framework for balancing costs and benefits, and analysis under conditions of large financial and technological uncertainties.

9. **SYSTEMS ENGINEERING AND ANALYSIS:** The graduate will understand the basic principles of systems analysis as a basis for aiding key decisions on force requirements, weapon systems, and other defense matters. The graduate will also have an awareness of how maturity assessments (e.g., technology, manufacturing readiness) are conducted and potential impact on cost and scheduling.

10. **DEFENSE ACQUISITIION SYSTEM:** The graduate will have a fundamental understanding of defense requirements, acquisition and the planning, programming, budgeting and execution system (PPBES). The graduate will have satisfied all DAWIA acquisition and functional training requirements for Level I, II and III Certification in Business - Cost Estimating (Bus-CE).

11. **DECISION ANALYSIS:** Students will understand modern theory and methods for decision making in both single and multiple person decision-making situations.

12. **PRACTICE:** The graduate will have gained experience in all aspects of analytical studies, including construct, review, critique, and oversight of the work of others, as well as participate in the conduct of an analytical study.
   - The student will formulate problems, use analytical processes to define study requirements, and apply appropriate analytical methodologies.
   - The graduate will be competent in building a life cycle cost estimate
   - Practice also includes demonstrating proficiency in presenting results both orally and in writing.

13. **SOFTWARE COST ESTIMATION:** The graduate will understand software cost estimation, and be able to distinguish between development paradigms (e.g., waterfall, agile, incremental). The graduate will also be able to develop software cost estimates for both development and maintenance efforts.

14. **SCHEDULING:** The graduate will understand how schedule networks rely on logic and the critical path method as well as other top-level schedule methods. The graduate will also learn Schedule Risk Analysis, and how to update and baseline a schedule using industry best practices.

Curriculum Sponsor and ESR Approval Authority

Curriculum sponsor is Commander, Naval Sea Systems Command and Commander, Naval Air Systems Command

Operations Analysis PhD - Curriculum 382

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Brief Overview

The department offers the Doctor of Philosophy in Operations Research degree. The program begins with advanced course work guided by the student's doctoral committee and leading to qualifying examinations in optimization, statistics, and stochastic processes as well as completion of a minor field of study outside of operations research. The primary emphasis then shifts to the student's research program, culminating in the Ph.D. dissertation.

An applicant to the Ph.D. program who is not already a student at NPS should submit transcripts of previous academic and professional work, plus results of a current Graduate Record Examination (GRE) general test, to the Director of Admissions, admissions@nps.edu. Detailed admission procedures may vary depending on the individual's location and position. However, in all cases, the student must fulfill the general school requirements for the doctoral degree. Residency for this program generally requires three years beyond completion of a master's degree.

APC

The minimum APC requirement for entry to this program is 325.

Convenes

Fall, Spring

Subspecialty

3211D

Department of Physics

Chair

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Associate Chair, Academics

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Fabio Durante Pereira Alves, Associate Professor (2018)*, Ph.D., Instituto Tecnologico de Aeronautica, Brazil, 2008.

Joseph Blau, Research Associate Professor (1989); Ph.D., Naval Postgraduate School, 2002.

Abram Clark IV, Assistant Professor (2017); Ph.D., Duke University, 2014.

Keith Cohn, Senior Lecturer (2009); Ph.D., Stanford University, 2007.

Raymond M. Gamache, Associate Professor (2016); Ph.D., Rensselaer Polytechnic Institute, 1999.

Kay L. Gemba, Associate Professor (2021); Ph.D., University of Hawai'i at Mānoa, 2015.

Oleg A. Godin, Professor (2016); Ph.D., Moscow Institute of Physics and Technology, 1984.

Dragoslav Grbovic, Associate Professor (2010), Ph.D., University of Tennessee-Knoxville, 2007.

John Hammerer, Professor of the Practice (2019); M.S., Naval Postgraduate School, 1988 and M.A., Naval War College, 1993.

Joseph Hooper, Professor (2011); Ph.D., Tulane University, 2006.

Emil P. Kartalov, Associate Professor (2016); Ph.D., California Institute of Technology, 2004.

Paul Leary, Research Assistant Professor (2017); Ph.D., Stanford University, 2017.

Brian Mason, Research Associate Professor (2018); Ph.D., Cornell University, 2008.

Ian R. McNab, Research Professor (2018); Ph.D., Reading University, 1974.

Frank A. Narducci, Professor (2017); Ph.D., University of Rochester, 1996.

Kevin B. Smith, Professor (1995); Ph.D., University of Miami, 1991.

Christopher Smithtro, Col, USAF (ret), Senior Lecturer (2017), Ph.D., Utah State University, 2004.

Warren Tomlinson, CDR, USN, Assistant Professor (2017), Ph.D., Naval Postgraduate School, 2017.

Professors Emeriti:

Robert Louis Armstead, Associate Professor Emeritus (1964)*; Ph.D., University of California at Berkeley, 1964.

Steven Richard Baker, Associate Professor Emeritus (1985); Ph.D., University of California at Los Angeles, 1985.

Brett Borden, Professor Emeritus (2002); Ph.D., University of Texas at Austin, 1986.

William Boniface Colson, Distinguished Professor Emeritus (1989); Ph.D., Stanford University, 1997.

Alfred William Madison Cooper, Professor Emeritus (1957); Ph.D., The Queens University of Belfast, 1961.

Peter P. Crooker, Senior Lecturer Emeritus (2001); Ph.D., Naval Postgraduate School, 1967.

David Scott Davis, Associate Professor Emeritus (1989); Ph.D., Purdue University, 1976.

Bruce C. Denardo, Associate Professor Emeritus (1998); Ph.D., University of California at Los Angeles, 1990.

Richard M. Harkins, Senior Lecturer Emeritus (2000); MS, Naval Postgraduate School, 1988, MA Naval War College, 1993.

Daphne Kapolka, LCDR, USN (ret), Senior Lecturer Emeritus (2000); Ph.D., Naval Postgraduate School, 1997.

Gamani Karunasiri, Distinguished Professor Emeritus (2000); Ph.D., University of Pittsburgh, 1984.

Andres Larraza, Associate Professor Emeritus (1994); Ph.D., University of California at Los Angeles, 1987.

James H. Luscombe, Professor Emeritus (1994); Ph.D., University of Chicago, 1983.

Xavier K Maruyama, Professor Emeritus (1987); Ph.D., Massachusetts Institute of Technology, 1971.

Craig F. Smith, Research Professor Emeritus (2004); Ph.D., University of California at Los Angeles, 1975.

David M. Trask, Col, USAF (ret), Professor of the Practice Emeritus (2001); M.B.A., Embry-Riddle University, 1991.

Donald Lee Walters, Professor Emeritus (1983); Ph.D., Kansas State University, 1971.

* The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

Current expertise in the Department of Physics includes the following specializations:
Optical and Electromagnetic Signal Propagation, Detection and Sensor Systems.
Underwater Acoustics
Conventional weapons and their effects
Explosives and high strain rate deformation of materials
Directed Energy Weapons Physics
Physical Acoustics
Condensed-Matter, Device and Sensor Physics
Micro-Electrical and Mechanical Systems (MEMS)
Autonomous Systems and Sensors
Energy

All of these specializations are of relevance to modern and future weapons technologies. The faculty supports an ongoing research program in these areas and student thesis topics are available in all of them.

Degree Requirements

The Department of Physics offers the Master of Science in Applied Physics and Master of Science in Combat Systems Technology degrees, as well as the Ph.D. degree in Applied Physics. It also offers the Master of Science and PhD in Engineering Acoustics and the Master of Engineering Acoustics jointly with the Department of Electrical and Computer Engineering. Upon approval by the department, courses taken at other institutions may be applied toward satisfying degree requirements to the extent allowed by the general Postgraduate School regulations.

Degrees

A student is able to earn one of the academic degrees listed below while enrolled in the following programs: Applied Physics of Combat Systems (Curriculum 533), Undersea Warfare (Curriculum 525/526), Space Systems Engineering (under Curriculum 566), Applied Physics PhD (Curriculum 537), or Engineering Acoustics PhD (Curriculum 536).

Master of Science in Applied Physics

A candidate for the Master of Science in Applied Physics degree must satisfactorily complete a program of study approved by the Chairman of the Physics Department that includes:

1. At least 32 quarter-hours of graduate level courses in physics, mathematics, and engineering including 20 at the 4000 level. Of these 32 hours, at least 20 will be physics courses including 12 at the 4000 level.
2. At least one graduate level course in each of the following areas: mechanics, electromagnetism, and quantum physics.
3. An area of concentration containing a four-course sequence of graduate-level courses in addition to the above requirements, at least two at the 4000 level, in an area related to applied physics.
4. An acceptable thesis advised or co-advised by a member of the Physics Department.

Master of Science in Combat Systems Technology

A candidate for the Master of Science in Combat Systems Technology degree must satisfactorily complete a program of study approved by the Chairman of the Physics Department that includes:

1. A minimum of 32 quarter-hours of graduate work in Physics, Mathematics, and Engineering, with at least 18 quarter-hours at the 4000 level. Included in these hours must be at least 20 quarter-hours of graduate-level physics, including 12 quarter-hours at the 4000 level.
2. Two approved sequences of courses related to combat systems technology. Each sequence must consist of at least four graduate-level courses with at least two

courses at the 4000 level. A list of approved sequences is available from the Chairman.
3. A thesis advised or co-advised by a member of the Physics Department.

Master of Science in Engineering Acoustics

A candidate for the Master of Science in Engineering Acoustics degree must satisfactorily complete a program of study approved by the Chair, Engineering Acoustics Academic Committee, that includes:

1. A minimum of 32 graduate credit quarter-hours of course work of which at least 20 must be taken in acoustics and its applications.
2. At least three 4000 level courses from any three of the following six areas: wave propagation; transducer theory and design; noise, shock, and vibration control; sonar systems; signal processing; and communications. These courses must include at least one from each of the sponsoring disciplines (physics and electrical engineering).
3. Completion of an acceptable thesis on a topic approved by the Engineering Acoustics Academic Committee.

Master of Engineering Acoustics

A candidate for the Master of Engineering Acoustics degree must complete the same program of study listed above for the Master of Science degree with the exception of the thesis. An acceptable one-quarter capstone project advised by a member of the Electrical and Computer Engineering or Physics Departments replaces the thesis requirement for this degree.

Doctor of Philosophy in Applied Physics

The Department of Physics offers the Ph.D. in several areas of specialization which currently include acoustics, electro-optics, free electron lasers, space physics, and theoretical physics.

Requirements for the degree may be grouped into three categories: courses, dissertation research, and examinations.

The required examinations are outlined under the general school requirements for the Ph.D. In particular, the department requires a preliminary examination to show evidence of acceptability as a doctoral student. This examination may be taken before or after commencement of graduate studies at NPS.

The department offers the Ph.D. in Applied Physics requiring 40 credit hours of 4000 level courses, but a portion of these hours may be taken in other departments in technical subjects related to physics.

A more detailed description of departmental requirements for the Ph.D. is contained in the booklet "Doctoral Study in Applied Physics at the Naval Postgraduate School," available from the Academic Associate.

An applicant to the Ph.D. program who is not already a student at NPS should submit transcripts of previous

academic and professional work, plus results of a current Graduate Record Examination (GRE) general test, to the Director of Admissions, Code 01C3, Naval Postgraduate School, Monterey, California 93943-5100.

Doctor of Philosophy in Engineering Acoustics

The Department of Electrical and Computer Engineering and the Department of Physics jointly sponsor an interdisciplinary program in Engineering Acoustics leading to the Doctor of Philosophy degree. Areas of special strength in the departments are physical acoustics, underwater acoustics, acoustic signal processing, and acoustic communications. A noteworthy feature of this program is that a portion of the student's research may be conducted away from the Naval Postgraduate School at a cooperating laboratory or other federal government installation. The degree requirements and examinations are as outlined under the general school requirements for the doctorate degree. In addition to the school requirements, the departments require a preliminary examination to show evidence of acceptability as a doctoral student.

Physics Laboratories

The physics laboratories are equipped to carry on instruction and research work in acoustics, atomic and molecular physics, electro-optics, spectroscopy, laser physics, computational physics, optical propagation, and sensor physics.

The Optical Physics and Sensors Laboratory uses imaging, spectroscopic and sensing systems from far infrared to ultraviolet wavelengths, including instrumentation for seagoing, airborne and ground-based measurements.

The Acoustics Laboratory equipment includes a large anechoic chamber, a small reverberation chamber and a multiple-unit acoustics laboratory for student experimentation in acoustics in air. Sonar equipment, test and wave tanks and instrumentation for investigation in underwater sound comprise the Underwater Acoustics Laboratory. The Physical Acoustics Laboratories are equipped with a variety of modern data collection and processing equipment.

The Sensor Research Laboratory is capable of design, packaging and characterization of optical and infrared detectors using I-V measurement, Fourier transform spectroscopy and variable temperature photocurrent spectroscopy. Facilities exist for advanced micro-characterization, including cathodoluminescence, EBIC, X-ray analysis, and transport imaging in a scanning electron microscope with variable temperature capability.

The Microsystems Fabrication Laboratory provides microfabrication capabilities including photolithography, thermal and PECVD thin film deposition, dry and wet etching and carbon nanotube growth. It also has a range of thin film characterization capabilities and optical profilometer. This cleanroom laboratory supports design and fabrication of sensors based on MEMS (Micro-Electro Mechanical Systems).

The Undersea Sensing Systems Laboratory supports deployable platforms for exploring the development, integration, and application of novel acoustic and other undersea sensing systems with an emphasis on environmental assessment, undersea networking, and directional acoustic sensing, tracking, and localization.

Physic Course Descriptions

PC Courses (p. 490)

PH Courses (p. 492)

Combat Systems Science and Engineering Certificate - Curriculum 233 (Resident) / 235 (DL)

Program Officer

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Academic Associate

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Brief Overview

The Combat Systems Science and Engineering Certificate addresses the technologies and theoretical foundations of current and future combat systems. The courses available in the certificate cover fundamental physical principles governing combat systems and their integration, ranging from sensor technologies, weapons and their effects, modern missile technologies, and advanced weapon systems.

Convenes

Fall, Spring

Program Length

4 Quarters

Requirements for Entry

A Bachelor's degree from an accredited institution including an undergraduate physics sequence.

- Understand energy release in explosives, material response to shocks, and ballistics
- Understand the basic principles of solid-state lasers and propagation issues related to atmospheric effects
- Understand the basic physics of nuclear bombs, design of nuclear weapons, and related damage mechanisms
- Understand the design of chemical warheads and the lethality of each type
- Identify the types of electromagnetic (EM) radiation,

corresponding sensors, and how different regions of the spectrum can be exploited
- Understand the mechanisms of detection for optical, infrared, and thermal sensors, including noise mechanisms
- Describe the tradeoffs in radar system design and performance and understand the concept of radar cross section
- Appreciate the capabilities of advanced weapons and how they are integrated in modern combat systems

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain at least a 3.0 GQPR in the courses to be awarded a certificate.

Required Courses

Course	Title	Lecture	Lab
PC3200	Survey of Electromagnetic Sensors and Detection	4	0
PC3800	Survey of Weapons and their Effects -and-	4	0
ELECT	Elective		

In addition to the two required courses (PC3200 and PC3800), students will choose one elective course from the following options: ME4700, ME4751, PC3400, PC4022, PC4860, TS4000.

Applied Physics of Combat Systems - Curriculum 533

Combat Systems Web Page:
https://www.nps.edu/web/physics

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Associate Chairman, Instruction and Administration

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Brief Overview

This program is designed to meet the needs of the military services for an officer having a broad-based advanced technical education applicable to combat systems design, development, test and evaluation, acquisition, operation, and support. The majority of students earn a degree in Applied Physics; degrees in Engineering Acoustics and Combat Systems Technology are also available. Included in the core of the program are courses on electromagnetic radiation, applied optics, optoelectronics, explosives and warheads, fluid dynamics of weapons, combat simulation,

underwater acoustics, semiconductor devices, detection and engagement elements, combat systems integration, and computing resources for advanced combat systems. The officer will also conduct thesis research on a military-relevant technical problem.

Requirements for Entry

A baccalaureate degree with mathematics through differential and integral calculus and a calculus-based basic physics sequence are required for direct input. Courses in the physical sciences and engineering are highly desirable. An APC of 323 is required.

Convenes

Winter, Summer

Program Length

24 Months

Subspecialty

The Applied Physics of Combat Systems curriculum has options ranging from an accelerated four-quarter program for students ready to commence graduate-level courses, to a standard eight-quarter course of study for students who require a review of undergraduate coursework. Completion of the full eight-quarter curriculum qualifies an officer as an Applied Physics of Combat Systems sub-specialist with a subspecialty code of 5701-5705P depending on specialization track. U.S. Navy students entering the curriculum through the one-year Immediate Graduate Education Program (IGEP) receive a sub-specialty code of 5701-5704I. The curriculum sponsor is the Program Executive Officer, Integrated Weapons Systems (PEO-IWS).

Typical Subspecialty Assignments

Combat Systems, Weapons, Plans and Tactics, or Operations Officer
Defense Threat Reduction Agency, Los Alamos, NM
DOE National Nuclear Security Agency, Washington, DC
Fleet and Type Commander Combat Systems Officers
Missile Defense Agency, Washington, DC
Naval Sea Systems Command, Washington, DC
Naval Surface Warfare Center - White Sands, NM, Dahlgren, VA, or Port Hueneme, CA
Naval Information Warfare Systems Command, San Diego, CA
OPNAV N95/96/97/98 - Resource Sponsor / Requirements Officer
Program Executive Officer Carriers, Washington, DC
Strategic Weapons Facility Atlantic or Pacific
Supervisor Shipbuilding - Groton, Newport News, Bath, or Pascagoula
United States Naval Academy or United States Military Academy (military faculty)
Warfare Tactics Instructor

Typical Course of Study - Applied Physics Option

Quarter 1

Course	Title	Lecture	Lab
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
PH2151	Particle Mechanics	4	1
PH2001	Research Seminar in Physics	1	0
ELECT	Elective		

Quarter 2

PC2911	Introduction to Computational Physics	3	2
PH3152	Analytical Mechanics	4	0
PH3991	Theoretical Physics	4	1
PH0999	Physics Colloquium	0	1
ELECT	Elective		

Quarter 3

PH2351	Electromagnetism	4	1
PH2652	Modern Physics	4	1
PH3782	Thermodynamics and Statistical Physics	4	0
PH0999	Physics Colloquium	0	1
ELECT	Elective		

Quarter 4

PH3352	Electromagnetic Waves	4	0
PH3655	Semiconductor Device Physics	4	0
PH3011	Thesis Proposal Preparation	1	0
	Track Course		
	Track Course		

Quarter 5

PH0810	Thesis Research	0	8
PH4656	Quantum Mechanics	4	1
PH0999	Physics Colloquium	0	1
	Track Course		
	Track Course		

Quarter 6

PC3800	Survey of Weapons and their Effects	4	0
PC4860	Modern Missile Systems	4	1
PH0999	Physics Colloquium	0	1
	Track Course		
	Track Course		

Quarter 7

PH0810	Thesis Research	0	8
PH0810	Thesis Research	0	8
PH0999	Physics Colloquium	0	1
	Track Course		
	Track Course		

Quarter 8

PH0810	Thesis Research	0	8
PH0810	Thesis Research	0	8

PC3400	Survey of Underwater Acoustics	4	0
PC4022	Combat Systems Capabilities	4	0
PH4001	Physics Thesis Presentation	1	0

Joint Professional Military Education (JPME):

All Unrestricted Line Naval Officers are required to take the following four courses for JPME; these courses are normally added to the matrix in the first 4 quarters:

NW3230	Strategy & War	4	2
NW3275	Joint Maritime Operations - part 1	4	0
NW3276	Joint Maritime Operations - part 2	2	2
NW3285	Theater Security Decision Making	4	0

Engineering Duty Officers and students from other services are not required to take JPME courses.

Concentration Areas

The Physics department offers three concentration areas: Acoustics, Sensors, and Weapons. Each concentration consists of four or five "track" courses. The approved track courses are:

- Acoustics - PH3119 (p. 493), PH3451 (p. 494), PH3452 (p. 494), PH4454 (p. 497), PH4455 (p. 497)
- Sensors - PH3280 (p. 494), PH3292, PH3655 (p. 494), PH4272, PH4274
- Weapons - ME4700 (p. 408), PH4171 (p. 496), PH4857, PH4858

U.S. Navy students pursuing the 570X subspecialty code will complete two tracks.

Note: Final approval of a student's degree program rests with the department Chair.

Engineering Acoustics PhD - Curriculum 536

Program Officer

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Academic Associate

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Brief Overview

The Department of Electrical and Computer Engineering and the Department of Physics jointly sponsor an interdisciplinary program in Engineering Acoustics leading to the Doctor of Philosophy degree. Areas of special strength in the departments are physical acoustics, underwater acoustics, acoustic signal processing, and

acoustic communications. A noteworthy feature of this program is that a portion of the student's research may be conducted away from the Naval Postgraduate School at a cooperating laboratory or other federal government installation. The degree requirements and examinations are as outlined under the general school requirements for the doctorate degree. In addition to the school requirements, the departments require a preliminary examination to show evidence of acceptability as a doctoral student. A more detailed description of departmental requirements for the Ph.D. is contained in the document "Doctoral Study in Engineering Acoustics," available from the Academic Associate.

An applicant to the Ph.D. program who is not already a student at NPS should submit transcripts of previous academic and professional work, plus results of a current Graduate Record Examination (GRE) general test, to the Director of Admissions, Code 01C3, Naval Postgraduate School, Monterey, California 93943-5100.

Completion of this curriculum qualifies an officer as an Engineering Acoustics Subspecialty with a code of 57XXD.

Applied Physics PhD - Curriculum 537

Program Officer

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Academic Associate

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Brief Overview

The Department of Physics offers the Ph.D. in several areas of specialization which include acoustics, electro-optics, lasers, weapons, and theoretical physics.

Requirements for the degree may be grouped into three categories: courses, dissertation research, and examinations.

The required examinations are outlined under the general school requirements for the Ph.D. In particular, the department requires a preliminary examination to show evidence of acceptability as a doctoral student.

The Ph.D. in Applied Physics requires 40 credit hours of 3000 and 4000 level courses, but a portion of these hours may be taken in other departments in technical subjects related to physics. Final course selections will be approved by the department's Ph.D. Committee.

A more detailed description of departmental requirements for the Ph.D. is contained in the booklet "Doctoral Study in Applied Physics at the Naval Postgraduate School," available from the Academic Associate.

An applicant to the Ph.D. program who is not already a student at NPS should submit transcripts of previous academic and professional work, plus results of a current Graduate Record Examination (GRE) general test, to the Director of Admissions, Code 01C3, Naval Postgraduate School, Monterey, California 93943-5100.

Department of Systems Engineering

Chair

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Ronald R. Carlson, Professor of Practice and Program Officer (2009); M.PHIL, Stevens Institute of Technology, 2017.

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Jonathan Lussier, Faculty Associate - Research (2021); B.S., University of Denver, 2020.

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Eugene P. Paulo, Associate Professor (2000); Ph.D., University of Central Florida, 1998.

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Wayne Porter*, USN (Ret.), Senior Lecturer (2015); Ph.D. Naval Postgraduate School, 2014.

Mark M. Rhoades, Senior Lecturer (1999); M.S., Naval Postgraduate School, 2006.

Mark R. Stevens, Senior Lecturer and Academic Associate (2003); M.S., Rensselaer Polytechnic Institute, 1988.

Joseph Sweeney III, Lecturer and Program Officer (2010); M.S., Southern Methodist University, 2018.

Douglas Van Bossuyt, Assistant Professor (2018); Ph.D., Oregon State University, 2012.

Warren Vaneman, Professor of Practice (2012); Ph.D., Virginia Tech, 2002.

Christopher Wolfgeher, Faculty Associate-Research (2011); M.ENG., Colorado State University, 2011.

Oleg Yakimenko, Distinguished Professor and Chair (2001); Ph.D., Russian Academy of Sciences, 1991.

The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

(* indicates faculty member has a joint appointment to another department at NPS)

Mission

The mission of the Department of Systems Engineering is to provide relevant, tailored, and unique advanced education and research programs in Systems Engineering in order to increase the combat effectiveness of US and allied armed forces and to enhance the security of the United States.

Brief Overview

The Department of Systems Engineering provides rigorous academic programs on the design, development, and operation of large, complex weapon systems. The programs cover the technical activities for the entire system life-cycle.

Students in the Systems Engineering Department are admitted to one of several available curricula. Curriculum details are provided in the catalog with each one identified by a unique curriculum number. Each curriculum is defined using educational skill requirements and related academic coursework. For active duty US naval officer students, the successful completion of a curriculum leads to the award of a sub-specialty code, or p-code, and award of a degree in one of the masters programs offered for the curriculum. For other active duty US military, foreign military, and civilian students, successful completion of a curriculum leads to the award of a degree in one of the masters programs offered for the curriculum.

The Systems Engineering Department offers six degree programs:

- Master of Science in Systems Engineering (MSSE) Program – requires an ABET EAC undergraduate engineering degree, or equivalent. Four curricula options (308, 311, 312, 580) allow a student to earn a MSSE degree.
- Master of Science in Engineering Systems (MSES) Program – does not require an undergraduate engineering degree. Three curricula options (311, 312, 580) allow a student to earn a MSES degree.
- Master of Science in Systems Engineering Analysis (MSSEA) Program – does not require an undergraduate engineering degree. One curriculum option (308) allows a student to earn a MSSEA degree.
- Master of Science in Product Development (MSPD) Program – does not require an undergraduate engineering degree. One curriculum option (721) allows a student to earn a MSPD degree.
- Master of Science in Systems Engineering Management (MSSEM) Program – does not require an undergraduate engineering degree. Four curricula options (522, 711, 721, 722) allow a student to earn a MSSEM degree.

- Doctor of Philosophy (Ph.D.) Program in Systems Engineering. One curriculum option (581) allows a student to earn a Ph.D. degree.Any student study plan leading to award of a degree offered by the SE department must be approved by the Chairman of the Department of Systems Engineering at least two quarters before completion. In general, approved curricula may require more than minimum degree requirements in order to conform to the needs and objectives of the service or agency sponsoring the student.

A specific curriculum must be consistent with the general minimum requirements for the degree program as determined by the Academic Council.

SE Degree Programs

Master of Science in Systems Engineering Program

The Systems Engineering Department offers the MSSE Program through the 308, 311, 312, and 580 curricula options. The specific course of study leading to the MSSE differs for each curriculum. Refer to the 308, 311, 312, and 580 curricula for details.

The MSSE program is ABET EAC accredited. The other Systems Engineering Department programs, MSES, MSSEA, MSPD, MSSEM, and Ph.D. are not ABET EAC accredited.

Program Educational Objectives

The overall educational objective of the Systems Engineering Department is to support the NPS mission by producing graduates who have, at an advanced level, knowledge and technical competence in systems engineering and an application domain; and who can use that knowledge and competence to support national security. Specific program educational objectives (i.e., skills and abilities that graduates can bring to their position after having graduated from NPS and having received 3-5 more years of on-the-job training and professional development) are:

- **Technical Leadership:** Graduates will be known and respected for applying their engineering knowledge in leadership roles along diverse career paths in government service.
- **Program Management:** Graduates will be known and respected for their research, design, development, procurement, integration, maintenance, and life-cycle management of systems for defense and national security.
- **Operational Utilization:** Graduates will be known and respected for their application of systems engineering in diverse military settings and understand its capabilities and limitations.

Student Outcomes

In order to achieve the program educational objectives for the master of science in systems engineering (MSSE) program, graduates must complete at least one year of study, or at least 45 quarter credit hours, beyond a baccalaureate level program, achieve a mastery of systems engineering, and complete a thesis or capstone project report, where each student attains outcomes demonstrating competency in:

1. Advanced mathematics, including probability and statistics, and computing fundamentals, with practical applications thereof.
2. Engineering topics necessary to define, synthesize, analyze, design, and evaluate complex systems containing hardware and software, and human elements (where appropriate), in a holistic manner across the lifecycle.
3. Systems design and analysis topics, such as decision analysis, risk analysis (cost, schedule and performance), trade-off analysis, optimization, modeling based engineering, simulation, sensitivity analysis techniques, or requirements engineering.
4. Communication: Communicate effectively both orally and in writing.

In addition to attaining these student outcomes, each student will have had post-secondary educational and/or professional experiences that supports that attainment of student outcomes as defined in the ABET EAC general criteria for baccalaureate programs, Criterion 3; and includes at least one year of math and basic science, at least one-and-a-half years of engineering topics, and a major design experience that meets the requirements in the general criteria for baccalaureate programs, Criterion 5. Students that have attained an ABET EAC accredited undergraduate degree meet these post-secondary requirements.

Requirements for the degree of Master of Science in Systems Engineering:

An ABET EAC accredited Bachelor of Science degree in an engineering discipline or established equivalency.

1. Completion of an approved curriculum that includes:
   a. A minimum of 36 quarter credit hours of 3000 and 4000 level courses, 16 of which must be at the 4000 level.
   b. A series of courses in systems engineering defined by each curriculum.
2. Completion of a 12 quarter credit hour thesis course sequence and a thesis or a capstone project course sequence and capstone project report, depending on curriculum requirements.

Master of Science in Engineering Systems Program

A candidate shall have earned the Bachelor of Science or Bachelor of Arts degree. Degree requirements:

1. Completion of an approved curriculum that includes:
   a. A minimum of 36 quarter credit hours of 3000 and 4000 level courses, 16 of which must be at the 4000

level.

b. A series of courses in systems engineering defined by each curriculum.

2. Completion of a 12 quarter credit hour thesis course sequence and a thesis or a capstone project course sequence and capstone project report, depending on curriculum requirements.

Master of Science in Product Development Program

A candidate shall have earned the Bachelor of Science or Bachelor of Arts degree. Degree requirements:

1. The Master of Science degree in Product Development requires a minimum of 48 quarter-hours of graduate level work.

2. The candidate must take all courses in an approved curriculum, which must satisfy the following requirements:

   a. There must be a minimum of 36 quarter-hours of credits in 3000 and 4000 level courses, including a minimum of 16 quarter-hours at the 4000 level.

   b. The course work must include four courses in systems engineering methods, defined by each curriculum.

3. Additional courses must be selected from an approved list.

4. The candidate must complete an approved thesis.

Master of Science in Systems Engineering Management Program

The Systems Engineering Department offers the MSSEM Program through the 522 and 722 curricula options. The specific course of study leading to the MSSEM differs for each curriculum. Refer to the 522 and 722 curricula for details.

The MSSEM program is not ABET accredited.

Program Educational Objectives

The overall educational objective of the Systems Engineering Department is to support the NPS mission by producing graduates who have, at an advanced level, knowledge and technical competence in systems engineering and an application domain; and who can use that knowledge and competence to support national security. Specific program educational objectives (i.e., skills and abilities that graduates can bring to their position after having graduated from NPS and having received 3-5 more years of on-the-job training and professional development) are:

- Technical Leadership: Graduates will be known and respected for applying their engineering management knowledge in leadership roles along diverse career paths in government service.

- Program Management: Graduates will be known and respected for their research, design, development, procurement, integration, maintenance, and life-cycle management of systems for defense and national security.

- Operational Utilization: Graduates will be known and respected for their application of systems engineering management in diverse military settings and understand its capabilities and limitations.

Student Outcomes

To achieve the program educational objectives for the Master of Science in Systems Engineering Management (MSSEM) program, graduates must complete at least one year of study, or at least 48 quarter credit hours, beyond a baccalaureate level program, achieve a mastery of systems engineering management, and complete a thesis or capstone project report, where each student attains outcomes demonstrating competency in:

1. The engineering relationships between the management tasks of planning, organization, leadership, and control, as well as the human element of managing engineering professionals in production, research, and service organizations.

2. The stochastic nature of management systems.

3. Systems engineering management to include an understanding of the systems engineering process, and the ability to contribute to the definition of system requirements, evaluation of system architecture, verification and validation activities, system integration, and system design.

4. Deriving and defining system requirements and specifications. This includes performing system assessment, evaluating system design alternatives, estimating and analyzing the system cost, schedule, and performance risk, and analyzing and planning for system verification and validation.

5. The planning and management of complex projects and the principles and current approaches to manage systems design, integration, verification and validation in a holistic manner across the system lifecycle.

6. Communication: Communicate effectively both orally and in writing.

Requirements for the degree of Master of Science in Systems Engineering Management:

- An accredited Bachelor of Science or Bachelor of Arts degree.

- Completion of an approved curriculum that includes:

1. A minimum of 36 quarter credit hours of 3000 and 4000 level courses, 16 of which must be at the 4000 level.

2. A series of courses in systems engineering defined by each curriculum.

- Completion of a thesis course sequence and a thesis, or a capstone project course sequence and capstone project report, depending on curriculum requirements.

Doctor of Philosophy Degree Programs

The Department of Systems Engineering offers a Doctor of Philosophy (Ph.D.) degree in Systems Engineering. Students take graduate level course in systems

engineering (as needed to pass the oral and written qualifying examinations), advanced graduate courses in systems engineering and an application domain and perform research that leads to a dissertation involving some aspect of systems engineering. Research topics may be selected from a broad variety of studies of the systems engineering process, applications of systems engineering to solving complex problems, systems level modeling and simulation, and systems suitability assessment. Subject to approval of the student's dissertation committee chairman, dissertation research may be conducted away from NPS at cooperating facilities. Students must satisfy a one-year residency requirement. This may be met by completing an NPS M.S. degree plus periodic extended stays (nominally two weeks per quarter) at an NPS campus spread throughout the duration of the student's program. The M.S. degree may be completed before enrollment in the Ph.D. program.

Applicants should possess an M.S. degree in Systems Engineering. Applicants with only a B.S. degree or an M.S. degree in another discipline will be required to take a number of systems engineering courses (equivalent to the coursework portion of an MSSE degree program) to pass the qualifying examinations.

Laboratories and Research

Students in the Systems Engineering Department participate in a variety of research activities ranging from course-based experiments and individual classroom projects to larger team-based design projects and individual thesis research. Systems Engineering Department faculty members conduct a variety of research in four broad areas.

Systems Engineering Methodology involves the investigation or development of tools and techniques for conceptualizing, designing, and developing systems. Study areas include discovery of fundamental principles of systems theory, elucidating the use of these principles through systems engineering tools and techniques, analyzing the conditions of employing the tools and techniques, and determining the efficacy of those tools and techniques. Specific methodology areas include system requirements generation, requirements allocation, system architecture, system dynamics and control, and risk engineering.

Systems Engineering Applications involves the application of systems engineering processes to the solution of specific complex problems. This can include conceptual design of systems, investigation of issues associated with integration of system components into system segments, investigation of issues associated with integration of system segments into systems, and the analysis of case studies of successful and/or unsuccessful systems engineering applied to military acquisition programs. Specific application areas include combat systems integration, ship systems engineering, and enterprise systems engineering.

System Simulation and Modeling involves the development of simulations and models of military systems, evaluation of the efficacy of these simulations and models in providing the information to accomplish systems engineering functions (especially system design requirements and comparison of alternative solutions), and investigation of the characteristics of simulations and models that lead to outputs useful in the systems engineering process.

System Suitability Assessment involves the study of tools, techniques, and disciplines that permit the assessment of the suitability of systems in meeting requirements. Requirements can include performance, availability, operability, and cost. Specific suitability assessment areas include reliability engineering, system survivability, and system cost estimation and control.

The Systems Engineering Department maintains a number of laboratories to its support instructional and research objectives. These laboratories serve to:

- Provide broad, hands-on, practical engineering experiences to systems engineering students enhancing application domain understanding at the component level and subsystem levels and balancing analysis with exploratory development and prototyping.

- Provide an environment (facilities and equipment) that fosters student projects with resulting hardware prototypes and investigations that reach beyond concept definition to later stages of the life cycle.

- Provide an environment that facilitates student and faculty experimental research in applications of systems engineering.

Administratively the research facilities of the Systems Engineering Department are organized into five laboratories. Each of these laboratories contains one or more instructional research spaces.

The **SE Demonstrations Lab** provides space & equipment for developing and housing a wide variety of demonstrations that enhance courses in the systems engineering curricula.

The **SE Computation Lab** provides computational support for large-scale simulation, modeling, and systems engineering projects. It houses Lockheed Martin systems engineering software, a variety of complex simulation & modeling software (such as the Navy Simulation System), and the 75 interconnected computers needed to run that software. The lab also provides a general-purpose computing facility that supports all systems engineering classes, thesis projects, and capstone projects. It may be utilized by distance learning students as well as resident students.

The **SE Projects Lab** provides an environment in which students can work together to pursue team-based systems engineering projects or pursue independent study related to courses or thesis research. In addition, facilities, tools, and materials are provided to permit

fabrication, assembly, integration, and test of electronic and mechanical equipment in support of projects and theses.

The **SE Foundations Lab** provides direct exposure to the scientific concepts and techniques that underlie modern engineering disciplines. It provides facilities and equipment to perform basic experiments in physics, chemistry, biology, electronics, and materials science. This laboratory also provides basic equipment that facilitates hardware-oriented thesis research programs and student capstone projects. Administered within the SE Foundations Lab are the Physical Systems Lab, the Defense Applications Lab, the Nuclear Detector Lab, the Electro-Optical Sensor Systems Lab, and the Virtual Lab.

The **Physical Systems Lab** supports experiments that elucidate the fundamental properties, characteristics, and interactions of mechanical, thermodynamic, and electromagnetic systems. The Defense Applications Lab supports experiments involving wet chemistry, microorganisms, and/or biological materials. It provides facilities and equipment for simple chemical synthesis, chemical analysis, electrochemistry, microbial culture, microscopy, DNA analysis, and other biotechnologies. The Nuclear Detector Lab supports experiments involving detection of nuclear radiation. It hosts a variety of low-level radioactive sources, detector systems, signal processing electronics, and shielding against background radiation. The Electro-Optical Sensor Systems Lab supports experiments involving electro-optical sensors (television, image intensifiers, thermal imaging, etc.) that require complete darkness for some measurements. The Virtual Lab supports portable laboratory concepts, especially software-based virtual experiments and software that is not available for network use in the SE Computation Lab. It also supports distance learning activities by providing a foundation for future insertion of laboratory experiences into the DL systems engineering courses.

The **SE Applications Lab** augments lecture courses in the engineering applications tracks (including combat systems, ship systems, and enterprise systems, among others) in the SE curriculum. It provides hands-on experience with important concepts and permits direct observation of critical phenomena associated with combat systems and sensor/weapon networks. It also provides equipment that can be used in student thesis projects and capstone design projects. Experiments cover the gamut from signal propagation to sensor fundamentals to specific sensor technologies to weapons operational concepts to sensor & weapon networks to technologies associated with the integration of sensors, weapons, and control technologies into modern military platforms of all types. Administered within the SE Applications Lab are the Ship Systems/Combat Systems Lab, the Enterprise Systems Lab, and the Laser/Lidar Development Lab.

The **Ship Systems/Combat Systems Lab** supports experiments in the Ship Systems and Combat Systems track courses. It hosts a variety of active & passive microwave, infrared, acoustic, & magnetic sensor hardware, weapon subsystems & simulators of weapon systems, and devices permitting the investigation of platform characteristics. The Enterprise Systems Lab supports experiments in the Enterprise Systems Engineering track courses. It provides network hardware, communication systems, and electronic measurement and analysis equipment, as well as multiple sensor types to provide input and network-controllable systems to utilize output. The Laser/Lidar Development Lab provides optical tables, breadboard optical hardware, laser measurement equipment, and a variety of laser sources in a laser safety-qualified laboratory.

Systems Engineering Course Descriptions

SE Courses (p. 500)

SI Courses (p. 508)

Capability and Mission Engineering Certificate - Curriculum 131 (DL)

Program Officer

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Academic Associate

Ray Madachy, Professor
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Brief Overview

The Department of Systems Engineering offers a four-course academic certificate in systems capability and mission engineering that enables students to apply systems engineering in defense acquisition and system lifecycle support. Practicing systems engineers require technical and management competence with digital and model-based engineering, statistical operational analysis, requirements and capability engineering, lifecycle cost management, and verification and validation. This program is targeted for mid- and upper-level engineers working in or in support of the Defense Acquisition System but has great benefit for all who seek further knowledge in the theory and practice of systems engineering.

Convenes

Fall, Winter, Spring, Summer

Program Length

4 Quarters

Entry Requirements

Undergraduate engineering, science or technical degree with a minimum 2.6 grade point average and at least one

college calculus sequence (one year of undergraduate courses - two semesters or three quarters).

Prerequisite

Successful completion of the System Engineering Fundamentals Certificate (282).

- Define the digital environment and apply digital modeling tools to the solution of an engineering problem to include an assessment of model accuracy, completeness, trust, and reusability
- Use modeling languages, concepts, and data attributes to create model artifacts and generate diagrams.
- Construct a capabilities portfolio for a given set of missions
- Model the effectiveness and cost of a capability portfolio and analyze and interpret the results of a simulation model for the capability portfolio.
- Develop life-cycle cost models
- Apply cost estimating techniques to develop cost estimates incorporating uncertainty. Quantify and evaluate cost risk.
- Describe the role of V&V within systems engineering and formulate traceable requirements for testing complex systems using the dendritic approach.
- Develop test scenarios and identify required test resources. Apply statistical tools for evaluating specification compliance and designing experiments.

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
SE3050	Introduction to Digital Engineering with Model-Based Systems Engineering	3	2

Quarter 2

SE3011	Engineering Economics and Cost Estimation	3	0

Quarter 3

SE3250	Capability Engineering	3	2

Quarter 4

SE4354	System Verification and Validation	4	0

Model-Based Systems Engineering Design and Development Certificate - Curriculum 133 (DL)

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Program Officer
Senior Lecturer Joseph Sweeney

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Brief Overview

The Department of Systems Engineering offers a four-course academic certificate in Model-Based Systems Engineering Design and Development that enables students to apply systems engineering in defense acquisition and system lifecycle support. MBSE is an increasingly important domain in systems engineering, especially with the introduction of digital engineering initiatives. It requires the skills necessary to create, analyze and execute models and to formally apply them throughout system development from requirements to validation. MBSE requires mastery of modeling languages, methods and tools. This program is targeted for mid- and upper-level engineers working in or in support of the Defense Acquisition System but has great benefit for all who seek further knowledge in the theory and practice of systems engineering.

Convenes

Fall, Winter, Spring, Summer

Program Length

4 Quarters

Requirements for Entry

–Undergraduate degree in engineering, math or basic science with minimum 2.6 grade point average and at least one college calculus sequence (one year of undergraduate courses - two semesters or three quarters).

Prerequisite

–Successful completion of System Engineering Fundamentals Certificate (282).

- Create system architectures that are responsive to capability needs using model-based systems engineering (MBSE) methods.
- Create architectures for balanced system solutions, applying design heuristics and divergent thinking using multiple languages, methods, and tools.
- Evaluate an architecture's feasibility through simulation, conduct trades, compare alternatives, and justify recommendations with appropriate analysis.
- Develop the cognitive structures to carry out integration and development, account for the impacts of emergence including system suitability, and apply appropriate tools to systems and
- system of systems integration.
- Evaluate MBSE compliant designs in specialized application areas, such as simulation for acquisition or software systems.
- Understand software in the context of systems engineering, the distinction between live, virtual, and constructive simulations, and discrete event, agent based, and systems dynamics simulations.

- Apply MBSE to enhance the overall benefits of systems engineering. Select and tailor or create a set of methods, tools, and techniques for decision support, operational effectiveness modeling, dashboard design, and trade space analysis.

Typical Course of Study

The certificate consists of 3 core courses: SE4150, SE4151, and SE4930, and a choice of one course in an application area: either SE4003, SE4420, or SE4950.

Quarter 1

Course	Title	Lecture	Lab
SE4150	Systems Architecting and Design	3	2

Quarter 2

SE4151	Systems Integration and Development	3	2

Quarter 3

SE4930	Model-Based Systems Engineering	3	2

Quarter 4

SE4420	Modeling and Simulation in Acquisition	3	2
	-or-		
SE4003	Systems Software Engineering	3	2
	-or-		
SE4950	System of Systems Engineering	4	0

Advanced Systems Suitability Certificate - Curriculum 135 (DL)

Brief Overview

The Department of Systems Engineering offers a four-course academic certificate in Advanced Suitability topics that enables students to apply systems engineering in defense acquisition and system lifecycle support. This certificate offers more detailed courses focused on specific suitability areas providing additional expertise useful in system design through integration and manufacturing, development and production efforts. Students create strategies that incorporate human factor considerations, software, production and risk in the overall systems engineering process and product lifecycle. This program is targeted for mid- and upper-level engineers working in or in support of the Defense Acquisition System but has great benefit for all who seek further knowledge in the theory and practice of systems engineering.

Convenes

Fall, Winter, Spring, Summer

Program Length

4 Quarters

Requirements for Entry

-Undergraduate degree with minimum 2.6 grade point average.

Prerequisite

- Successful completion of System Engineering Certificate (282).

- A year (two semesters or three quarters) of college calculus.

Upon successful completion of this certificate students will have:

1. Greater knowledge of concepts and principles relevant to four system suitability areas including human factors, reliability, availability, maintainability, systems software, risk analysis and management, or system manufacturing and production.
2. The ability to apply appropriate planning and assessment tools in the context of the human system, software, risk, manufacturing and production or RMA domains.
3. The ability to analyze suitability considerations in reliability, software, human systems, risk, or manufacturing and production and produce design recommendations based on the results.
4. An improved ability to communicate effectively in technical writing and presentations.

Typical Course of Study

Students must complete any four of the following courses:

Course	Title	Lecture	Lab
OS3401/OA3401	Human Factors in System Design	3	1
	-or-		
SE3321	Reliability Management and Data Systems	3	2
	-or-		
SE4003	Systems Software Engineering	3	2
	-or-		
SE4353	Risk Analysis and Management for Engineering Systems	3	2
	-or-		
SE4520	System Manufacturing Development and Production	3	2

Systems Engineering Management Certificate - Curriculum 171 (DL)

Brief Overview

The Department of Systems Engineering offers a four-course academic certificate in Systems Engineering Management (SEM) that enables students to apply systems engineering and management in defense acquisition and system lifecycle support. Integrated product development team members work with systems engineers in both technical and management competency areas requiring skills in effective teamwork and communications, statistical operational analysis, lifecycle cost management, system verification and validation, and manufacturing and production. This program is targeted for mid- and upper-level integrated product team members working in or in support of the Defense Acquisition System but has great benefit for all who seek further knowledge in the theory and practice of systems engineering and the implementation of sound systems engineering management principles within an organization.

Convenes

Fall, Winter, Spring, Summer

Program Length

4 Quarters

Requirements for Entry

Successful completion of System Engineering Certificate (282)

- Understand basics of cost behavior and cost allocation with an emphasis on how cost is used in choosing between alternatives, costs change over the life-cycle of a system, and how cost issues are related to program management. Students will develop life-cycle cost models that incorporate uncertainty into cost estimates and quantify and evaluate cost risk.

- Describe the role of verification and validation (V&V) within systems engineering and throughout the acquisition process, characterize and distinguish the key characteristics of developmental and operational test and evaluation (T&E) as conducted by DoD, and apply statistical tools for evaluating specification compliance and designing experiments. Student will prepare a draft Operational Test input to the Test and Evaluation Master Plan (TEMP) using the Integrated Evaluation Framework (IEF) and demonstrate familiarity with principles and statistical tools of design of experiments (DoE) to develop test scenarios and identify the required resources for tests.

- Describe practical considerations and fundamentals of modeling and simulation (M&S), to include distinctions between live, virtual, and constructive (LVC) simulations and the role of humans in M&S development. Students will create model-based systems engineering (MBSE) compliant system architecture descriptions responsive to capability needs , understand and construct appropriate operational system models and simulations, and conduct M&S assessments appropriate to support system acquisition.

- Understand the principles of production and supply chain management, with emphasis on managing tradeoffs between inventory, production, supply chain, capacity, response time, and variability through mathematical and queueing models. Students will describe the process of quality control, describe the effect of automation on production, and explain the current state of the U.S. Defense Industrial Base and its ability to support future DoD production requirements to include its ability to surge in times of conflict.

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
SE3011	Engineering Economics and Cost Estimation	3	0

Quarter 2

Course	Title	Lecture	Lab
SE4420	Modeling and Simulation in Acquisition	3	2

Quarter 3

Course	Title	Lecture	Lab
SE4354	System Verification and Validation	4	0

Quarter 4

Course	Title	Lecture	Lab
SE4520	System Manufacturing Development and Production	3	2

Systems Engineering and Integration of Naval Weapons Systems Certificate (DL) - Curriculum 174

Brief Overview

The Department of Systems Engineering offers a four-course academic certificate in Systems Engineering and Integration of Naval weapons systems for distance learning (DL) students. The certificate is designed introduce the student to critical weapons concepts that are necessary for enlightened examination of both technology development and military planning. The overall emphasis is on what elements contribute to a combat system, their basic principles of operation, their performance limitations, trade-offs, and their interfaces with the rest of the combat system. The student is introduced to the nature of physical observables and propagators, the effects of the propagation medium on sensor performance, the relationship between signals and noise, and the characteristics of critical sensor functions (including detection, estimation, imaging, and tracking).

With that foundation, students then apply systems engineering principles to understand the design and operation of combat sensor systems. Sensor technologies covered include radars, ESM, active and passive sonar, infrared, and electro-optical sensors. Target engagement topics include the effects that conventional weapons (artillery, bombs, and missiles) can produce as well as the technologies needed by weapons systems to create those effects. Finally, techniques for integrating combat sensor systems and engagement elements into a common platform, including technology development, system development and integration, network integration, and system of systems integration are presented, including engineering analysis of interfaces for power, data, mechanical, and other attributes; engineering change management; advanced collaboration environments; technology readiness levels; and integration risk mitigation.

Convenes

Spring

Program Length

4 Quarters

Requirements for Entry

For entry, the student must have at least a 2.6 undergraduate grade point average (GPA) with a lower-level calculus sequence with a C or better and a calculus-based physics sequence with a B average or above.

After completion of the certificate students will be able to:

- Understand and describe the fundamental physical and operational principles of naval weapon systems, to include sensors, engagement elements (weapons), and C4ISR systems.
- Understand and explain the impact of both the natural and man-made environment on weapon system performance.
- Apply quantitative tools to estimate and assess the performance of naval weapons systems.
- Apply systems engineering principles to the design, integration, and operation of sensors, weapons, and C4ISR systems.
- Understand the considerations, techniques, and trade-offs involved in the integration of multiple sensor systems and engagement elements on a common platform (system of systems).

Certificate Requirements

All students must take:

Course	Title
SE3121	C4ISR Systems
SE3122	Naval Weapons Systems Technology I
SE3123	Naval Weapons Systems Technology II

SE4115   Combat Systems Integration

Systems Engineering Fundamentals Certificate - Curriculum 282

Program Officer

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Brief Overview

The Department of Systems Engineering offers a four-course academic certificate that introduces students to the fundamentals of systems engineering. The four courses are offered in both a resident and DL format.

Convenes

Fall, Spring

Program Length

4 Quarters

Requirements for Entry

Baccalaureate degree with at least a 2.6 undergraduate grade point average (GPA) and at least one college level mathematics course.

After completion of this certificate, students should be able to:

- Apply advanced mathematics including probability and statistics.
- Create basic system functional and physical architectures that represent a balanced approach to meeting stakeholder needs, derived system requirements, and suitability objectives. Understand basic system architecture frameworks and their role in architecture development. Apply basic model-based systems engineering techniques, based on UML or SySML, to create, define, and develop system architectures. Create, analyze, and evaluate alternative architectures against appropriate, system-level evaluation criteria and select the best system design based on quantitative and qualitative analysis.
- Apply the basic system design process in a holistic context to include defining system requirements; conducting functional analysis and allocation to hardware, software, and human elements; designing a system; deriving and defining requirement

specifications; allocating requirement specifications to sub-systems; designing for suitability, including reliability, maintainability, availability, supportability, producibility, usability, survivability, and interoperability; evaluating the system cost and risk; and incorporating risk mitigation strategies.

- Apply basic qualitative and quantitative methods of engineering design analysis to include problem formulation, alternatives development, systems analysis, alternatives comparison, cost analysis, failure analysis, and risk analysis. Mathematical techniques include probabilistic analyses.

- Demonstrate competence in the planning and management of a complex defense-related systems engineering project. Demonstrate an understanding of basic project management principles including project planning, organizational structures, cost estimating, project scheduling, time-phased budgets, earned-value management, risk and configuration management, and contracts.

Certificate Requirements

Mandatory Courses

Students must take the following courses:

Course	Title	Lecture	Lab
SE3100	Fundamentals of Systems Engineering	3	2
SI3400	Fundamentals of Engineering Project Management	3	2
SE3302	System Suitability	3	2

Probability and Statistics

Students pick one course from the following list of courses:

OS3180	Probability and Statistics for Systems Engineering -or-	4	1
OS3111	Probability and Statistics for HSI and MOVES	4	0

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
OS3180	Probability and Statistics for Systems Engineering -or-	4	1
OS3111	Probability and Statistics for HSI and MOVES	4	0

Quarter 2

SE3100	Fundamentals of Systems Engineering	3	2

Quarter 3

SI3400	Fundamentals of Engineering Project Management	3	2

Quarter 4

SE3302	System Suitability	3	2

Systems Engineering Analysis Program - Curriculum 308

This curriculum is described under the Systems Engineering Analysis Curriculum and Program section of this Catalog. The Department of Systems Engineering supports this curriculum with courses, faculty and project advisors.Completion of all the requirements of curriculum 308 leads to the award of either the MSSEA or MSSE degree. Refer to the Systems Engineering Department MSSE or the joint Systems Engineering and Operations Research Department MSSEA program requirements for eligibility.

Educational Skill Requirements

Systems Engineering Analysis Curriculum

Broad Objective

This curriculum teaches U.S. Navy Unrestricted Line Officers how the Navy builds and operates large combat systems of systems. The primary objective is to prepare officers to serve afloat and in key operational staff billets by giving them the technological and analytical understanding to fight the fleet today and in the future. The emphasis is on integration of complex warfare systems with compatible tactics. In addition, graduates with experience afloat will be prepared to serve ashore as program managers and in technical/analytical billets on headquarters staffs.

1. **Basics.** Introduction to the mathematics, physics, and computer skills needed to understand the technical aspects of combat, information, and decision systems.

2. **Systems Engineering.** Understand the systems engineering process and how to perform systems engineering studies, to include a knowledge of system design, development, and deployment; technical and cost trade-offs; human-in-the-loop issues and project management. Be able to integrate relevant technological disciplines that bear on weapons, sensor and information systems. Understand responsiveness to realistic military requirements, specifications and cost limitations. Study the linkage between strategic planning, requirements, project organization, and technology.

3. **Operations Analysis.** Learn how to apply advanced management and operations research ideas to defense problems, to include cost-benefit and cost-effectiveness analysis. Understand uncertainty and risk and their impact on military planning, decision making and operations. Become familiar with complexity and the modeling of competitive systems. Gain a basic knowledge of modeling, simulation and gaming. Learn how Operations Research techniques, including experimental design, are applied to operational test and evaluation; planning and analyzing fleet battle

experiments; and to military decision making.

4. **Sensor and Weapon Systems.** Gain a solid understanding of the scientific, mathematical and engineering principles behind existing and future military systems. Understand the elements that impact sensor system performance. Understand the principles behind existing and emerging sensor technologies, including radar, sonar, electro-optical sensors, and other sensors. Understand the technologies underlying weapons systems, and the principles that guide successful integration of weapons and sensors with platforms.

5. **Information Systems Technology.** Develop knowledge of information systems technology including computer systems; computer networks and communications systems; software engineering; and data base management. Demonstrate awareness of the capabilities, limitations, design and operation, and vulnerabilities of information systems. Understand the concepts of defensive and offensive Information Warfare.

6. **Independent Study.** Each student must demonstrate the ability to conduct independent and team oriented research and analysis on problems that link technical solutions to tactical problems, and to present the results in writing and oral briefings. A substantive project report or thesis will be required of all students.

7. **Department of Defense Resource Allocation.** Develop a working knowledge of resource allocation within the Department of Defense including the PPBE, JCIDS, and Acquisition processes. It is imperative that students understand key issues regarding the scheduling of budget delivery to, and the related interface with Congress, as well as the critical milestones involved in development of the President's Budget. In addition, a working knowledge of the interfaces between PPBE, JCIDS, and Acquisition is necessary to gain an appreciation for the synergies and disconnects between these two processes - and in particular to understanding the manner in which they impact warfighting acquisition programs.

Systems Engineering - Curriculum 311 (DL)

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Brief Overview

The Systems Engineering DL curriculum is designed for Navy System Commands and DoD organizations involved in a wide range of systems engineering and integration challenges. These commands can partner with NPS to educate and train engineers with tools and technologies relevant to their work, resulting in employees with greater knowledge and expertise to enable them to better meet the needs of their customers.

DoD organizations or sponsors provide the students, and the Department of Systems Engineering provides the instruction, course materials, and hands-on experience. Courses are delivered at the students' local sites using a combination of on-site instruction and web-enhanced online courses. The program can begin any academic quarter, depending on student demand.

Students normally take two courses per quarter over a two-year period. There is one foundational course, OS3180, eight core SE courses, one focused SE elective, and a three- course capstone project sequence in the 16-course program.

Students will receive an ABET accredited Master of Science in Systems Engineering or a Master of Science in Engineering Systems, depending on their undergraduate degree.

The Associate Chair for Distance Learning Programs and Outreach will help establish partnership arrangements with other organizations if desired. Additional information on the program can be found at the SE Department website.

Convenes

Fall, Winter, Spring, Summer

Program Length

24 Months

Requirements for Entry

An entering student must possess a Bachelor of Science degree in an engineering or related discipline with at least a 2.6 undergraduate grade-point average, including a college calculus sequence (one year of undergraduate courses - two semesters or three quarters). The minimum APC requirement for entry to this program is 234.

Upon completion of the 311 curriculum, students will be able to

• Model and analyze military operations in the context of achieving needed capability. Apply model-based systems engineering approaches, in accordance with (IAW) the Unified Modeling Language (UML) or the Systems Modeling Language (SysML), and modeling and simulation techniques. Assess legacy systems, emerging technological concepts, and as-yet-to-be-developed concepts into the joint warfighting environment considering technology readiness levels, effectiveness, cost, and risk. Understand the process from identifying warfighting gaps to synthesis of as-yet-to-be-realized

system concepts to meet emerging capability needs. Understand and apply modeling and simulation to include deterministic and stochastic modeling of systems, economic models, cost models, and life-cycle suitability analyses. Demonstrate the ability to develop original discrete-event and continuous run-time simulations.

- Perform system architecting, applying and integrating methods for software, hardware, and human elements. Construct feasible system functional and physical architectures that represent a balanced approach to meeting stakeholder needs and expectations, stated, implied, and derived system requirements, and suitability objectives such as being open, modular, extensible, maintainable, and reusable. Understand system architecture frameworks and their role in architecture development. Use model-based systems engineering techniques IAW the UML or the SysML to create, define, and develop system architectures. Develop, analyze, and compare alternative architectures against appropriate, system-level evaluation criteria. Select the best alternative based on quantitative and\or qualitative analysis.

- Employ the system design process holistically for both software and hardware systems, with particular emphasis on identifying capability needs, defining requirements, conducting functional analysis and function-to-component mapping, creating a system functional design, designing a system, deriving and defining system specifications, allocating system specifications to sub-systems (for hardware, software, and human elements), and designing for suitability. Perform system assessment by conducting cost-benefit analysis, trade-off studies, evaluating system design alternatives against system capability needs expressed as military effectiveness, estimating and analyzing the system risk, integrating human elements into the system design, and analyzing and planning for system test and evaluation.

- Apply core qualitative and quantitative methods of engineering design analysis, to include problem formulation, alternatives development, alternatives modeling and evaluation, alternatives comparison, decision analysis, failure analysis, risk analysis, and futures analysis.

- Apply the core skills of system integration and development to include integrating relevant technological disciplines that bear on the system effectiveness and cost during the system's entire life cycle, while being responsive to realistic military capability needs and warfighting effectiveness, requirements, functions, specifications, and risk. Understand system realization methods and processes, including prototyping and production.

- Incorporate fundamental verification and validation principles to systems development. Apply the core skills of system verification and validation to determine

system effectiveness while being responsive to realistic military capability needs and warfighting effectiveness, requirements, functions, and specifications. Apply test and evaluation methods during the system's entire life cycle using inferential statistics methods, including design of experiments (DOE), hypothesis testing, and analysis of variance (ANOVA).

- Apply a holistic SE design process to design, produce, and test a system solution for a current DoD problem. Demonstrate an understanding of project management principles and competence in the planning and management of complex projects. Understand the principles of and apply current industry approaches and technology to manage systems design, integration, test, and evaluation for large engineering projects.

Typical Course of Study

The typical course of study for curriculum 311 includes the following courses.

Quarter 1

Course	Title	Lecture	Lab
OS3180	Probability and Statistics for Systems Engineering	4	1
SE3050	Introduction to Digital Engineering with Model-Based Systems Engineering	3	2

Quarter 2

Course	Title	Lecture	Lab
SE3011	Engineering Economics and Cost Estimation	3	0
SE3100	Fundamentals of Systems Engineering	3	2

Quarter 3

Course	Title	Lecture	Lab
SI3400	Fundamentals of Engineering Project Management	3	2
SE3250	Capability Engineering	3	2

Quarter 4

Course	Title	Lecture	Lab
SE3302	System Suitability	3	2
SE4354	System Verification and Validation	4	0

Quarter 5

Course	Title	Lecture	Lab
SE4150	Systems Architecting and Design	3	2
ELECT	Advanced SE Elective		

Quarter 6

Course	Title	Lecture	Lab
SE3201	Engineering Systems Conceptualization	2	4
SE4151	Systems Integration and Development	3	2

Quarter 7

Course	Title	Lecture	Lab
SE3202	Engineering Systems Design	2	4

SE4420	Modeling and Simulation in Acquisition	3	2
	-or-		
SE4003	Systems Software Engineering	3	2
Quarter 8			
SE3203	Engineering Systems Implementation & Operation	2	4
SE4930	Model-Based Systems Engineering	3	2

Aviation Systems Engineering – Curriculum 312

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Brief Overview

The objective of this program is to provide graduates of the U.S. Naval Test Pilot School (USNTPS), or equivalent, the opportunity to obtain a Master of Science in Systems Engineering or Master of Science in Engineering Systems with an Aviation Systems specialization leading to a 5804P subspecialty code. The program is delivered by distance learning and builds upon the TPS academic and flight test instruction, with the student's TPS final flight test project and report (DTII) serving in lieu of a thesis, and will provide the advanced systems engineering knowledge, tools and skills necessary for the graduate to be successful as a class desk systems engineer in a Naval Aviation Systems Command (NAVAIR) mission billet.

Convenes

Fall, Spring

Program Length

24 Months

Requirements for Entry

Entrance into the program is restricted to graduates of the U.S. Naval Test Pilot School (USNTPS), or equivalent as approved by the USNTPS Director of Academics. Further requirements include a minimum 2.6 GPA undergraduate degree in engineering or a related science or technology field and completion of a college calculus course. The minimum APC requirements for entry to this program is 234. All entrants will be board selected by NAVAIR and the Director of USNTPS in coordination with the NPS program

academic team. All nominees will be instructed to apply for the program through the NPS online admissions site and to send official transcripts from all undergraduate and graduate institutions attended plus TPS transcripts for determination of academic acceptance.

Credit for Completion of U.S. Naval Test Pilot School

The program is designed to build upon the USNTPS academic instruction and final flight test project and report. USNTPS graduates are given 12 quarter-hours of transfer credit (4 at the 3000-level and 8 at the 4000-level) for the Test Pilot School academic curriculum. Their USNTPS final flight test project and report (DTII) serves in lieu of a thesis and is recorded as 12 quarter credit hours of SE0811.

Credit for Completion of an Approved Test Pilot School other than USNTPS

Graduates from approved TPS programs other than the USNTPS will be given credit towards meeting the 5804P subspecialty code but will not be given academic transfer credits. To meet credit hour degree requirements, these students may either take two additional relevant NPS courses, one of which must be at the 4000 level, or request transfer of relevant graduate level credit hours from another academic institution. Additionally, their final test project and report (equivalent to the USNTPS DTII), or similar seminal academic product from their TPS program must also be assessed and accepted by NPS to serve in lieu of a thesis and is recorded as 12 quarter credit hours of SE0811.

Degrees

Completion of all the requirements of curriculum 312 leads to the award of the MSSE or MSES degree depending on student qualifications. Refer to the MSSE and MSES program requirements for eligibility.

Typical Course of Study

Upon entry into the curriculum students will typically enroll in one course per quarter to be taken via distance learning. All requirements must be completed within three calendar years from entry.

The 312 curriculum course of study is:

- Eight NPS DL courses, which include four systems engineering fundamentals and methods core courses (31 credit hours – see course list below)
- Award of 12 total transfer quarter credit hours for TPS courses equivalent to NPS courses (SE3303, SE4354, and SE4115) toward degree requirements.
- Award of 12 transfer quarter credit hours for the USNTPS Developmental Test – (DTII) or TPS final test project and report in lieu of a thesis or capstone project report and submission of the DTII to the Systems Engineering Department for assessment and acceptance.

A typical course sequence would include:

NPS Courses:

Course	Title	Lecture	Lab
SE3100	Fundamentals of Systems Engineering	3	2
SE3011	Engineering Economics and Cost Estimation	3	0
SE3302	System Suitability	3	2
SI3400	Fundamentals of Engineering Project Management	3	2
SE3250	Capability Engineering	3	2
SE4150	Systems Architecting and Design	3	2
SE4151	Systems Integration and Development	3	2
SE4353	Risk Analysis and Management for Engineering Systems	3	2

Educational Skill Requirements (ESRs)
Systems Engineering- Aviation Systems Specialization Curriculum 312
Subspecialty Code 5804P

Officers entering into the 312 curriculum must be graduates of the U.S. Naval Test Pilot School (USNTPS) curriculum. In the context of systems engineering, the term "systems" shall be used to include both systems and systems-of-systems (SoS). At the graduate level, the officer will acquire the competence to effectively contribute as a systems engineer to naval systems research, design, development, maintenance and acquisition. The officer will gain the ability to effectively integrate future technological, engineering, and acquisition approaches with existing practice through a combination of core systems engineering courses, specialization studies, and project/thesis research. An officer will meet the below-listed ESRs through the completion of a program of study determined by the officer, the program officer and the academic associate. Individual programs and how they support the officer's attainment of the ESRs will be specifically designed to meet the needs of the Navy and the officer's interests.

1. **Capability Engineering.** Model and analyze military operations in the context of achieving needed capability. Apply model-based systems engineering approaches, based on UML or SysML, and modeling and simulation techniques, and be able to assess legacy systems, emerging technological concepts, and as-yet-to-be-developed concepts into the joint war fighting environment considering technology readiness levels, effectiveness, cost, and risk. Understand the process of war fighting gaps to synthesis of as-yet-realized system concepts to meet emerging capability needs. Understand and apply modeling and simulation to include deterministic and stochastic modeling of systems, economic models, cost models, and lifecycle suitability analyses. This includes the ability to develop original discrete-event and continuous run-time simulations, as well some familiarity with large-scale government and commercial war fighting simulations.

2. **System Architecting.** Perform system architecting, applying and integrating methods for both software and hardware aspects. Construct feasible system functional and physical architectures that represent a balanced approach to meeting stakeholder needs and expectations, stated, implied, and derived system requirements, and suitability objectives such as being open, modular, extensible, maintainable, and reusable. Understand system architecture frameworks, including the Department of Defense Architecture Framework (DODAF), and their role in architecture development. Use model-based systems engineering techniques, based on UML or SySML to create, define, and develop system architectures. Develop, analyze, and compare alternative architectures against appropriate, system-level evaluation criteria and select the best based on quantitative and qualitative analysis, as appropriate.

3. **System Design.** Understand and apply the system design process in a holistic context, applying and integrating methods for both software and hardware aspects for manned or unmanned and autonomous systems including identifying needed capabilities, defining requirements, conducting functional analysis and allocation to hardware, software, and human elements, creating a system functional design, designing a system, deriving and defining requirement specifications, allocating requirement specifications to sub-systems (for hardware, software, and human elements), designing for characteristic such as suitability, including reliability, availability, maintainability, interoperability, system security, and logistical supportability. Perform system assessment by conducting trade-off studies, evaluating system design alternatives against system capability need expressed as military effectiveness, estimating and analyzing the system cost and risk, including risk mitigation strategies, integrating human elements into the system design, and analyzing and planning for system testing and evaluation.

4. **Engineering Design Analysis.** Understand and apply core qualitative and quantitative methods of engineering design analysis, to include problem formulation, alternatives development, alternatives modeling and evaluation, alternatives comparison, optimization, decision analysis, failure analysis, risk analysis, and futures analysis. Mathematical techniques may include multiple criteria optimization, design of experiments, response surface methods, set-based design, real options, systems dynamics, and probabilistic analyses.

5. **System Integration and Development.** Apply the core skills of system integration and development to include integrating relevant technological disciplines that bear on the system effectiveness and cost, including system security, weapons, sensor and information systems,

while being responsive to realistic military capability need and war fighting effectiveness, requirements, functions, specifications, cost, and risk. Integrate systems and analyze aspects during the entire lifecycle through aging, life extension and disposal. Understand system realization methods and processes, including prototyping and production.

6. **System Test & Evaluation.** Apply the core skills of system test and evaluation to include system effectiveness while being responsive to realistic military capability need and war fighting effectiveness, requirements, functions, and specifications. Evaluate systems and analyze test and evaluation aspects during the entire life-cycle using inferential statistics methods, including design of experiments (DOE) and analysis of variance (ANOVA). Apply fundamental verification and validation principles to systems development methods. This ESR will be obtained through the US Navy Test Pilot School Curriculum.

7. **Human Systems Integration.** Address human factors during requirements definition, as well as workload, safety, training, operability and ergonomics during design. Conduct functional analysis and allocation to human elements, performing cost risk-effectiveness trade-offs among hardware, software, and human elements. Evaluate proposed designs for man-machine integration, human performance testing and usability during development test and evaluation. This ESR will be obtained through the US Navy Test Pilot School.

8. **Project Management.** Work as a team member or leader on a military systems engineering project. Demonstrate an understanding of project management principles. Demonstrate competence in the planning and management of complex projects. Understand the principles of and apply current industry approaches and technology to manage systems design, integration, test, and evaluation for large engineering projects.

9. **Aviation Systems Specialization.** Demonstrate an understanding of the principles, technologies, and systems used in the aviation systems specialization area. Demonstrate broad understanding of systems context of the specialization. Apply that understanding to the design of system components, sub-systems, and interfaces in the holistic context of the engineering of systems. Relevant course work and/or experience needed to meet the aviation systems specialization ESR can be acquired at accredited graduate level academic institutions, service specific schools such as the U.S. Navy Test Pilot School, on the job experience or a combination of all.

10. **Thesis.** Conduct independent analysis and research in the area of Systems Engineering, and show proficiency in presenting the results in writing and orally by means of a thesis or a Capstone project and command-oriented briefing appropriate to this curriculum. This ESR will be obtained through the DTII Report in the US Navy Test Pilot School Curriculum.

Systems Engineering Management – System Acquisition – Curriculum 522

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Brief Overview

The Systems Engineering Management program is an interdisciplinary program combining systems engineering with acquisition management knowledge and skills. The program is intended to broaden the technical capabilities of officers who may have non-technical backgrounds so they are able to manage and lead acquisition programs for the complex combat systems the DoD needs. Students in this program learn the systems engineering process from establishing system requirements through test and evaluation. Simultaneously students learn how to manage, schedule, and budget programs as well as work with DoD suppliers through contracts to meet program obligations.

Convenes

Winter, Summer

Program Length

18 Months

Requirements for Entry

A baccalaureate degree with above-average grades is required. Completion of at least two semesters of college algebra or trigonometry is considered the minimum mathematical preparation. An APC of 245 is required for entry. International students should refer to the Admissions section for current TOEFL and entrance requirements.

Degree

Completion of all the requirements of curriculum 522 leads to the award of the MSSEM degree. Refer to the MSSEM program requirements for eligibility.

Sponsor

Director, Acquisition Career Management, Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology): ASA/ALT (DACM)

Typical Course of Study
The typical course of study reflects the Army Acquisition Officer sequence of courses to meet desire for JPME and qualification for DAWIA in

Project Management, Contracting, and Systems Engineering. Other students may work with the academic associate to develop an alternative course of study adhering to the MSSEM degree requirements.

Quarter 1

Course	Title	Lecture	Lab
MN3331	Principles of Acquisition and Program Management	5	1
MN3303	Principles of Acquisition and Contract Management	4	0
OS3111	Probability and Statistics for HSI and MOVES	4	0
NW3275	Joint Maritime Operations - part 1	4	0

Quarter 2

SE3100	Fundamentals of Systems Engineering	3	2
OA3411	Introduction to Human Systems Integration	3	0
MN3312	Government Contracts Law	4	0
NW3276	Joint Maritime Operations - part 2	2	2
MN3384	Acquisition Production, Quality and Manufacturing Decision Science	3	2

Quarter 3

SI3400	Fundamentals of Engineering Project Management	3	2
SE3011	Engineering Economics and Cost Estimation	3	0
MN3320	Contract Cost and Price Analysis	3	0
MN3321	Federal Contract Negotiations	3	0
NW3285	Theater Security Decision Making	4	0

Quarter 4

SE3302	System Suitability	3	2
SE3077	Methods in Engineering Research	3	0
SE4003	Systems Software Engineering	3	2
SE4150	Systems Architecting and Design	3	2
MN3309	Software Acquisition Management for Defense Systems	3	2

MN4470	Strategic Planning and Policy for the Acquisition Logistics Manager	4	0

Quarter 5

SE3211	Systems Engineering Management Capstone I	2	4
SE4354	System Verification and Validation	4	0
SE4520	System Manufacturing Development and Production	3	2
NW3230	Strategy & War	4	2

Quarter 6

SE3212	Systems Engineering Management Capstone II	2	4
SE4012	Management of Advanced Systems Engineering	4	0
MN4307	Defense Acquisition Program Management Case Studies	4	0

Educational Skill Requirements (ESRs)
Systems Acquisition Management - Curriculum 522

1. **System Engineering Management:** The graduate will have an understanding of the systems engineering process, and be able to contribute to the definition of system requirements, evaluation of system architecture, verification and validation activities, system integration, and system design in the context of defense system acquisition.

2. **System Architecting:** Perform system architecting, applying and integrating methods for both software and hardware aspects. Construct feasible system functional and physical architectures that represent a balanced approach to meeting stakeholder needs and expectations, stated, implied, and derived system requirements, and suitability objectives such as being open, modular, extensible, maintainable, and reusable. Understand system architecture frameworks, including the Department of Defense Architecture Framework (DODAF), and their role in architecture development. Use model-based systems engineering techniques, based on UML or SySML to create, define, and develop system architectures. Develop, analyze, and compare alternative architectures against appropriate, system-level evaluation criteria and select the best based on quantitative and qualitative analysis, as appropriate.

3. **System Design:** Understand and apply the system design process in a holistic context, applying and integrating methods for both software and hardware aspects for manned or unmanned and autonomous systems including identifying needed capabilities, defining requirements, conducting functional analysis and allocation to hardware, software, and human elements, creating a system functional design, designing a system, deriving and defining requirement

specifications, allocating requirement specifications to sub-systems (for hardware, software, and human elements), designing for characteristic such as suitability, including reliability, availability, maintainability, interoperability, system security, and logistical supportability. Perform system assessment by conducting trade-off studies, evaluating system design alternatives against system capability need expressed as military effectiveness, estimating and analyzing the system cost and risk, including risk mitigation strategies, integrating human elements into the system design, and analyzing and planning for system testing and evaluation.

4. **Human Systems Integration:** Address human factors during requirements definition, as well as workload, safety, training, operability and ergonomics during design. Conduct functional analysis and allocation to human elements, performing cost risk-effectiveness trade-offs among hardware, software, and human elements. Evaluate proposed designs for man-machine integration, human performance testing and usability during development test and evaluation.

5. **Project Management:** Work as a team member or leader on a military systems engineering project. Demonstrate an understanding of project management principles. Demonstrate competence in the planning and management of complex projects. Understand the principles of and apply current industry approaches and technology to manage systems design, integration, test, and evaluation for large engineering projects.

6. **System Test & Evaluation:** Apply the core skills of system test and evaluation to include system effectiveness while being responsive to realistic military capability need and war fighting effectiveness, requirements, functions, and specifications. Evaluate systems and analyze test and evaluation aspects during the entire life-cycle using inferential statistics methods, including design of experiments (DOE) and analysis of variance (ANOVA). Apply fundamental verification and validation principles to systems development methods.

7. **Program Leadership and Management Principles:** The graduate will have an understanding of and will be able to apply the principles, concepts, and techniques of Program Leadership and Program Management to the acquisition of major defense weapon systems. This includes the principles of risk management and tradeoff decision analysis using Total Ownership Cost, schedule and performance dynamics from a total life cycle management perspective.

8. **Program and Contract Management Policies:** The graduate will have an ability to formulate and execute defense acquisition policies, strategies, plans and procedures; an understanding of the policy-making roles of various federal agencies of the executive, legislative and judicial branches of the U.S. government, particularly the Department of Defense (DoD), the General Accounting Office (GAO),

congressional committees, the Office of Management and Budget (OMB); the federal and military contracting offices, the Boards of Contract Appeals, and the court system; and an understanding of the strategies necessary to influence policy development and implementation.

9. **Systems and Acquisition Process:** The graduate will understand the theory of and have an ability to lead program teams and manage the systems acquisition process. This involves the system life cycle process for requirements determination, research and development, funding and budgeting, procurement, systems engineering, including systems of systems, and applying the system design process in a holistic context, integrating methods for both software and hardware aspects for manned, unmanned and autonomous systems including identifying needed capabilities, defining requirements, conducting functional analysis and allocation to hardware, software, and human elements, creating a system functional design, test and evaluation, including its role in Systems Acquisition, DT and OT test planning, design, and conduct of tests, spanning live fire testing, modeling and simulation, and human systems integration, manufacturing and quality control, integrated logistics support, ownership and disposal; the interrelationship between reliability, maintainability and logistics support as an element of system effectiveness in defense system/equipment design; and embedded weapons system software, particularly related to current policies and standards, software metrics, risk management, inspections, testing, integration, and post-deployment software support.

10. **Contract Management:** The graduate will understand the role of the contracting process within the acquisition environment, including financial, legal, statutory, technical, and managerial constraints in the process. They will have knowledge of acquisition laws and regulations, particularly the Federal Acquisition Regulation (FAR) and the DoD FAR Supplement (DFARS); and the application of sound business principles and practices to defense contracting problems in order to be able to apply innovative and creative approaches to re-solve difficult acquisition and contracting issues.

11. **Business Theory and Practices:** The graduate will have an understanding of the business and operating philosophies, concepts, practices and methodologies of defense industry with regard to major weapon systems acquisition, particularly the application of sound business practices.

12. **Ethics and Standards of Conduct:** The graduate will have an ability to manage and provide leadership in the ethical considerations of defense acquisition, including the provisions of procurement integrity, and to appropriately apply defense acquisition standards of conduct.

Systems Engineering - Curriculum 580

Program Officer

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Brief Overview

Systems Engineering at NPS provides a broad education in systems engineering methods and tools, and depth in a particular domain of application. Several domain tracks are offered, including combat systems engineering, ship systems engineering, and network-centric systems engineering. Other tracks are added, based on sponsor and student demand. The tracks consist of seven or more courses to gain depth in the domain area. These tracks complement the standard set of systems engineering courses. The curriculum is interdisciplinary and draws on courses from across campus.

Students come from the uniformed services, civilian members of government, and from foreign military services. Navy Engineering Duty Officers constitute a substantial portion of the students.

Convenes

Fall, Spring

Program Length

21 Months

Subspecialty

Completion of this curriculum qualifies a naval officer as a systems engineering sub-specialist, subspecialty code 5800. The curriculum sponsor is the Director, Strategic Systems Program (SSP).

Requirements for Entry

Students must have an academic profile code of 234, which implies a 2.2 or better undergraduate GPA, a calculus sequence with a C+ or better grade, and a calculus-based physics sequence with a C+ or better grade.

Degree

Completion of all the requirements of curriculum 580 leads to the award of the MSSE or MSES degree. Refer to the MSSE or MSES program requirements for eligibility.

Typical Course of Study

Students have a wide set of options for their specialization tracks. Below is a typical course matrix for the ship systems track.

Refresher Quarter

Quarter 1

Course	Title	Lecture	Lab
OS3180	Probability and Statistics for Systems Engineering	4	1
SE3100	Fundamentals of Systems Engineering	3	2
AE2440	Introduction to Scientific Programming	3	2
SE3112	Combat Systems Engineering I- Intro to Sensors	4	2
SE3811	Critical Thinking in Systems Engineering	2	0

Quarter 2

Course	Title	Lecture	Lab
SI3400	Fundamentals of Engineering Project Management	3	2
SE3250	Capability Engineering	3	2
SE3810	Systems Engineering Seminar	0	2
SE3011	Engineering Economics and Cost Estimation	3	0
SE4112	Combat Systems Engineering III	4	2

Quarter 3

Course	Title	Lecture	Lab
SE4150	Systems Architecting and Design	3	2
SE3302	System Suitability	3	2
SE3121	C4ISR Systems	3	2
SE3113	Combat Systems Engineering II- Conventional Weapons	4	2

Quarter 4

Course	Title	Lecture	Lab
SE3201	Engineering Systems Conceptualization	2	4
SE4115	Combat Systems Integration	4	2
OA4603	Test and Evaluation	4	0
ELECT	Advanced SE Elective		

Quarter 5

Course	Title	Lecture	Lab
SE3202	Engineering Systems Design	2	4
SE0811	Thesis in Systems Engineering	0	8
SE4113	Combat Systems Engineering IV- Unconventional Weapons	3	2
OS4680	Naval Systems Analysis	4	0
SE3000	Systems Engineering Colloquium	1	0

Quarter 6

Course	Title	Lecture	Lab
SE0811	Thesis in Systems Engineering	0	8

SE3203	Engineering Systems Implementation & Operation	2	4
EO2701	Introduction to Cyber Systems	4	2
SE3000	Systems Engineering Colloquium	1	0

Quarter 7

ELECT	Advanced SE Elective		
SE0811	Thesis in Systems Engineering	0	8
ELECT	Track Elective		
SE3000	Systems Engineering Colloquium	1	0
ELECT	General Elective		

Educational Skill Requirements
Systems Engineering Curriculum 580
Subspecialty Code 5800P

Officers entering the Systems Engineering curriculum will be offered the necessary preparatory-level courses to satisfy the equivalent of a baccalaureate degree in engineering. They shall meet, as a minimum, the requirements set forth by the Engineering Accreditation Commission of ABET. At the graduate level, the officer will acquire the competence to effectively contribute as a systems engineer to naval systems research, design, development, maintenance and acquisition. The officer will gain the ability to effectively integrate future technological, engineering, and acquisition approaches with existing practice through a combination of core systems engineering courses, specialization studies, and project/thesis research. An officer will meet the below-listed ESRs through the completion of a program of study determined by the officer, the Program Officer, and the Academic Associate. Individual programs, and how they support the officer's attainment of the ESRs, will be specifically designed to meet the needs of the Navy and the officer's interests.

1. **Undergraduate Mathematics and Basic Sciences:** Understand and apply engineering-baccalaureate-equivalent mathematics and basic sciences. For mathematics, this includes single- and multi-variable differential and integral calculus, ordinary differential equations, probability, and statistics. Basic sciences include physics, chemistry, and terrestrial sciences. This can be met by the appropriate undergraduate work.

2. **Capability Engineering:** Model and analyze military operations in the context of achieving needed capability. Apply model-based systems engineering approaches, based on UML or SysML, and modeling and simulation techniques, and be able to assess legacy systems, emerging technological concepts, and as-yet-to-be-developed concepts into the joint warfighting environment considering technology readiness levels, effectiveness, cost, and risk. Understand the process of warfighting gaps to synthesis of as-yet-realized system

concepts to meet emerging capability needs. Understand and apply modeling and simulation to include deterministic and stochastic modeling of systems, economic models, cost models, and life-cycle suitability analyses. This includes the ability to develop original discrete-event and continuous run-time simulations, as well some familiarity with large-scale government and commercial warfighting simulations.

3. **System Architecting:** Perform system architecting, applying and integrating methods for both software and hardware aspects. Construct feasible system functional and physical architectures that represent a balanced approach to meeting stakeholder needs and expectations, stated, implied, and derived system requirements, and suitability objectives such as being open, modular, extensible, maintainable, and reusable. Understand system architecture frameworks and their role in architecture development. Use model-based systems engineering techniques, based on UML or SySML to create, define, and develop system architectures. Develop, analyze, and compare alternative architectures against appropriate, system-level evaluation criteria and select the best based on quantitative and qualitative analysis, as appropriate.

4. **System Design:** Understand and apply the system design process in a holistic context, applying and integrating methods for both software and hardware aspects including identifying capability need, defining requirements, conducting functional analysis and allocation to hardware, software, and human elements, creating a system functional design, designing a system, deriving and defining requirement specifications, allocating requirement specifications to sub-systems (for hardware, software, and human elements), design for suitability, including reliability, availability, maintainability, operability, and logistical supportability, perform system assessment by conducting trade-off studies, evaluating system design alternatives against system capability need expressed as military effectiveness, estimating and analyzing the system cost and risk, including risk mitigation strategies, integrating human elements into the system design, and analyzing and planning for system testing and evaluation.

5. **Engineering Design Analysis:** Understand and apply core qualitative and quantitative methods of engineering design analysis, to include problem formulation, alternatives development, alternatives modeling and evaluation, alternatives comparison, optimization, decision analysis, failure analysis, risk analysis, and futures analysis. Mathematical techniques may include multiple criteria optimization, design of experiments, response surface methods, set-based design, real options, systems dynamics, and probabilistic analyses.

6. **System Integration and Development:** Apply the core skills of system integration and development to include

integrating relevant technological disciplines that bear on the system effectiveness and cost, including weapons, sensor and information systems, while being responsive to realistic military capability need and warfighting effectiveness, requirements, functions, specifications, cost, and risk. Integrate systems and analyze aspects during the entire life-cycle. Understand system realization methods and processes, including prototyping and production. Apply production quality methods for continuous process improvement, such as statistical process control, lean, and six sigma.

7. **System Test & Evaluation:** Apply the core skills of system test and evaluation to include system effectiveness while being responsive to realistic military capability need and warfighting effectiveness, requirements, functions, and specifications. Evaluate systems and analyze test and evaluation aspects during the entire life-cycle using inferential statistics methods, including design of experiments (DOE) and analysis of variance (ANOVA). Apply fundamental verification and validation principles to systems development methods.

8. **Human Systems Integration:** Address human factors during requirements definition, as well as workload, safety, training, operability and ergonomics during design. Conduct functional analysis and allocation to human elements, performing cost-risk-effectiveness trade-offs among hardware, software, and human elements. Evaluate proposed designs for man-machine integration, human performance testing, and usability during development test and evaluation. Understand basic human biology as applied to human systems.

9. **Project Management:** Work as a team member or leader on a military systems engineering project. Demonstrate an understanding of project management principles. Demonstrate competence in the planning and management of complex projects. Understand the principles of and apply current industry approaches and technology to manage systems design, integration, test, and evaluation for large engineering projects.

10. **Specialization:** Demonstrate in-depth understanding of the principles, technologies, and systems used in at least one major specialty area. These areas can be specific warfare areas, such as combat systems, total ship systems, EW, IW, avionics, undersea warfare, or net-centric systems, a single traditional engineering specialty, such as mechanical, electrical, software, aerospace engineering, or naval architecture, or specialized disciplines such as human factors, availability, or safety. Demonstrate in-depth understanding of the scientific and engineering principles of the respective specialty, such as sensors, weapons, C4I systems, information systems, ship structures, hydrodynamics, power systems, and reliability. Demonstrate broad understanding of systems context of the specialization. Apply that understanding to the design of system components, sub-systems, and interfaces in the holistic context of

the engineering of systems.

11. **Cyber*:** Understand and apply the fundamentals of the underlying principles of cyber infrastructure and systems; inherent vulnerabilities and threats, including industrial control systems; and defensive security procedures. (*ESR required for 14XX designators only)

12. **Thesis:** Conduct independent analysis and research in the area of Systems Engineering, and show proficiency in presenting the results in writing and orally by means of a thesis and command-oriented briefing appropriate to this curriculum.

Systems Engineering PhD - Curriculum 581/582 (Res and DL)

Program Officer

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Brief Overview

The Department of Systems Engineering offers a Doctor of Philosophy (Ph.D.) degree in Systems Engineering. Students take graduate level courses in systems engineering (as needed to pass the oral and written qualifying examinations), advanced graduate courses in systems engineering and an application domain, and perform research that leads to a dissertation involving some aspect of systems engineering. Research topics may be selected from a broad variety of studies of the systems engineering process, applications of systems engineering to solving complex problems, systems level modeling and simulation, and systems suitability assessment. Subject to approval of the student's dissertation committee chairman, dissertation research may be conducted away from NPS at cooperating facilities. Students must satisfy a one-year residency requirement. This may be met by completing periodic extended stays (nominally two weeks per quarter) at an NPS campus spread throughout the duration of the student's program.

Ideally, applicants should possess an M.S. degree in Systems Engineering. Applicants with only a B. S. degree or an M.S. degree in another discipline will be required to take a number of systems engineering courses (equivalent to the coursework portion of an MSSE degree program) to pass the qualifying examinations. Unless an M.S. thesis and any other ABET EAC accreditation requirements are also satisfied, an M.S. in Systems Engineering degree will not be awarded for this preparatory work.

Systems Engineering Management / Product Development - Curriculum 721 (DL)

Program Officer

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Brief Overview

The Naval Postgraduate School (NPS), as a partner in the Massachusetts Institute of Technology's (MIT) "Educational Consortium for Product Development Leadership in the 21st Century" (PD21), is delivering a joint executive systems engineering management degree using distance learning methods to military officers, senior enlisted, federal civilians, and a limited number of defense contractor civilians. The program's joint focus is on joint services, joint engineering-management and joint government-industry. The executive SEM-PD21 degree program is modeled after the graduate program developed jointly by MIT's School of Engineering and Sloan School of Management. The executive SEM-PD21 degree program is designed to produce a cadre of change agents skilled in engineering and management to bring about dramatic improvements in the way American corporations and the defense industry develop and build new systems and products.

Participants in this unique program are exposed to state-of-the-art concepts and tools, as well as world-class companies, leaders, and cross-industry best practices. Students acquire the basic skills and strategic perspective necessary to become future leaders and senior managers responsible for driving product development and business growth through innovation and to become effective change agents at their organizations. They develop a mindset receptive to change and continuous improvement, an understanding of the enablers to business success, and an enhanced ability to recognize barriers to success early in the product development cycle when corrective actions are least costly.

The SEM-PD21 curriculum is an eight-quarter distance learning curriculum with entry in the Fall quarter, which begins in late September with an on-site two-week kickoff at NPS in Monterey, CA. After the kickoff, classes are taken at students' locations by web teleconferencing or online web-based courses. Students are expected to participate in two or three industry trips during the two-year course of study and a graduation ceremony in Monterey at the completion of the program. There will also be occasional Systems Engineering and Product

Development seminars for all SEM-PD21 students within their existing course of study. **SEM-PD21 website:** www.nps.edu/DL

Convenes

Fall

Program Length

24 Months

Subspecialty

5000P

Requirements for Entry

For admission into the PD-21 program, the student must hold an undergraduate degree in engineering, a related scientific or technical field, with high academic achievement. The student must be sponsored by an organization committed to supporting the student's full participation and have at least five years of experience directly related to product development (three years if student holds a master's degree). The application requirements can be found at the joint executive SEM-PD21 website at: www.nps.edu/DL.

Degree

Completion of all the requirements of curriculum 721 leads to the award of the MSSEM degree. Refer to the MSSEM program requirements for eligibility.

Graduates also earn an MIT certificate signed by Dean of the MIT Sloan School of Management and Dean of the MIT School of Engineering.

Students enrolled in curriculum 721 can optionally be awarded the MSPD degree. Refer to the MSPD program requirements for eligibility.

Curriculum Sponsors

Any federal organization or defense contractor can sponsor students into the SEM-PD21 program. In addition to earning a master's degree, the curriculum satisfies the mandatory Defense Acquisition University (DAU) Systems Planning, Research, Development, and Engineering (SPRDE) course requirements of the Defense Acquisition Workforce Improvement Act (DAWIA) through Level III. Students who select the Systems Acquisition elective track also earn mandatory DAU course requirements for Program Management through Level III. The other elective tracks offer additional NPS certificates in Space Systems, Information Systems, Software Engineering, and Advanced Systems Engineering. Students who complete the program also earn a MIT certificate of recognition.

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
SE3810	Systems Engineering Seminar	0	2
	-or-		

Course	Title	Lecture	Lab
MN3108	Leadership in Product Development	3	2
MN3117	Organizational Processes	4	0
SE3810	Systems Engineering Seminar	0	2
Quarter 2			
MN3145	Marketing Management	4	0
SI4021	Systems Engineering for Product Development	4	0
SE3810	Systems Engineering Seminar	0	2
Quarter 3			
ME4702	Engineering Systems Risk Benefit Analysis -or-	3	2
OS4010	Engineering Risk Benefit Analysis	3	2
SI4022	Systems Architecture for Product Development	4	0
SE3810	Systems Engineering Seminar	0	2
Quarter 4			
MN3392	Systems and Project Management	4	0
MN3156	Financial and Managerial Accounting	4	0
SE3810	Systems Engineering Seminar	0	2
Quarter 5			
OS3211	Systems Optimization	4	0
ELECT	MGMT/ENG Elective		
SE3810	Systems Engineering Seminar	0	2
Quarter 6			
MN4379	Operations Management	4	0
ELECT	MGMT/ENG Elective		
SE3810	Systems Engineering Seminar	0	2
Quarter 7			
SE0811	Thesis in Systems Engineering	0	8
ELECT	MGMT/ENG Elective		
SE3810	Systems Engineering Seminar	0	2
Quarter 8			
SE0811	Thesis in Systems Engineering	0	8
ELECT	MGMT/ENG Elective		
SE3810	Systems Engineering Seminar	0	2

* First quarter SE3810 Includes a Probabilities refresher course

(Note: Seminar used throughout program but credits given final quarter)

Elective Tracks

Sponsors and students have great flexibility in designing their elective structure. Currently, there are numerous specified elective tracks that, when taken with SEM-PD21 core courses, earn participating students additional academic certifications. See program announcement for specific elective options. A tailored elective track can be designed by contacting the Program Officer or Academic Associate.

Systems Engineering Management / Systems and Program Management - Curriculum 722 (DL)

Program Officer

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Brief Overview

The Systems Engineering Management program is an interdisciplinary program combining systems engineering with program management knowledge and skills. The program is intended to broaden the technical capabilities of the acquisition workforce who may have less technical backgrounds so they are able to successfully manage and lead programs/projects in support of the Defense Acquisition System. Students in this program learn the systems engineering process from establishing system requirements through verification and validation. Simultaneously students learn how to manage, schedule, and budget programs as well as work with DoD suppliers through contracts to meet program obligations.

Convenes

Fall

Program Length

24 Months

Requirements for Entry

Candidates for the program must have a baccalaureate degree with a minimum undergraduate GPA of 2.6, and at least one college level mathematics course.

Degree

Completion of this curriculum leads to award of the

MSSEM degree. Refer to the MSSEM program requirements for eligibility.

1.System Engineering Management: The graduate will have an understanding of the systems engineering process, and be able to contribute to the definition of system requirements, evaluation of system architecture, verification and validation activities, system integration, and system design in the context of defense system acquisition.

2.System Architecting and Design: Perform system architecting, applying and integrating methods to construct feasible system functional and physical architectures that represent a balanced approach to meeting stakeholder needs and expectations, stated, implied, and derived system requirements, and suitability objectives such as being open, modular, extensible, maintainable, and reusable. Understand system architecture frameworks, including the Department of Defense Architecture Framework (DODAF), and their role in architecture development. Use model-based systems engineering techniques, based on UML or SySML to create, define, and develop system architectures. Develop, analyze, and compare alternative architectures against appropriate, system-level evaluation criteria and select the best based on quantitative and qualitative analysis, as appropriate. Understand and apply the system design process in a holistic context, defining requirements, conducting functional analysis, creating a system functional design, designing a system, and deriving and defining requirement specifications. Perform system assessment by conducting trade-off studies, evaluating system design alternatives against system capability need expressed as military effectiveness, estimating and analyzing the system cost and risk, and analyzing and planning for system testing and evaluation.

3.Project Management: Work as a team member or leader on a military systems engineering project. Demonstrate an understanding of project management principles. Demonstrate competence in the planning and management of complex projects. Understand the principles of and apply current industry approaches and technology to manage systems design, integration, test, and evaluation for large engineering projects.

4.Verification and Validation: Apply the core skills of system test and evaluation to include system effectiveness while being responsive to realistic military capability need and war fighting effectiveness, requirements, functions, and specifications. Evaluate systems and analyze test and evaluation aspects during the entire life-cycle using inferential statistics methods, including design of experiments (DOE) and analysis of variance (ANOVA). Apply fundamental verification and validation principles to systems development methods.

5.Program Leadership and Management Principles: The graduate will have an understanding of and will be able to apply the principles, concepts, and techniques of Program Leadership and Program Management to the acquisition of major defense weapon systems. This includes the principles of risk management and tradeoff decision analysis using Total Ownership Cost, schedule and performance dynamics from a total life cycle management perspective.

6.Program and Contract Management Policies: The graduate will have an ability to formulate and execute defense acquisition policies, strategies, plans and procedures; an understanding of the policy-making roles of various federal agencies of the executive, legislative and judicial branches of the U.S. government, particularly the Department of Defense (DoD), the General Accounting Office (GAO), congressional committees, the Office of Management and Budget (OMB); the federal and military contracting offices, the Boards of Contract Appeals, and the court system; and an understanding of the strategies necessary to influence policy development and implementation.

7.Systems and Acquisition Process: The graduate will understand the theory of and have an ability to lead program teams and manage the systems acquisition process. This involves the system life cycle process for requirements determination, research and development, funding and budgeting, procurement, systems engineering, including systems of systems, and applying the system design process in a holistic context, integrating methods for both software and hardware aspects for manned, unmanned and autonomous systems including identifying needed capabilities, defining requirements, conducting functional analysis and allocation to hardware, software, and human elements, creating a system functional design, test and evaluation, including its role in Systems Acquisition, DT and OT test planning, design, and conduct of tests, spanning live fire testing, modeling and simulation, and human systems integration, manufacturing and quality control, integrated logistics support, ownership and disposal; the interrelationship between reliability, maintainability and logistics support as an element of system effectiveness in defense system/equipment design; and embedded weapons system software, particularly related to current policies and standards, software metrics, risk management, inspections, testing, integration, and post-deployment software support.

8.Contract Management: The graduate will understand the role of the contracting process within the acquisition environment, including financial, legal, statutory, technical, and managerial constraints in the process. They will have knowledge of acquisition laws and regulations, particularly the Federal Acquisition Regulation (FAR) and the DoD FAR Supplement (DFARS); and the application of sound business principles and practices to defense contracting problems in order to be able to apply innovative and creative approaches to re-solve difficult acquisition and contracting issues.

9.Business Theory and Practices: The graduate will have an understanding of the business and operating philosophies, concepts, practices and methodologies of defense industry with regard to major weapon systems acquisition, particularly the application of sound business practices.

10.Ethics and Standards of Conduct: The graduate will have an ability to manage and provide leadership in the ethical considerations of defense acquisition, including the provisions of procurement integrity, and to appropriately apply defense acquisition standards of conduct.

Fall

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
OS3111	Probability and Statistics for HSI and MOVES	4	0
MN3301	Acquisition of Defense Systems	4	0

Quarter 2

SE3100	Fundamentals of Systems Engineering	3	2
MN3384	Acquisition Production, Quality and Manufacturing Decision Science	3	2

Quarter 3

SI3400	Fundamentals of Engineering Project Management	3	2
MN4470	Strategic Planning and Policy for the Acquisition Logistics Manager	4	0

Quarter 4

SE3302	System Suitability	3	2
MN4307	Defense Acquisition Program Management Case Studies	4	0

Quarter 5

SE3011	Engineering Economics and Cost Estimation	3	0
SE3050	Introduction to Digital Engineering with Model-Based Systems Engineering	3	2

Quarter 6

SE4420	Modeling and Simulation in Acquisition	3	2
MN3303	Principles of Acquisition and Contract Management	4	0

Quarter 7

SE4354	System Verification and Validation	4	0
SE3211	Systems Engineering Management Capstone I	2	4

Quarter 8

SE4520	System Manufacturing Development and Production	3	2
SE3212	Systems Engineering Management Capstone II	2	4

Groups and Committees

Cyber Academic Group

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David L. Alderson, Associate Professor (2006), Ph.D., Stanford University, 2003.

John Arquilla, Distinguished Professor Emeritus (1993), Ph.D., Stanford University, 1991.

Kathryn Aten, Associate Professor (2010), Ph.D., University of Oregon, 2009.

Dan Boger, Professor Emeritus (1979), Ph.D., University of California at Berkeley, 1979.

Alex Bordetsky, Chair, Department of Information Sciences, Ph.D., Chelyabinsk State Technical University of Russia, 1982.

Chad Bollmann, CDR, USN, Director Center for Cyber Warfare and Assistant Professor (2018), Ph.D., Naval Postgraduate School, 2018.

Douglas Brinkley, Senior Lecturer (1998), Ed.D., Nova Southeastern University, 2003.

Raymond J. Buettner, Jr., Associate Professor (1999), Ph.D., Stanford University, 2003.

David Canright, Associate Professor (1988), Ph.D., University of California, Berkeley, 1987.

Richard S. Cote, Senior Lecturer (2001), M.S., Naval Postgraduate School, 2000.

Rudy Darken, Professor (1996), Ph.D., George Washington University, 1995.

Duane T. Davis, Senior Lecturer (2012), Ph.D., Naval Postgraduate School, 2006.

Dorothy Denning, Emeritus Distinguished Professor (2002), Ph.D., Purdue University, 1975.

Peter Denning, Distinguished Professor (2002), Ph.D., Massachusetts Institute of Technology, 1968.

George Dinolt, Professor of Practice, Director, Center for Cyber Warfare (2002), Ph.D., University of Wisconsin at Madison, 1971.

Chris Eagle, Senior Lecturer (1997), M.S., Naval Postgraduate School, 1995.

Nelson Emmons, M.S., U.S. Military Academy, West Point, NY, 1997 and 2013.

Christian Fitzpatrick, Faculty Associate for Research (2018), M.S., Naval Postgraduate School, 2009.

Douglas Fouts, Chair, Department of Electrical and Computer Engineering and Professor (1990), Ph.D., University of California at Santa Barbara, 1990.

John D. (JD) Fulp, Senior Lecturer (2001), M.S., Naval Postgraduate School, 1996.

Shelley P. Gallup, Research Associate Professor (1999), Ph.D., Old Dominion University, 1998.

V. Bob Garza, Lecturer, M.S., Golden Gate University, 2000.

Britta Hale, Assistant Professor (2018), Ph.D., Norwegian University of Science and Technology, 2017.

Ted Huffmire, Associate Professor (2007), Ph.D., University of California at Santa Barbara, 2007.

Wade Lee Huntley, Senior Lecturer (2009), Ph.D., University of California at Berkley, 1993.

Cynthia E. Irvine, Distinguished Professor (1994), Ph.D., Case Western Reserve University, 1975.

Scott E. Jasper, Lecturer (2002), Ph.D., University of Reading, 2018.

Raymond Jones, COL, USA (Ret.), Lecturer (2012), M.A., Industrial College of the Armed Forces, 2003.

Thor Martinsen, CDR, USN, Assistant Professor (2012), Ph.D., Naval Postgraduate School, 2017.

Randy Maule, Visiting Associate Professor (2003), Ph.D., University of Florida, 1987.

John McEachen, Distinguished Professor (1996), Ph.D., Yale University, 1995.

J. Vinnie Monaco, Assistant Professor (2018), Ph.D., Pace University, 2015.

Luqi, Professor (1986), Ph.D., University of Minnesota, 1986.

Thuy Nguyen, Faculty Associate-Research (2002), B.A., University of California at San Diego, 1982.

Walter Owen, Associate Chair for Distributed Programs & Outreach, Dept. of Systems Engineering (1995), Ph.D., Golden Gate University.

Charles Prince, Faculty Associate — Research, B.S., Oregon State University, 1993.

Craig Rasmussen, Emeritus Professor (1991), Ph.D., University of Colorado at Denver, 1990.

Mark Rhoades, Senior Lecturer (2001), M.S., Naval Postgraduate School, 2006.

Clark Robertson, Professor (1992), Ph.D., University of Texas at Austin, 1983.

John Roth, Assistant Professor (2017), Ph.D., Naval Postgraduate School, 2016.

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Michael Senft, LTC USA, Instructor (2019), M.S., Naval Postgraduate School, 2015.

Alan Shaffer, Senior Lecturer (2008), Ph.D., Naval Postgraduate School, 2008.

Gurminder Singh, Chair, Department of Computer Science (2002), Ph.D., University of Alberta, 1989.

Keith Snider, Professor (1993), Ph.D., Virginia Polytechnic Institute and State University, 1997.

Pantelimon Stanica, Professor (2006), Ph.D., State University of New York at Buffalo, 1998.

Preetha Thulasiraman, Assistant Professor (2012), Ph.D., University of Waterloo, Ontario, Canada, 2010.

Brief Overview

Cyberspace is now a primary warfare area. Establishing US Tenth Fleet/Fleet Cyber Command, combined with the Deputy Chief of Naval Operations for Information Dominance (N2N6) forms an enterprise able to address the opportunities and challenges for Cyber Systems and Operations (CSO) within the Navy's vision for the Information Dominance Corps (IDC). Reflecting a growing cognizance of the importance of cyber operations, other elements of the U.S. military and U.S. Government, such as the Department of Homeland Security, have created similar or complementary organizations. Optimization of the military and U.S. Government value of cyber for future operations will require leaders who both understand how to defend our networks from penetration and employ cyber capabilities to ensure an advantage in future operations. Essential to this objective is a cadre of officers able to address the broad range of cyber operations: computer network attack, defense, and exploitation; cyber analysis, operations, planning and engineering; and cyber intelligence operations and analysis.

The Cyber Academic Group (CAG) is an association of faculty and academic professorships representing different academic disciplines. Established by the Naval Postgraduate School (NPS) on 23 September 2011, the Cyber Academic Group has responsibility for oversight and management of interdisciplinary education and research programs.

Cyber Systems and Operations (CSO) - Curriculum 326

Program Officer

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Brief Overview

The CSO curriculum uniquely prepares Officers with the educational background, problem solving, and critical thinking skills to serve in challenging Cyberspace Operations and Cyber Warfare key leadership, operational planning, systems management, and Cyber capability employment positions within the military. The program couples the factors of decision-making, operational warfare context, and technical specialization based in the disciplines of computer science, electrical engineering, and emerging Cyber academic programs. The CSO curriculum includes emphasis on means to support the Information Dominance pillars of Assured Command and Control, Battlespace Awareness, and Integrated Fires. The program directly supports Navy, USMC, and DOD goals of operating the network as a warfighting platform, delivering warfighting effects through cyberspace, creating shared situational awareness, and aiding in maturing of Cyber Mission Forces.

The CSO curriculum requires students to choose one of four available tracks following completion of the first instructional quarter. The systems and operations, computational, engineering science, and electrical engineering tracks augment a common CSO core that is administered by the Cyber Academic Group and the Computer Science, Information Sciences, and Electrical and Computer Engineering Departments. Each track is managed independently to meet all sponsor-approved educational skill requirements and culminates in the award of a degree appropriate to the track.

Convenes

Winter, Summer

Program Length

24 Months

Requirements for Entry

This curriculum is open to officers of the U.S. Armed Forces and civilian employees of the U.S. Federal Government. A baccalaureate degree, or the equivalent, with grades resulting in an APC of at least 334, basic

computer programming capability, and a general understanding of computer architectures and operating systems is required. A TOP SECRET clearance is required with eligibility for SCI access.

Degree

Students completing the CSO core matrix and track shall be eligible for one of the following track-specific degrees:

Systems and Operations Track (administered by the Information Sciences Department)

Master of Science in Cyber Systems and Operations

Computational Track (administered by the Computer Science Department)

Master of Science in Computer Science

Engineering Science Track (administered by the Electrical and Computer Engineering Department)

Master of Science in Engineering Science (with emphasis in Electrical Engineering)

Electrical Engineering Track (administered by the Electrical and Computer Engineering Department)

Master of Science in Electrical Engineering

Typical Course of Study -- Summer Entry

Quarter 1

Course	Title	Lecture	Lab
CS2020	Introduction to Programming	3	2
EC2700	Introduction to Cyber Systems	3	3
MA2025	Bridge to Advanced Mathematics	4	1
MA1113	Single Variable Calculus I	4	0

Quarter 2

CS3600	Introduction to Cybersecurity	4	1
EC3730	Cyber Network and Physical Infrastructures	3	2
CS3040	Low Level Programming	3	2
CY3000	Introduction to Cyber Systems and Operations	3	0
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 3

EC3760	Information Operations Systems	3	2
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
CY4900	Research Topics in Cyber Systems and Operations	1	0

Quarter 4

CS3690	Network Security	4	1
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
CS4903	Research Methods in Computer Science	2	0

Quarter 5

ELECT	CSO Track Requirement		
CS3250	Introduction to Cyber Physical Systems	3	2
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
NW3230	Strategy & War	4	2
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 6

NW3285	Theater Security Decision Making	4	0
ELECT	CSO Track Requirement		
ELECT	CSO Track Requirement		
CY0810	Thesis Research	0	8
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 7

EC3740	Reverse Engineering in Electronic Systems	3	2
NW3275	Joint Maritime Operations - part 1	4	0
ELECT	CSO Track Requirement		
CY0810	Thesis Research	0	8
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Quarter 8

CY4400	Cyber Mission Planning	3	0
NW3276	Joint Maritime Operations - part 2	2	2
ELECT	CSO Track Requirement		
CY0810	Thesis Research	0	8
CS4924	Seminar Series in Computer Science and Cyber Systems and Operations	1	0

Curriculum Major Area Sponsor

DCNO for Information Dominance (N2/N6).

Educational Skill Requirements

1. **Cyberspace Operations (CO) Foundations.** Graduates of the CSO program will: have acquired knowledge of

Cyber Warfare and Cyberspace Operations concepts and methodologies; demonstrate a proficient application of the technical dimensions of Cyberspace Operations; and be able to analyze, synthesize, and evaluate management, engineering, and operational approaches to solve complex problems within cyber warfare. This foundation must provide graduates who possess the educational skills to:

- Develop and execute well-formed strategies and plans to effectively operate and maintain ready information and control networks supporting military operations.
- Develop and execute best practices and methodologies for effective Defensive Cyberspace Operations (DCO) to include assessment of threat vectors and vulnerability assessment, means to mitigate cyber attacks and exploitation through active defense, and network maneuver methodologies.
- Build and assess disparate behaviors and indicators within cyberspace to ascertain Cyber Intelligence supporting military operations.
- Define, identify, and assess Cyber Key Terrain from with supporting System of Systems and associated functional processes.
- Be able to generate operational risk factors in support of mission assurance and cyber operations.

2. **Technical Foundations.** Graduates will be able to apply critical thinking, fundamental mathematical, computer science, and engineering concepts underpinning Cyberspace Operations in an operational context. In particular, graduates will be able to employ Cyberspace Operations concepts to solve operationally relevant problems. This education will be founded in the following technical areas: computer architecture; operating systems; virtualization; networking, mobile, and wireless technologies; cyber physical systems and industrial control systems; computer and network security; computer programming; reverse engineering and digital forensics; data analytics; probability; statistics; and signals operations.

3. **Military Application.** Officers will be able to analyze cyber requirements within military operations and synthesize and evaluate courses of action that include the use of Cyber capabilities within the full range of military capabilities (kinetic to non-kinetic). These skills will be reinforced through the use of the Joint Operational Planning Process, Joint Targeting Cycle, Joint Doctrine on Cyberspace Operations, and related operational concepts. The officer is to build skills for the effective application of cyber capabilities, effects, and be able to integrate Cyberspace Operations within operational planning and execution processes. In particular, the Officer will be able to develop, compare, and evaluate courses of action incorporating Cyberspace Operations and identify targets and

processes against which cyber capabilities can be employed to achieve operational effects in support of operational objectives.

4. **Organizational Construct and Policy Context.** The officer will be able to describe the administrative and operational structures and command relationships of the organizations and commands that operate within the cyberspace domain. The officer must have foundational understanding of the application of DOD / DON policies, related strategies, authorities, and the Law of Armed Conflict in the execution of Cyberspace Operations, Cyber Warfare, and associated capabilities. The officer will be able to illustrate the employment of these organizational relationships and policy, strategy, authorities, and legal context in an operational environment (i.e., Cyberspace Operations implications from U.S. law, National Security Strategy, DOD Cyber strategies, DOD and related policies, Rules of Engagement, etc.)

5. **Comprehension of the Cyberspace Environment.** The officer will understand the characteristics of friendly, neutral, and adversary Cyber environments and likely methodologies for adversary employment of cyber capabilities (e.g., infrastructure, prevalent technologies, policy limitations or deterrence, etc.). The officer will understand the parameters of Cyberspace Situational Awareness methodologies for attribution, collateral damage effects, and operational risk of Cyberspace Operations. Further, the officer will understand architecture and design principles that underpin cyberspace as well as demonstrate the ability to analyze specific cyber system implementations to identify vulnerabilities and potential attack vectors. The officer must also understand operational implications when the environment shifts from a permissive to a contested environment.

6. **Relationship to other Warfare Areas.** The officer will understand and illustrate the relationships, overlaps, and interdependencies between cyberspace and traditional warfare areas to include air, surface, undersea, amphibious, strike, and expeditionary warfare. Further, the officer will also demonstrate understanding of the relationships and interdependencies between cyberspace and Distributed Maritime Operations. In particular, the officer will be able to describe alternative approaches to conducting Cyberspace Operations within an Anti-Access/Area Denial scenario.

7. **Independent Research.** The officer will demonstrate the ability to conduct independent research and investigation through the completion of a thesis or capstone project which meets the requirements of the conferred degree. Thesis or capstone work will be conducted in a framework that exercises the practice of innovation, critical thinking, problem solving, and real-world applicability. Where possible, the topic of the thesis or capstone project will support operational

focus areas defined by the mission area sponsor. Further, the officer will be able to present research goals and results in both written and oral form.

8. **Joint Professional Military Education (JPME).** Per community requirements, the officer will have an understanding of warfighting within the context of operational art to include: strategy and war, theater security decision making, and joint maritime operations. Completing the Naval War College four-course series leading to Intermediate Level Professional Military Education and JPME phase I certification fulfills this requirement.

Energy Academic Group

Chair

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Program Officer

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Academic Associate

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Brief Overview

The overall objective for the Energy Academic Group (EAG) is to develop and maintain NPS as a Navy Center of Excellence for Energy Graduate Education and Research. The EAG will also actively explore educational and research partnerships across the full spectrum of Department of Defense (DOD) related organizations, Department of Energy (DOE), as well as other universities, industry, and nonprofit sectors.

EN Courses (p. 379)

Unmanned Autonomous Persistence Certificate - Curriculum 117 (DL)

Program Officer

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Brief Overview

The Unmanned Systems Persistence Graduate Certificate will provide graduate level coursework to active duty, reservists, and civilian DoD employees to increase

proficiency in developing systems and concepts that enable greater reach and endurance of unmanned capabilities.

Background in General Physics and Probability and Statistics are a prerequisite for Naval Tactical Analysis and Join Campaign Analysis as evidenced by transcripts or work history is required for enrollment.

Convenes

Winter, Summer

Program Length

4 Quarters

- Understand the development, use, and recent applications of campaign analysis in actual procurement, force structure, and operations planning.
- Formulate energy problems, choosing assumptions, structure the analysis, and measure effectiveness
- Provide students with information and guidance in the basic technologies, concepts, laws and assumptions associated with the use of autonomous, robotic, and unmanned systems in military operations.
- Demonstrate knowledge and understanding of unmanned autonomous persistence as applied to military operations.
- Understand systems and their incorporation into the exclusively human domain of conflict.

Winter

Course Requirements

Course	Title	Lecture	Lab
OS3680	Naval Tactical Analysis	4	0
OA4602	Joint Campaign Analysis	4	0
IS3460	Networked Autonomous and Unmanned Systems	4	0
EN3010	Introduction to Energy Systems for Robotics	4	0

Directed Energy Certificate - Curriculum 119 (DL)

Program Officer

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Brief Overview

The Directed Energy Graduate Certificate will provide graduate level coursework to educate active duty and civilian DoD employees to increase proficiency in development and integration of DE systems, and to expedite fielding DE capabilities. The certificate program is designed to provide that skill set. Upon successful completion of the course work, students will be awarded an Academic Certificate in keeping with standard

practices of the Naval Postgraduate School. Strong background in calculus as evidenced by transcripts or work history is required for enrollment.

Convenes

Summer

Program Length

4 Quarters

Review the laws of physics from ancient science to classical science to modern quantum and relativity physics.

Explore physics concepts and their relevance to military technologies.

Understand and describe the role of sensors from a systems perspective.

Understand and explain the physics underlying common sensors including radar, sonar, and EO/IR.

Understand the effects of the natural environment on sensors.

Analyze and quantify the impact of the atmospheric and weather related phenomena on sensor performance.

Describe and quantify the impact of multipath and ducting phenomena on detection sensors.

Course Requirements

Course	Title	Lecture	Lab
PH1000	The Nature and Structure of Physics	4	0
EC3110	Electrical Energy: Present and Emerging Technologies	3	2
SE3122	Naval Weapon Systems Technology I	3	0
PH4858	Directed Energy Weapons	4	1

Refuel Logistics Certificate - Curriculum 121 (DL)

Program Officer

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Brief Overview

The Refuel Logistics Graduate Certificate will provide graduate level coursework to educate active duty and civilian DoD employees to increase proficiency in integration and planning of refueling capabilities specifically within contested environments.

Convenes

Spring

Program Length

4 Quarters

- Understand energy basics, energy usage, fossil fuels, solar energy, wind and hydro power, waves, tides and OTEC, geothermal and biomass.
- Assess realistic problems encountered in energy applications and employ appropriate tools for analyzing them.
- Evaluate the structure of research formulations and select appropriate solution methods.
- Implement mathematical formulations using a software tool (Excel Solver) analyze solver output in terms of solution quality and sensitivity to changes in input parameters.
- Utilize appropriate techniques to forecast values of interest and assess the quality of forecast models in terms of uncertainty and any risks posed by this uncertainty.
- Construct simulation models to model complex and/or nondeterministic energy systems.
- Evaluate the output of research models and draw appropriate conclusions about the actual system.

Certificate Requirements

The following four courses are required:

Course	Title	Lecture	Lab
PH3700	Fundamentals of Energy	4	0
OS3007	Operations Research for Energy Systems Analysts	4	0
OA3611	Principles of Operational Logistics	4	0
OS3613	Introduction to Energy Logistics in Warfare Operations	3	0
	-or-		
OA3501	Inventory I	4	0

OA3501 should be substituted for OS3613 only when a student has completed the Energy Certificate (236).

Certificate in Defense Energy - Curriculum 234

Program Officer

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Brief Overview

The Academic Certificate Program in Energy is designed to support the Secretary of the Navy's energy goals by providing an energy education option to NPS resident students who are not directly detailed into the established Energy programs. The certificate program is also available

for those who do not have the opportunity to enroll in an NPS degree program. To earn a certificate, students must enroll in the 234 curriculum and complete a series of energy courses.

Earning the certificate requires a student to complete a minimum of 16 graduate credit hours of energy course offerings and achieve an average of 3.0 Graduate Quality Point Rating (GQPR) in these courses. This is accomplished by enrolling in four graduate energy courses and earning a "B" or "P" in each course. One of the four courses is mandatory for all certificates. The other three are selected from a list of acceptable energy courses. In lieu of exactly one of these three elective courses a student may enroll and pass two consecutive offerings of EN3000, Defense Energy Seminar.

PH3700 Fundamentals of Energy is the required course. Students may select their electives during any quarter the course is offered, but all courses must be completed within three years of admission to the certificate program. Each student's required course work is developed individually under the direction of the EAG Academic Associate, and falls within one of three focus areas: Energy (Science & Technology); Energy (Policy & Analysis); or Energy (General) which combines S&T with P&A.

Requirements for Entry

APC requirements will vary with the courses selected. Students must satisfy any course prerequisites.

Convenes

Fall, Winter, Spring, Summer

Program Length

4 Quarters

Graduate Certificate Requirements

The academic certificate program must be completed within 3 years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Required Course

Course	Title	Lecture	Lab
PH3700	Fundamentals of Energy	4	0

Elective Courses in SCIENCE and TECHNOLOGY (S&T)

EN3000	Defense Energy Seminar	2	0
EC3110	Electrical Energy: Present and Emerging Technologies	3	2
EC3240	Renewable Energy at Military Bases and for the Warfighter	3	2
ME4101	Advanced Thermodynamics	4	0
ME4231	Advanced Turbomachinery	3	2
ME4251	Engine Design and Integration	3	2
ME4420	Advanced Power and Propulsion	4	0
ME4731	Engineering Design Optimization	4	0
ME4901	Advanced Topics in Mechanical (Aerospace) Engineering	V	V
MS4410	Advanced Energy Materials	4	1

EN3000: two consecutive offerings.

Elective Courses in POLICY and ANALYSIS (P&A)

EN3000	Defense Energy Seminar	2	0
MN4070	Energy Economics	4	0
MN3811	Innovation Adoption & Implementation	3	0
NS4960	Energy Security and Geopolitics	4	0
OS3007	Operations Research for Energy Systems Analysts	4	0
OA4613	Energy Logistics in Warfare Operations	4	0

EN3000: two consecutive offerings.

Certificate in Energy - Curriculum 236 (DL)

Program Officer

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Brief Overview

The Energy Academic Group's Distributed Learning (DL) Certificate Program in Energy is designed to support the Office of the Secretary of Defense and the Secretary of the Navy's Energy goals. The DL Energy Certificate provides those working military and civilian employees of the Department of Defense the opportunity to understand the complex issues facing the Operational and Installation Energy segments of DoD.

The Certificate program is designed to expose students to the technical, operational, and security aspects of DoD energy needs. Courses are offered via web-based medium on a schedule of one course per quarter for four quarters.

The Certificate requires successful completion of four graduate DL courses (minimum of 16 credit hours). Any of the four courses can be substituted with the corresponding NPS resident course. The Energy Academic Group Academic Associate may also approve a resident course that is identified as an elective in the Resident Certificate Program as a substitute for a DL course.

Requirements for Entry

APC requirements will vary with the courses selected. Students must satisfy any course prerequisites.

Convenes

Spring

Program Length

4 Quarters

Graduate Certificate Requirements

The academic certificate program must be completed within 3 years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Required Courses

Course	Title	Lecture	Lab
PH3700	Fundamentals of Energy	4	0
EC3110	Electrical Energy: Present and Emerging Technologies	3	2
OS3613	Introduction to Energy Logistics in Warfare Operations	3	0
NS4960	Energy Security and Geopolitics	4	0
	-or-		
NS4967	Energy Security and Geopolitics (DL)	4	0

Delete OA4613 as a required course, and replace with OS3613.

The Certificate program is designed to expose students to the technical, operational, and security aspects of DoD energy needs. Courses are offered via web-based medium on a schedule of one course per quarter for four quarters.   OS3613 is designed to be more accessible for DL students without the technical prerequisites of OA4613, delivered as a (3-0) credit hour course, with a syllabus tailored for delivery via asynchronous distance learning.

Engineering Acoustics Academic Committee

Chair

Oleg Godin, Ph.D.

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Roberto Cristi*, Associate Professor, Department of Electrical and Computer Engineering (1985); Ph.D., University of Massachusetts, 1983.

Monique P. Fargues*, Professor, Department of Electrical and Computer Engineering (1989); Ph.D., Virginia Polytechnic Institute and State University, 1988.

Kay L. Gemba, Associate Professor (2021); Ph.D., University of Hawaiʻi at Mānoa, 2015.

Oleg A. Godin*, Professor, Department of Physics (2016); Ph.D., Moscow Institute of Physics and Technology, 1984.

Kevin B. Smith*, Professor, Department of Physics (1995); Ph.D., University of Miami, 1991.

(* indicates faculty member has a joint appointment to another department at NPS)

Brief Overview

The academic character of the programs in Engineering Acoustics is interdisciplinary, with courses and laboratory work drawn principally from the fields of physics and electrical engineering. Although broadly based, the emphasis of the programs is on those aspects of acoustics and signal processing applied to undersea warfare. Subjects covered include the generation, propagation and reception of sound in the ocean; military applications of underwater sound; and acoustic signal processing. These programs are designed specifically for students in the Applied Physics of Combat Systems, Undersea Warfare, and Underwater Acoustic Systems curricula, government employees in acoustics-related laboratories and systems commands, and international students.

Degrees

Master of Science in Engineering Acoustics

A candidate for the Master of Science in Engineering Acoustics degree must satisfactorily complete a program of study approved by the Chair, Engineering Acoustics Academic Committee, that includes:

1. a minimum of 32 graduate credit quarter-hours of course work of which at least 20 must be taken in acoustics and its applications.
2. at least three 4000 level courses from any three of the following six areas: wave propagation; transducer theory and design; noise, shock, and vibration control; sonar systems; signal processing; and communications. These courses must include at least one from each of the sponsoring disciplines (physics and electrical engineering).
3. Completion of an acceptable thesis on a topic approved by the Engineering Acoustics Academic Committee.

Approval of each program by the Chair of the Engineering Acoustics Academic Committee must be obtained prior to reaching the mid-point of the degree program.

Master of Engineering Acoustics

A candidate for the Master of Engineering Acoustics degree must satisfactorily complete a program of study approved by the Chair, Engineering Acoustics Academic Committee, that includes:

1. a minimum of 32 graduate credit quarter-hours of course work of which at least 20 must be taken in acoustics and its applications.
2. at least three 4000 level courses from any three of the

following six areas: wave propagation; transducer theory and design; noise, shock, and vibration control; sonar systems; signal processing; and communications. These courses must include at least one from each of the sponsoring disciplines (physics and electrical engineering).

3. an acceptable one-quarter capstone project advised by a member of the Electrical and Computer Engineering or Physics Departments.

Approval of each program by the Chair of the Engineering Acoustics Academic Committee must be obtained prior to reaching the mid-point of the degree program.

Doctor of Philosophy

The Department of Electrical and Computer Engineering and the Department of Physics jointly sponsor an interdisciplinary program in Engineering Acoustics leading to the Doctor of Philosophy. Areas of special strength in the departments are physical acoustics, underwater acoustics, acoustic signal processing, and acoustic communications. A noteworthy feature of this program is that a portion of the student's research may be conducted away from the Naval Postgraduate School at a cooperating laboratory or other federal government installation. The degree requirements and examinations are as outlined under the general school requirements for the doctorate degree. In addition to the school requirements, the departments require a preliminary examination to show evidence of acceptability as a doctoral student.

Fundamentals of Engineering Acoustics Certificate - Curriculum 114

Brief Overview

The **Fundamentals of Engineering Acoustics (Resident)** curriculum is available to resident students only. It can be combined with **SONAR System Applications (Resident)** and/or **Underwater Acoustics (Resident)** academic certificate programs for partial fulfillment of requirements for Master of Science in Engineering Acoustics or Master of Science in Applied Physics degrees. Students typically take one course per quarter within a period of 4 quarters. The course of studies is designed to improve the student's performance in operational, maintenance, research, engineering, and acquisition positions by providing them with a firm background in the fundamentals of physical acoustics and sonar engineering with emphasis on naval applications.

Convenes

Summer

Program Length

4 Quarters

Upon successful completion of the program, you will be able to:

- determine and solve equivalent electrical circuits for a broad range of mechanical oscillators;
- solve for normal modes and the driven steady-state response of the following wave systems for a variety of boundary conditions: transverse waves on strings; longitudinal, flexural, and torsional waves on bars; and transverse waves on membranes.
- identify nonideal behavior in experiments of mechanical oscillations and waves, and offer explanations for this behavior;
- model actual acoustic sources by using the radiation patterns, radiation impedances, and directivities of the standard sources of a pulsating line segment, sphere, and baffled circular piston;
- calculate the reflection and transmission of plane sound waves incident on the planar interface between two different acoustic mediums, and for the sound incident on a layer. Use the method of images for spherical waves incident on planar boundaries;
- calculate the effects of different attenuation mechanisms of sound in various gases and liquids;
- calculate the frequencies of Helmholtz resonators, as well as normal mode frequencies of sound in pipes and cavities;
- set up controlled acoustics experiments and gather reliable data. Do quantitative error analyses, and account for deviations of the experimental data from the theory;
- calculate the receiving and transmitting sensitivities of an underwater transducer by using the canonical electromechanical transduction equations;
- design an underwater piezoceramic transducer with specific desired characteristics;
- identify an appropriate underwater projector for use at very-low frequencies, where piezoceramic projectors are insufficient;
- calculate the signal-to-noise ratio of a hydrophone in the ocean and implement changes in the design to improve this ratio;
- experimentally calibrate a hydrophone by using reciprocity and measure the efficiency of an underwater sound projector.

Certificate Requirements

Course	Title	Lecture	Lab
PH3119	Oscillation and Waves -and-	4	2
PH3451	Fundamental Acoustics -or-	4	2
PH3352	Electromagnetic Waves -or-	4	0
PH3991	Theoretical Physics -and-	4	1

Course	Title	Lecture	Lab
PH4454	Sonar Transducer Theory and Design	4	2

If PH3451 has been taken to fulfill requirements of another academic certificate program than either PH3352 or PH3991 are taken as directed study.

Underwater Acoustics Certificate - Curriculum 115

Brief Overview

The **Underwater Acoustics (Resident)** curriculum is available to resident students only. It can be combined with **Fundamentals of Engineering Acoustics (Resident)** and/or **SONAR System Applications (Resident)** academic certificate programs for partial fulfillment of requirements for Master of Science in Engineering Acoustics or Master of Science in Applied Physics degrees. Students typically take one course per quarter within a four-quarter period (12 months). The course of studies is designed to improve the student's performance in operational, acquisition, research, engineering, and maintenance positions by providing the students with a firm background in the fundamentals of the science of underwater acoustics and its naval applications.

Convenes

Fall

Program Length

4 Quarters

Upon successful completion of the program, you will be able to:

- plot ray paths in layers of isogradient water;
- estimate transmission loss for simple models such as mixed layer, convergence zone, bottom bounce, reliable acoustic path, and SOFAR channel;
- use sonobuoy data to calculate the speed, depth, and distance of closest approach of an uncooperative target;
- determine source levels and beam patterns for sources and arrays;
- evaluate detected noise levels and reverberation levels for various environmental conditions;
- calculate the target strength of basic scatterers, including gas bubbles;
- for given sonar and target characteristics, estimate the range of detection.
- evaluate and interpret various underwater propagation phenomena;
- identify the limitations of different numerical prediction algorithms;
- compute basic solutions to the acoustic wave equation using normal mode and parabolic equation approaches.

Certificate Requirements

Course	Title	Lecture	Lab
PH3451	Fundamental Acoustics -or-	4	2
PH3991	Theoretical Physics -and-	4	1
PH3452	Underwater Acoustics -and-	4	2
PH4455	Sound Propagation in the Ocean	4	0

Students may take PH3991 as directed study if PH3451 has been taken to fulfill requirements of another academic certificate program.

SONAR System Applications Certificate - Curriculum 116

Brief Overview

The **SONAR System Applications (Resident)** curriculum is available to resident students. It can be combined with **Fundamentals of Engineering Acoustics (Resident)** and **Underwater Acoustics (Resident)** academic certificate programs for partial fulfillment of requirements for Master of Science in Engineering Acoustics or Master of Engineering Acoustics degrees. Students typically take one course per quarter within a four-quarter period (12 months). The course of studies is designed to improve the student's performance in operational, maintenance, research, engineering, and acquisition positions by providing the students with a firm background in the fundamentals of the theory and practice of the signal processing techniques that underlie naval applications of SONAR systems.

Convenes

Summer

Program Length

4 Quarters

Upon successful completion of the program, you will be able to

- calculate and analyze the Fourier transform of periodic and non-periodic signals;
- recognize and manipulate linear time-invariant (LTI) systems;
- compute the transfer function and frequency response of linear time-invariant systems;
- design systems to amplitude modulate and demodulate a signal for communication applications;
- analyze signal frequency contents using the FT and/or the DFT;
- apply basic theoretical principles and concepts that govern the design, analysis, and operation of passive and active sonar systems;

- predict the consequences and understand design tradeoffs associated with altering important sonar system parameters such as beamwidth, array gain, probability of detection, probability of false alarm, range and Doppler resolution, etc.;
- estimate the design parameters for a sonar system to achieve specified operational requirements.

Certificate Requirements

1. Either EO2402 – Introduction to Linear Systems (4/1) or EC2410 – Analysis of Signals and Systems (4/1)

2. Either EO3402 -– Signals and Noise (3/1) or EC3410 – Discrete-Time Random Signals (3/2).

3. EC4450 – Array Signal Processing (3/2)

4. PH4409 - Engineering Acoustics Capstone Project (2/4)

Fundamentals of Engineering Acoustics Certificate (DL) - Curriculum 124

Brief Overview

The **Fundamentals of Engineering Acoustics** curriculum is available to resident and Distance Learning students. It can be combined with **SONAR System Applications** and **Underwater Acoustics** academic certificate programs for partial fulfillment of requirements for Master of Science in Engineering Acoustics or Master of Engineering Acoustics degrees by Distance Learning students. Students typically take one course per quarter within a period of 4 quarters (12 months). The Distance Learning classes are usually timed to coincide with resident offerings. The course of studies is designed to improve the student's performance in operational, maintenance, research, engineering, and acquisition positions by providing them with a firm background in the fundamentals of physical acoustics and sonar engineering with emphasis on naval applications.

Requirements for Entry

This curriculum is open to US and allied active duty military, government civilians, and major defense contractors. A baccalaureate degree with mathematics through differential and integral calculus and a calculus-based basic physics sequence are required for direct entry. Courses in the physical sciences and engineering are highly desirable.

Convenes

Summer

Program Length

4 Quarters

Upon successful completion of the program, you will be able to:

determine and solve equivalent electrical circuits for a broad range of mechanical oscillators;

solve for normal modes and the driven steady-state response of the following wave systems for a variety of boundary conditions: transverse waves on strings; longitudinal, flexural, and torsional waves on bars; and transverse waves on membranes;

identify nonideal behavior in experiments of mechanical oscillations and waves, and offer explanations for this behavior;

model actual acoustic sources by using the radiation patterns, radiation impedances, and directivities of the standard sources of a pulsating line segment, sphere, and baffled circular piston;

calculate the reflection and transmission of plane sound waves incident on the planar interface between two different acoustic mediums, and for the sound incident on a layer. Use the method of images for spherical waves incident on planar boundaries;

calculate the effects of different attenuation mechanisms of sound in various gases and liquids;

calculate the frequencies of Helmholtz resonators, as well as normal mode frequencies of sound in pipes and cavities;

set up controlled acoustics experiments and gather reliable data. Do quantitative error analyses, and account for deviations of the experimental data from the theory;

calculate the receiving and transmitting sensitivities of an underwater transducer by using the canonical electromechanical transduction equations;

design an underwater piezoceramic transducer with specific desired characteristics;

identify an appropriate underwater projector for use at very-low frequencies, where piezoceramic projectors are insufficient;

calculate the signal-to-noise ratio of a hydrophone in the ocean and implement changes in the design to improve this ratio;

experimentally calibrate a hydrophone by using reciprocity and measure the efficiency of an underwater sound projector.

Certificate Requirements

1. *PH3119 - Waves and Oscillations (4/2)*

2. *PH3451 - Fundamental Acoustics (4/2)*, or one of *PH3352 – Electromagnetic Waves (4/0)* and *PH3991 – Theoretical Physics (4/1)* taken as directed study if PH3451 has been taken to fulfill requirements of another academic certificate program

3. *PH4454 - Sonar Transducer Theory and Design (4/2)*

Underwater Acoustics Certificate (DL) - Curriculum 125

Brief Overview

The **Underwater Acoustics** curriculum is available to resident and Distance Learning students. It can be

combined with **Fundamentals of Engineering Acoustics** and **SONAR System Applications** academic certificate programs for partial fulfillment of requirements for Master of Science in Engineering Acoustics or Master of Engineering Acoustics degrees by Distance Learning students. Students typically take one course per quarter within a four-quarter period (12 months). The Distance Learning classes are usually timed to coincide with resident offerings. The course of studies is designed to improve the student's performance in operational, acquisition, research, engineering, and maintenance positions by providing the students with a firm background in the fundamentals of the science of underwater acoustics and its naval applications.

Requirements for Entry

This curriculum is open to US and allied active duty military, government civilians, and major defense contractors. A baccalaureate degree with mathematics through differential and integral calculus and a calculus-based basic physics sequence are required for direct entry. Courses in the physical sciences and engineering are highly desirable.

Convenes

Fall

Program Length

4 Quarters

Upon successful completion of the program, you will be able to:

- plot ray paths in layers of isogradient water;
- estimate transmission loss for simple models such as mixed layer, convergence zone, bottom bounce, reliable acoustic path, and SOFAR channel;
- use sonobuoy data to calculate the speed, depth, and distance of closest approach of an uncooperative target;
- determine source levels and beam patterns for sources and arrays;
- evaluate detected noise levels and reverberation levels for various environmental conditions;
- calculate the target strength of basic scatterers, including gas bubbles;
- for given sonar and target characteristics, estimate the range of detection;
- evaluate and interpret various underwater propagation phenomena;
- identify the limitations of different numerical prediction algorithms;
- compute basic solutions to the acoustic wave equation using normal mode and parabolic equation approaches.

Certificate Requirements

1. *PH3451 - Fundamental Acoustics (4/2*) or *PH3991 – Theoretical Physics (4/1)* taken as directed study if PH3451

has been taken to fulfill requirements of another academic certificate program

2. *PH3452 – Underwater Acoustics (4/2)*

3. *PH4455 – Sound Propagation in the Ocean (4/0)*

SONAR System Applications Certificate (DL) - Curriculum 126

Brief Overview

The **SONAR System Applications** curriculum is available to resident and Distance Learning students. It can be combined with **Fundamentals of Engineering Acoustics** and **Underwater Acoustics** academic certificate programs for partial fulfillment of requirements for Master of Science in Engineering Acoustics or Master of Engineering Acoustics degrees by Distance Learning students. Students typically take one course per quarter within a four-quarter period (12 months). The Distance Learning classes are usually timed to coincide with resident offerings. The course of studies is designed to improve the student's performance in operational, maintenance, research, engineering, and acquisition positions by providing the students with a firm background in the fundamentals of the theory and practice of the signal processing techniques that underlie naval applications of SONAR systems.

Requirements for Entry

This curriculum is open to US and allied active duty military, government civilians, and major defense contractors. A baccalaureate degree with mathematics through differential and integral calculus and a calculus-based basic physics sequence are required for direct entry. Courses in the physical sciences and engineering are highly desirable.

Convenes

Summer

Program Length

4 Quarters

Upon successful completion of the program, you will be able to

- calculate and analyze the Fourier transform of periodic and non-periodic signals;
- recognize and manipulate linear time-invariant (LTI) systems;
- compute the transfer function and frequency response of linear time-invariant systems;
- design systems to amplitude modulate and demodulate a signal for communication applications;
- analyze signal frequency contents using the FT and/or the DFT;
- apply basic theoretical principles and concepts that govern the design, analysis, and operation of passive and active sonar systems;

- predict the consequences and understand design tradeoffs associated with altering important sonar system parameters such as beamwidth, array gain, probability of detection, probability of false alarm, range and Doppler resolution, etc.;
- estimate the design parameters for a sonar system to achieve specified operational requirements.

Certificate Requirements

1. Either EO2402 – Introduction to Linear Systems (4/1) or EC2410 – Analysis of Signals and Systems (4/1)

2. Either EO3402 -– Signals and Noise (3/1) or EC3410 – Discrete-Time Random Signals (3/2).

3. EC4450 – Array Signal Processing (3/2)

4. PH4409– Engineering Acoustics Capstone Project (2/4)

Underwater Acoustic Systems - Curriculum 535

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Brief Overview

The Underwater Acoustic Systems curriculum is currently available to Distance Learning students and leads to either a Master of Science in Engineering Acoustics or a Master of Engineering Acoustics depending on whether the student completes a thesis. Students typically take one course per quarter for a period of 8 quarters (24 months) followed by a thesis or capstone project. They must also complete a one-week residency during their first 4000-level physics course to gain experience in experimental techniques. The courses are taught primarily via streaming video or video-teleconferencing (VTC.) Downloadable recordings of the classes are available for students who do not have access to VTC or miss a class. Instructors also use virtual classroom software for problem-solving sessions or individual help. The classes are usually timed to coincide with resident offerings. The course of studies is designed to improve the student's performance in operational, maintenance, and acquisition positions by providing them with a firm background in the fundamental science and engineering of acoustic systems.

Requirements for Entry

This curriculum is open to US and allied active duty military, government civilians, and major defense contractors. Admission requires a baccalaureate degree with a major in engineering or physical science, completion of mathematics through differential equations and integral calculus, plus one year of calculus-based physics. An APC of 323 is required for direct entry.

Convenes

Summer

Program Length

27 Months

Typical Course of Study

Quarter 1

Course	Title	Lecture	Lab
PH3119	Oscillation and Waves	4	2

Quarter 2

PH3451	Fundamental Acoustics	4	2

Quarter 3

PH3452	Underwater Acoustics	4	2

Quarter 4

PH4454	Sonar Transducer Theory and Design	4	2

Quarter 5

EO2402	Introduction to Linear Systems	4	1

Quarter 6

EO3402	Signals and Noise	3	1

Quarter 7

EC4450	Array Signal Processing	3	2

Quarter 8

PH4455	Sound Propagation in the Ocean	4	0

Quarter 9

PH4409	Engineering Acoustics Capstone Project.	2	4

Space Systems Academic Group

Chair

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Brij Agrawal*, Distinguished Professor, Ph.D., Syracuse, 1970.

Brannon Chapman, LCDR, USN, Program Officer, M.S., Naval Postgraduate School, 2019.

Alex Bordetsky*, Associate Professor, Ph.D., Chelyabinsk St Tec University, 1982.

Christopher Brophy*, Associate Professor, Ph.D., University of Alabama(Huntsville), 1997.

Matthew Crook, LCDR (ret), Lecturer, M.S., Naval Postgraduate School, 2009.

Ibrahim (Emre) Gunduz*, Associate Professor; Ph.D., Northeastern University, 2006.

James A. Horning, Faculty Associate - Research, M.S., Naval Postgraduate School, 1997.

Jennifer Hudson*, Associate Research Professor, Ph.D., University of Michigan, 2010.

Mark Karpenko*, Research Professor; Ph.D., University of Manitoba, Canada, 2009.

Mathias Kölsch*, Associate Professor; Ph.D., University of California at Santa Barbara, 2004.

Young W. Kwon*, Distinguished Professor; Ph.D., Rice University, 1985.

Wenschel Lan, Sr. Lecturer, Ph.D., Naval Postgraduate School, 2015.

Herschel H. Loomis, Jr.*, Distinguished Professor Emeritus, Ph.D., Massachusetts Institute of Technology, 1963.

Lara Magallanes, Faculty Associate - Research, Ph.D., Naval Postgraduate School, 2022.

Ian R. McNab*, Research Professor, Ph.D., Reading University (UK), 1974.

Sherif Michael*, Professor; Ph.D., University of West Virginia, 1983.

Giovanni Minelli, Faculty Associate - Research, Ph.D., Naval Postgraduate School, 2018.

Clay Moltz*, Professor, Ph.D., University of California Berkeley, 1989.

James H. Newman, Professor, Chair of Space Systems Academic Group, Astronaut, Ph.D., Rice University, 1984.

Mara Orescanin*, Assistant Professor, Ph.D., MIT, 2015.

Rudy Panholzer, Professor Emeritus, Volunteer, Ph.D., Technical University, GRAZ, Austria, 1961.

Ronald J. Proulx, Research Professor, Ph.D., Columbia University, 1976.

Charles M. Racoosin, CDR, USN, Ret., Volunteer, Lecturer, M.S., Naval Postgraduate School, 1989.

Marcello Romano*, Professor, Ph.D., Politecnico di Milano, Italy, 2001.

Michael Ross*, Distinguished Professor, Ph.D., Penn State University, 1991.

Alex Savattone, Faculty Associate - Research, B.S., California State University Monterey Bay, 2013.

Christopher Smithtro*, COL, AF, Ret., Sr. Lecturer, Ph.D., Utah State University, 2004.

Michael Stiller, Faculty Associate - Research, M.B.A, University of Wyoming, 2021.

Stephen Tackett, Lecturer, M.S., Naval Postgraduate School, 1995.

Gary W. Thomason, LtCol, USMC Ret., Space Systems, Lecturer; M.S., Naval Postgraduate School, 2003.

Todd Weatherford*, Professor, Ph.D., North Carolina State University, 1993.

Noah Weitz, Faculty Associate - Research, M.S., California Polytechnic State University - San Luis Obispo, 2018.

(* indicates faculty member has a joint appointment to another department at NPS)

Brief Overview

The Space Systems Academic Group (SSAG) is an interdisciplinary association of faculty and academic professors representing various academic disciplines. The SSAG currently has Chair professorships sponsored by NASA and Naval Space Systems Engineering and Acquisition (SSEA). The Space Systems Academic Group has responsibility for the academic content of the Space Systems Operations and Space Systems Engineering curricula. Instruction is carried out by faculty members attached to the group, as well as by faculty of various academic departments with courses fulfilling the interdisciplinary requirements for space systems curricula. The Space Systems Academic Group approves thesis topics for students in Space Systems Operations. For Space Systems Engineering, the group chairman approves the final thesis in addition to the academic department granting the degree.

Degrees

Space Systems Operations

The Space Systems Operations students are awarded the Master of Science in Space Systems Operations degree. Degree requirements:

1. A minimum of 32 quarter-hours of graduate level work is required, of which at least 15 hours must be at the 4000 level.
2. Graduate courses in at least four different subject areas must be included and in two areas, a course at the 4000 level must be included. There is also a requirement of three courses constituting advanced study in an area of specialization.
3. Each student is required to write a thesis that is space oriented.
4. The Chairman of the Space Systems Academic Group must approve all study programs.

Space Systems Engineering

The Space Systems Engineering students can earn a Master of Science degree or a Ph.D. degree. The Master's degree is offered in one of the following academic areas: Astronautical Engineering, Computer Science, Electrical

and Computer Engineering, or Physics. The Ph.D. degree is offered in one of the following academic areas: Astronautical Engineering, Electrical and Computer Engineering, or Physics. Refer to the degree requirements in the associated departments.

Nuclear Operations

The Nuclear Operations students are awarded Master's of Science in Nuclear Operations. Students must complete 24 credit hours from the Naval Postgraduate School as well as one 12-credit (3 or 4 course) pre-approved nuclear operations-related certificate from either The Air Force Institute of Technology (AFIT), Harvard University Extension School, or equivalent courses from the Naval Postgraduate School.

Group Facilities

- ARM (Articulated Robotics Manipulator) Laboratory
- Center for Radiation Hardened Electronics
- Cognitive Systems Laboratory
- CubeSat Development Lab
- DARK MIRROR (Spacecraft Engineering & Operations) Laboratory
- FLTSATCOM Satellite Operations Lab
- GNC (Guidance, Navigation and Control) Laboratory - Ross Magnetic Attitude Control Test Lab
- Nanosat Advanced Concepts Laboratory
- NPS-AFRL Optical-relay Spacecraft Lab
- NPS Vision Lab
- Photogrammetric System ID Laboratory
- Rocket Propulsion Lab
- Small Satellite Development and Test Lab
- Spacecraft Attitude Dynamics & Control Laboratory
- Spacecraft Robotics Laboratory
- Sensitive Compartmented Information Facility

Space Systems Course Descriptions

SS Courses (p. 509)

Space Control Tactics and Operations Certificate - Curriculum 266

Program Officer

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Academic Associate

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Brief Overview

The Space Control Tactics and Operations Certificate comprise four courses (SS3500, SS3600, SS4856, and

AE4860). Upon successful completion of the course work, students will be awarded a certificate of completion consistent with standard practices of the Naval Postgraduate School. The Space Control Tactics and Operations Certificate provides students with an education in rendezvous and proximity operations and space control.

This certificate provides a technical basis in orbital mechanics and space systems modeling and simulation, as well as the implications of operating space systems in a contested environment.

Requirements for Entry

Baccalaureate degree with completion of basic algebra, geometry, trigonometry and logarithms, and college level physics, and a TS/SCI clearance.

Convenes

Fall

Program Length

4 Quarters

Graduate Certificate Requirements

Requirements for the certificate in Space Systems are met by successful completion of all four courses. Certificate credit is obtained by maintenance of a 3.0 grade point average on a 4.0 scale.

Required Courses - Curriculum 266

Course	Title	Lecture	Lab
SS3500	Orbital Mechanics and Launch Systems	4	2
	-or-		
SS3400	Orbital Mechanics, Launch and Space Operations	4	2
SS3600	Space Systems Modeling and Simulation	2	3
SS4856	Rendezvous and Proximity Operations	3	0
AE4860	Space Control	2	2

Space Systems Operations and Engineering - Curriculum 566

Space Systems Operations (International)

Program Officer

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Brief Overview

The Space Systems Operations (International) program is designed to provide international officers with knowledge of military opportunities and applications in space. It is also available to US citizens who may not have a security clearance. Students are provided instruction about the operation, tasking, and employment of space surveillance, communications, navigation, and atmospheric/oceanographic/environmental sensing systems as well as payload design and integration — specifically for the exploitation of Space and Information products. For a complete description, see the Space Systems Operations (366) section of the catalog.

Requirements for Entry

This program is open to International Officers and US personnel. Admission requires a baccalaureate degree with above-average grades, completion of mathematics through differential equations and integral calculus, plus at least one course in calculus-based physics. An APC of 324 is required for direct entry. Students lacking this background may matriculate through the one-quarter Engineering Science program (Curriculum 460).

Convenes

Fall

Program Length

18 Months

Typical Course of Study - Space Systems Operations (International)

Quarter 1

Course	Title	Lecture	Lab
IT1600	Communication Skills for International Officers	3	0
IT1500	Informational Program Seminar for International Officers	4	0
SS3011	Space Technology and Applications	3	0
SS4000	Space Systems Seminars	0	1
SS1100	Intro to Programming for Space Applications	2	2

Quarter 2

SS3400	Orbital Mechanics, Launch and Space Operations	4	2
SS3610	Space Communications Systems: Fundamentals and Analysis	4	2
NS4677	Space and International Security	4	0
PH3052	Physics of Space and Airborne Sensor Systems	4	0
SS4000	Space Systems Seminars	0	1

Quarter 3

SS1810	Thesis Proposal Preparation	0	1
SS3041	Space Systems and Operations I	4	2
IT1700	Academic Writing for International Officers	3	0
ELECT	Elective		
SS3600	Space Systems Modeling and Simulation	2	3
SS4000	Space Systems Seminars	0	1

Quarter 4

SE3100	Fundamentals of Systems Engineering	3	2
PH2514	Introduction to the Space Environment	4	0
SS0810	Space Systems Thesis Research	0	8
SS4000	Space Systems Seminars	0	1

Quarter 5

AE4830	Spacecraft Systems I	3	2
SS0810	Space Systems Thesis Research	0	8
MN3301	Acquisition of Defense Systems	4	0
SS4000	Space Systems Seminars	0	1

Quarter 6

AE4831	Spacecraft Systems II	3	2
SS0810	Space Systems Thesis Research	0	8
IS3502	Network Operations I	4	2
ELECT	Elective (4000 level)		
SS4000	Space Systems Seminars	0	1

Space Systems Operations

Program Officer

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Brief Overview

The Space Systems Operations program is designed to provide officers with knowledge of military opportunities and applications in space. Students are provided instruction about the operation, tasking and employment of space surveillance, communications, navigation and atmospheric, oceanographic, and environmental sensing systems as well as payload design and integration— specifically for the exploitation of Space and Information

products.

The Space Systems Operations program is one of the Information Superiority (IS) curricula, which encompasses several degree tracks: Computer Sciences, Joint C4I Systems, Information Systems and Technology, Information Warfare, Intelligence Information Management, Modeling, Virtual Environments and Simulation, and Space Systems Operations. The Professional Practice Core of the Information Superiority (IS) curricula consists of material in Information Sciences and Technology, Command and Control, C4ISR Systems, Acquisition, C4ISR System Evaluation, Information Operations/Warfare, and Enterprise Policy, Strategy and Change.

Requirements for Entry

This program is open to officers of the U.S. Armed Forces and selected civilian employees of the U.S. Federal Government. Admission requires a baccalaureate degree with above-average grades, completion of mathematics through differential equations and integral calculus, plus at least one course in calculus-based physics. An APC of 334 is required for direct entry. Students lacking this background may matriculate through a one-quarter preparatory course sequence beginning before the normal fall start. A TOP SECRET security clearance is required with SPECIAL INTELLIGENCE (SI) clearance for all students.

Convenes

Fall

Program Length

21 Months

Subspecialty

Completion of this program qualifies an officer as a Space Systems Operations Subspecialist with a subspecialty code of 6206P. The program sponsor is OPNAV N2/N6. The designated Subject Matter Expert is U.S. Fleet Cyber Command, Commander, U.S. TENTH Fleet.

Typical Subspecialty Jobs

Project Officer: OPNAV (N2/N6) TENCAP, Arlington, VA
Project Officer: NAVWAR Space Field Activity (NSFA)/NRO, Chantilly, VA
Space Advisor: NAVNETWARCOM, Norfolk, VA
Detachment OIC: Naval Space Operations Command (NAVSOC), Colorado Springs, CO

Typical Course of Study - Space Systems Operations-Fall Entry

Quarter 1

Course	Title	Lecture	Lab
NW3230	Strategy & War	4	2
SS1100	Intro to Programming for Space Applications	2	2

Course	Title	Lecture	Lab
MN3301	Acquisition of Defense Systems	4	0
SS3011	Space Technology and Applications	3	0
SS4000	Space Systems Seminars	0	1
Quarter 2			
PH3052	Physics of Space and Airborne Sensor Systems	4	0
NS4677	Space and International Security	4	0
SS3610	Space Communications Systems: Fundamentals and Analysis	4	2
SS3400	Orbital Mechanics, Launch and Space Operations	4	2
SS4000	Space Systems Seminars	0	1
Quarter 3			
SS3041	Space Systems and Operations I	4	2
SS3613	Military Satellite Communications	3	0
SS3051	Military Applications of DoD and Commercial Space Systems	3	2
SS3600	Space Systems Modeling and Simulation	2	3
SS4000	Space Systems Seminars	0	1
Quarter 4			
PH2514	Introduction to the Space Environment	4	0
SS3001	Military Applications of National Space Systems	4	1
IW3101	Military Operations in the Information Environment	4	0
SS4000	Space Systems Seminars	0	1
Quarter 5			
AE4830	Spacecraft Systems I	3	2
SS4051	Military Space Systems and Architectures II	3	2
SS0810	Space Systems Thesis Research	0	8
NW3285	Theater Security Decision Making	4	0
SS4000	Space Systems Seminars	0	1
Quarter 6			
AE4831	Spacecraft Systems II	3	2
SS0810	Space Systems Thesis Research	0	8
NW3275	Joint Maritime Operations - part 1	4	0
SS4000	Space Systems Seminars	0	1

Quarter 7

SS4055	Space Operations for the Warfighter	2	2
NW3276	Joint Maritime Operations - part 2	2	2
SS0810	Space Systems Thesis Research	0	8

Educational Skill Requirements (ESR)
Information Sciences, Systems, and Operations
Subspecialty Code: 6206P

Graduates of the Space Systems Operations Specialization of the Information Sciences, Systems, and Operations (ISSO) program shall be able to determine space systems requirements which support the following operational concepts: control of space, global engagement, full force integration, and global partnerships. The graduates shall be able to analyze courses of action for the best employment of available space assets for ongoing and future military operations and communicate this assessment to shore and afloat staffs and commanders.

Supporting these goals are the following specific requirements:

1. Orbital Mechanics and Space Environment:

a. Graduates will examine the basic physics of orbital motion and calculate and distinguish the parameters used in the description of orbits and their ground tracks.

b. Graduates will examine the design of orbits and constellations, and analyze how they are achieved, maintained, and controlled; to include spacecraft maneuver and orbit transfer calculations.

c. Graduates will examine the fundamentals of spacecraft tracking and command/control from a ground station.

d. Graduates will analyze the relationship between various orbital characteristics and the satisfaction of mission requirements, including the advantages and disadvantages of various orbits.

e. Graduates examine the space environment impacts on spacecraft parts, materials, and operations to spacecraft and mission design.

2. Spacecraft Design:

a. Graduates will examine the basic system design of a spacecraft including its various subsystems: propulsion; structure; thermal; attitude determination and control; electrical power; and telemetry, tracking and commanding.

b. Graduates will assess key interactions between the various subsystems and their effects on system performance.

3. National Security Systems:

a. Graduates will examine the nature of space warfare (theory, history, doctrine, and policy); distinguish how space operations as discussed in JP 3-14 enable joint force capabilities; and interpret how current and planned space capabilities contribute to the satisfaction of mission objectives.

b. Graduates will examine the roles, responsibilities, and relationships of National and DoD organizations in establishing policies, priorities, and requirements for National Security Space systems; and in the design, acquisition, operation, and exploitation of these systems.

c. Graduates will examine the role of the Services / Agencies in establishing required space system capabilities, and will translate these capabilities into system performance requirements.

d. Graduates will examine: current and planned Intelligence, Surveillance, and Reconnaissance (ISR) capabilities; how space systems contribute to these capabilities; the intelligence collection and analysis process; and how war-fighters access information from these sources.

e. Graduates will develop concepts of employment and assess space tactics and CONOPS. The development and assessment shall consider end-to-end capabilities and system-of-systems architectures that enhance, support, and integrate into military operations to include resiliency concepts in a contested environment.

f. Graduates will identify how proposed space-related capabilities and doctrine transition from concept to real-world implementation.

g. Graduates will examine the capabilities of DoD, other government, and commercial space systems, and how those systems relate to National Space Systems to include potential overlaps and leverage opportunities.

4. Management / Acquisition:

a. Graduates will examine project management and DoD system acquisition methods and procedures to include contract management, financial management and control, and the Planning, Programming, Budgeting and Execution system (PPBE).

b. Graduates will examine system acquisition organizational responsibilities and relationships (e.g., Congress, DoD, Services, Resource Sponsor, Systems Commands, Operating Forces) as they pertain to the acquisition of systems for DoD, Naval, and civilian agency users.

c. Graduates will examine the unique nature of space acquisition programs using the Space Systems Acquisition Policy process. Based on this knowledge, they will plan and structure a notional space system acquisition program.

d. Graduates will examine how proposed space-related capabilities and DOTMLPF requirements are translated from concept to real-world implementation.

e. Graduates will apply the tools of project management (e.g., scheduling, costing, budgeting, planning, resource negotiation, risk management) to a space project.

f. Graduates will prepare for and conduct program reviews, from systems requirements through critical

design, during spacecraft and architecture design projects.

5. Communications:

a. Graduates will examine the basic principles of networks and communications systems operations and engineering to include both the space and ground segments.

b. Graduates will examine digital and analog communications architecture and networks design, including such topics as frequency reuse, multiple access, link design, repeater architecture, source encoding, waveforms/modulations, and propagation media.

c. Graduates will calculate and analyze link budgets to assess communication system suitability to support mission requirements, and to translate mission requirements into communications system design characteristics.

d. Graduates will differentiate, compare, and contrast the characteristics and capabilities of current and future space related networks and communications systems in use or planned by Naval operating and Joint forces afloat and ashore and understand the threats (both kinetic and non-kinetic) to these capabilities and associated countering or mitigation strategies.

e. Graduates will recognize the national and international issues involving use of the frequency spectrum and the relative priority and criticality of various segments of the frequency spectrum, and the space systems that employ them, to national defense.

f. Graduates will discuss the nature of the rapid evolution in commercial satellite communications systems, and recognize the impact of such advancements on military operations and systems development.

6. Remote Sensing:

a. Graduates will examine principles of active and passive sensors in current or planned use.

b. Graduates will examine the effects of the space, atmospheric, and terrestrial environments (including countermeasures) on sensor performance.

c. Graduates will examine tradeoffs among various sensors and platforms, evaluating how each satisfies mission requirements such as access area, resolution, timeliness, and capacity.

7. Analysis and Evaluation:

a. Graduates will derive, assess, and articulate capabilities necessary for the use of National Security Space systems in support of military operations.

b. Graduates will examine various engineering and mathematical definitions of cost functions (revisit time, dwell time, local coverage, etc.)

c. Graduates will use business case (economic) and performance data to analyze trade-offs between commercial and DoD systems to provide desired operational capabilities.

d. Graduates will understand and apply the development

and applicability of models and simulations, with a focus on specific space applications. Graduates will apply these concepts simulate a space architectures, evaluate system performance, and compare alternative solutions.

e. Graduates will analyze and evaluate system characteristics to satisfy required capabilities in a cost-effective manner using modeling and simulation, field and laboratory experiments, and/or other quantitative and qualitative methods.

8. Architecting Missions:

a. Graduates will examine and relate the principles of architecting a complex, Joint National Security Space mission, and the life cycle process by which a space system is conceived, structured, designed, built, tested, certified and operated in a way that ensures its integrity and performance.

b. Graduates will develop and assess system requirements; compose alternate architectures to satisfy those requirements; and evaluate and select the most effective alternative.

c. Graduates will develop system design criteria from stated performance requirements, and conduct trade-offs between payloads and other spacecraft subsystems.

d. Graduates will examine the design of current and planned space-based mission payloads (e.g., ISR, Communications, PNT, SIGINT).

e. Graduates will examine the basic principles and operational issues of space access to include launch vehicle performance, launch windows, and their impact on military operations.

9. Information Warfare Fundamentals:

a. Graduates will analyze military operations in the information environment with respect to assured information delivery, availability, and protection, with an awareness of attack and exploitation capabilities, and mitigation strategies.

b. Graduates will understand multi-domain concepts and operational framework in order to analyze the structure of organizational sub-components.

c. Graduates will understand the relationship between space operations and operations in the information environment.

d. Graduates will examine the role of Space Operations in the context of Multi-Domain Operations and the relationship between Space Operations, Cyberspace Operations, and Electromagnetic Spectrum Operations with emphasis on support during the periods of competition and armed conflict.

10. Operational Mission Planning:

a. Graduates will examine the basic elements of mission operations – spacecraft commanding, payload management, anomaly resolution, orbital maneuver planning – and will apply these concepts during satellite and architecture design projects.

b. Graduates will understand the role of space in the development of an OPLAN. Graduates will have the ability to assess space operations and associated capabilities as identified in JP 3-14. Graduates will demonstrate the ability to develop an acceptable command and control structure for space operations and the space annex of an OPLAN.

c. Graduates will develop space plans in support of global campaign plans and/or OPORDS to include staff estimates, ANNEX inputs and command recommendations for space based capabilities, limited Space Control, threat analysis and mitigation measures, and limiting factors culminating in a mission planning exercise.

d. Graduates will gain exposure to appropriate space planning and analysis tools and capabilities that exist within the DoD/Intel Communities and use them in execution of mission planning exercise.

11. Advanced Concepts and Technology:

a. Graduates will examine how current and future space systems contribute to National Security and will examine means to employ space-based capabilities to support information dominance.

b. Graduates will examine potential future military space requirements stemming from desired information dominance capabilities.

c. Graduates will examine future concepts of operation published by various DoD and international organizations (ESA, ISA, WSO, etc.) based on emerging technologies and appraise their impact on military space.

d. Graduates will examine the advanced concepts and technologies which could be used in future military space systems.

12. Space National Policy:

a. Graduates will analyze the space acquisition environment to develop an understanding of its impact on the delivery of space capabilities and national security.

b. Graduates will analyze the space-related policy and strategy environment to ascertain its influence on US national security.

c. Graduates will synthesize approaches to effectively advocate for space capabilities.

d. Graduates will synthesize approaches to effectively employ space capabilities in support of national leadership and joint/coalition forces.

13. Research:

a. Graduates will conduct independent or group research on a space systems problem, including resolution of the problem and presentation of the results and analysis in both written and oral form.

Program Sponsor and ESR Approval Authority

Deputy Chief of Naval Operations for Information Warfare (OPNAV N2/N6) & Commander, U.S. Fleet Cyber Command, Commander, U.S. TENTH Fleet Revised June 2018.

Space Systems Engineering

Program Officer

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Brief Overview

The Space Systems Engineering program provides officers, through graduate education, with a comprehensive scientific and technical knowledge of national security, military and naval space systems. This program is designed to equip officers with the theoretical and practical skills required to design and integrate national security and military space payloads with other spacecraft subsystems. Graduates will be prepared by their education to design, develop and manage the acquisition of space communications, navigation, surveillance, electronic warfare and environmental sensing systems.

Requirements for Entry

A baccalaureate degree, or its equivalent, in engineering or the physical sciences is preferred. An APC of 323 is required for direct entry. For candidates who do not meet all admission requirements, a one quarter Calculus and Physics refresher is available. For those wishing to pursue the electrical engineering or computer science degree option, the candidate will need to have earned the equivalent of an accredited BSEE or BSCS. A TOP SECRET security clearance is required with SPECIAL INTELLIGENCE (SI) clearance obtainable for all students.

Degree

Master of Science:
• Astronautical Engineering
• Electrical Engineering
• Mechanical Engineering
• Physics
• Applied Physics
• Computer Science
• Engineering Science (Astronautical Engineering)

Astronautical Engineer is also available.

Required classes vary by degree. The placement of these required classes in the course of study shown below indicate Degree Specialization Electives known as degree "track courses".

Convenes

Fall

Program Length

27 Months

Subspecialty

Completion of this program qualifies an officer as a Space Systems Engineering Specialist with a subspecialty code of 5500P. The program sponsor is NAVSEA and the designated Subject Matter Expert is the Naval Warfare Systems Command Space Field Activity (NSFA).

U.S. Marine Corps officers completing this program fulfill the requirements for MOS 8866.

Typical Subspecialty Jobs

Project Officer/Engineer: NAVWAR, San Diego, CA
Project Officer/Engineer: NAVWAR Space Field Activity/NRO, Chantilly, VA
Satellite Communications Engineer: NAVSOC, Point Mugu, CA
Space Advisor: Naval Network Warfare Command, Norfolk, VA
Project Officer: Space Warfare Center, USSTRATCOM, Omaha, NE
Project Officer/Engineer, C4ISR Programs: SPAWAR Systems Center, San Diego, CA

Typical Course of Study - (Astronautical Engineering Degree Track)

Multiple course of study tracks are available that result in a related Space Systems Engineering Master's Degree.

The course of study below has Astronautical track classes, as annotated in the course title block, which can be replaced with other track classes to obtain a different Master of Science degree.

NW courses listed are required for JPME 1 qualification, but may not be required by the student's designator or branch of service.

Quarter 1

Course	Title	Lecture	Lab
AE3840	Analysis of Spacecraft Structures	3	2
ME2801	Introduction to Control Systems	3	2
SS4000	Space Systems Seminars	0	1
SS1100	Intro to Programming for Space Applications	2	2
MN3331	Principles of Acquisition and Program Management	5	1
MA2097	Engineering Mathematics III	4	0

Quarter 2

SS3500	Orbital Mechanics and Launch Systems	4	2
SS4000	Space Systems Seminars	0	1
PH3052	Physics of Space and Airborne Sensor Systems	4	0
AE3804	Thermal Control of Spacecraft	3	2
EO3510	Space Communications Systems: Fundamentals and Analysis	4	2

Quarter 3

AE3815	Spacecraft Rotational Mechanics	3	2
SS4000	Space Systems Seminars	0	1
SS3861	Spacecraft Payload Design I	2	4
SS3101	Ground Systems and Mission Operations	3	2

Quarter 3 Degree Track Courses (Astronautical)

AE3811	Space Systems Laboratory	2	2
AE3830	Aerospace Guidance and Control	3	2

Quarter 4

SS4000	Space Systems Seminars	0	1
SS4861	Spacecraft Payload Design II	2	4
EC3230	Space Power and Radiation Effects	3	1
PH2514	Introduction to the Space Environment	4	0
SS1810	Thesis Proposal Preparation	0	1

Quarter 4 Degree Track Courses (Astronautical)

ME3521	Mechanical Vibration	3	2

Quarter 5

SS4000	Space Systems Seminars	0	1
AE4870	Spacecraft Design and Integration I	2	4
AE3851	Spacecraft Propulsion	3	2
AE0810	Thesis Research	0	8

Quarter 5 Degree Track Courses (Astronautical)

AE4850	Dynamic Optimization	3	2

Quarter 6

SS3001	Military Applications of National Space Systems	4	1
SS4000	Space Systems Seminars	0	1
AE4871	Spacecraft Design and Integration II	2	4
AE0810	Thesis Research	0	8

Quarter 6 Degree Track Courses (Astronautical)

AE4818	Acquisition, Tracking, and Pointing of Military Spacecraft	3	2

ME4881	Aerospace Trajectory Planning and Guidance	2	4

Quarter 7

AE0810	Thesis Research	0	8
AE0810	Thesis Research	0	8
SS4000	Space Systems Seminars	0	1
SS3051	Military Applications of DoD and Commercial Space Systems	3	2

Quarter 7 Degree Track Courses (Astronautical)

AE4860	Space Control	2	2
AE3820	Advanced Mechanics and Orbital Robotics	3	2
AE4824/ME4824	Applications of Deep Learning for Military Systems	3	2

Educational Skill Requirements (ESR)
Space Systems Engineering Program
Subspecialty Code: 5500P

The officer must understand the fundamental concepts and be familiar with the basic functional areas of Space Systems Engineering within the Department of the Navy (DON) and the Department of Defense (DoD) including the following numbered ESRs:

ESR-1. ORBITAL MECHANICS AND SPACE ENVIRONMENT:

a. Graduates will examine the basic physics of orbital motion, and calculate and distinguish the parameters used in the description of orbits and their ground tracks.

b. Graduates will examine the design of orbits and constellations, and analyze how they are achieved, maintained, and controlled; to include spacecraft maneuver and orbit transfer calculations.

c. Graduates will examine the fundamentals of spacecraft tracking and command/control from a ground station.

d. Graduates will examine the various orbital perturbations, including those due to non-spherical earth and due to atmospheric drag, and interpret their effects.

e. Graduates will analyze the relationship between various orbital characteristics and the satisfaction of mission requirements, including the advantages and disadvantages of various orbits.

f. Graduates will design and optimize mission orbits through the analysis of common performance measures such as access, coverage, and revisit; and will employ appropriate tools to conduct these analyses.

g. Graduates will examine the physical behavior of the upper atmosphere, ionosphere and space environment under the influence of both natural and artificial phenomena such as solar activity, geomagnetic and magnetospheric effects, and man-made disturbances.

h. Graduates will apply this understanding of how the space environment impacts spacecraft parts, materials, and operations to spacecraft and mission design.

ESR-2. NATIONAL SECURITY SPACE SYSTEMS:

a. Graduates will examine the nature of space warfare (theory, history, doctrine, and policy); distinguish how space operations as discussed in JP 3-14 enable joint force capabilities; and interpret how current and planned space capabilities contribute to the satisfaction of mission objectives.

b. Graduates will examine the roles, responsibilities, and relationships of National and DoD organizations in establishing policies, priorities, and requirements for National Security Space systems; and in the design, acquisition, operation, and exploitation of these systems.

c. Graduates will examine the role of the Services / Agencies in establishing required space system capabilities, and will translate these capabilities into end-to-end, system-of-systems performance requirements.

d. Graduates will examine: current and planned Intelligence, Surveillance, and Reconnaissance (ISR) capabilities; how space systems contribute to these capabilities; the intelligence collection and analysis process; and how war-fighters access information from these sources.

e. Graduates will examine concepts of employment, space tactics and CONOPS. The graduate shall consider end-to-end capabilities and system-of-systems architectures that enhance, support, and integrate into military operations to include resiliency concepts in a contested environment.

f. Graduates will identify how proposed space-related capabilities / doctrine transition from concept to real-world implementation through experimentation.

g. Graduates will examine the capabilities of unclassified DoD and commercial space systems, and how those systems relate to National Space Systems to include potential overlaps and leverage opportunities.

ESR-3. PROJECT MANAGEMENT AND SYSTEM ACQUISITION:

a. Graduates will examine project management and DoD system acquisition methods and procedures to include contract management, financial management and control, and the Planning, Programming, Budgeting and Execution (PPBE).

b. Graduates will recognize the role of the Defense Acquisition University and the acquisition courses and qualifications available.

c. Graduates will examine system acquisition organizational responsibilities and relationships (e.g., Congress, DoD, Services, Resource Sponsor, Systems Commands, Operating Forces) as they pertain to the acquisition of systems for DoD, Naval, and civilian agency

users.

d. Graduates will examine the unique nature of space acquisition programs and plan a notional space system acquisition program.

ESR-4. COMMUNICATIONS:

a. Graduates will examine the basic principles of communications systems engineering to include both the space and ground segments.

b. Graduates will examine digital and analog communications architecture design, including such topics as frequency reuse, multiple access, link design, repeater architecture, source encoding, waveforms/modulations, and propagation media.

c. Graduates will calculate and analyze link budgets to assess communication system suitability to support mission requirements, and to translate mission requirements into communications system design characteristics.

d. Graduates will differentiate, compare, and contrast the characteristics and capabilities of current and future communications systems in use or planned by Naval operating and Joint forces afloat and ashore.

e. Graduates will examine how current and planned space communications systems should be used to meet Joint communications requirements across the spectrum of operations.

f. Graduates will differentiate signal processing techniques, both digital and analog, as applied to missions such as spacecraft communications, surveillance, and signals intelligence.

g. Graduates will examine spacecraft vulnerabilities in an electronic warfare context.

ESR-5. COMPUTERS: HARDWARE AND SOFTWARE

a. Graduates will understand the fundamentals of digital logic and digital system design of simple digital computer subsystems.

b. Graduates will examine the design of current and planned computer hardware and software architectures for space-based applications to include their potential to support service life extensions and enable incremental capabilities of cyber and platform resiliency.

c. Graduates will examine the use of computers in complex systems such as guidance, signal processing, communications, and control systems.

d. Graduates will examine the fundamentals of electronic component design, fabrication, reliability, and testing (to include radiation hardening), with an emphasis on parts, materials, and processes.

e. Graduates will examine modern Information Technology capabilities and their applications for space systems ground processing, data storage, information sharing, and network design.

ESR-6. SPACECRAFT DYNAMICS, GUIDANCE, AND CONTROL

a. Graduates will analyze spacecraft dynamics, guidance, and control to include topics such as linear control, coordinate transformations, rotational kinematics, three-axis stabilization design, sources of and response to disturbance torques, and selection of attitude determination and associated sensors and actuators.

b. Graduates will apply these techniques to the analysis and design of resilient spacecraft guidance and control systems.

ESR-7. SPACECRAFT STRUCTURES AND MATERIALS

a. Graduates will examine the engineering and design of space structures, perform simplified sizing calculations, and analyze the dynamics of these structures.

b. Graduates will understand the use of materials for space structures and the associated trade space in spacecraft design.

ESR-8. PROPULSION SYSTEMS

a. Graduates will examine the operating principles (fluid mechanics, thermodynamics, electricity and magnetism) and propulsion devices used in current and proposed space applications.

b. Graduates will analyze and choose appropriate propulsion systems for spacecraft applications to include launch, orbit transfers, and spacecraft maneuvering with the potential for on-orbit serviceability.

ESR-9. SPACECRAFT THERMAL CONTROL

a. Graduates will examine the principles of heat transfer and how surfaces and materials are manipulated in spacecraft thermal control.

b. Graduates will examine the design, analysis, and applications of current active and passive thermal control devices (including heat pipes, louvers, and materials).

c. Graduates will examine the sources of heat in space (solar, terrestrial, reflected solar, internal vehicle generation) and their variation as a function of vehicle orbit, and apply this knowledge to thermal subsystem analysis and design.

ESR-10. SPACECRAFT POWER

a. Graduates will examine the principles and operating characteristics of major power generating systems for spacecraft, including the performance of photovoltaic sources in the natural and artificial radiation environment.

b. Graduates will examine the principles and operating characteristics of energy storage devices in power systems design to include the potential to support associated service life extensions.

ESR-11. REMOTE SENSING AND PAYLOAD DESIGN

a. Graduates will examine principles of active

and passive sensors in current or planned use, to include analysis of electromagnetic wave propagation and design of optics, detectors, and antennae.

b.   Graduates will examine the effects of the space, atmospheric, and terrestrial environments (including countermeasures) on sensor performance.

c.   Graduates will assess and conduct tradeoffs among various sensors and platforms, evaluating how each satisfies mission requirements such as access area, resolution, timeliness, and capacity.

d.   Graduates will examine the design of current and planned space-based mission payloads (e.g., ISR, Communications, PNT, SIGINT).

e.   Graduates will analyze mission capabilities and conduct associated trades in order to develop associated payload design requirements.

ESR-12. SPACECRAFT DESIGN, INTEGRATION, AND SYSTEMS ENGINEERING

a.   Graduates will develop and assess an overall space system architecture to meet defined mission requirements through the use of systems engineering tools and processes.

b.   Graduates will derive system and subsystem performance criteria from stated mission capabilities and conduct trade-offs between payload and other spacecraft subsystems in addressing these capabilities.

c.   Graduates will examine a broad spectrum of mission assurance concerns such as reliability, risk management, configuration management, qualification and acceptance testing, proto-flight strategy, spacecraft materials and manufacturing processes, resiliency considerations and cyber vulnerabilities.

d.   Graduates will examine various engineering and mathematical definitions of cost functions (revisit time, dwell time, local coverage, etc.) and apply emerging methods and tools to optimizing these utility measures in support of mission objectives.

e.   Graduates will examine the basic principles and operational issues of space access to include launch vehicle performance, launch windows, and their impact on military operations.

f.   Graduates will examine the capabilities of the various current and planned launch systems, and characterize the issues associated with integrating a spacecraft with a launch vehicle, to include the effects of launch environment.

g.   Graduates will perform a trade-off analysis in the selection of a launch vehicle based on mission requirements, performance and design constraints, and business issues involved (e.g., pricing, insurance, policy).

h.   Graduates will demonstrate proficiency in design, analysis, and modeling / simulation tools such as NX, MATLAB / Simulink, Systems Tool Kit (STK), and others.

i.   Graduates will examine the processes and methods of systems engineering including requirements analysis, functional analysis and allocation, system design, and verification.

ESR-13. GROUND SYSTEMS AND SYSTEMS ENGINEERING

a.   Graduates will understand the fundamentals of a space-ground system architecture including the system-of-systems that comprise a space-based, end-to-end capability across all mission areas.

b.   Graduates will examine Department of Defense Architecture Framework (DoDAF) views of real or notional space network architectures in order to understand necessary internal and external interfaces and domain interactions.

c.   Graduates will analyze enterprise and mission-specific frameworks from standard communications infrastructures (C&C, messaging, data, etc.), services, and tools to mission specific T&C, information products and data.

d.   Graduates will analyze network and non-network communications within an Information Technology Enterprise Domain context.

e.   Graduates will understand application program interface (API) challenges in relation to security requirements, risks and mitigation.

f.   Graduates will understand Risk Management Framework integration for cyber security system engineering efforts including information assurance and relevant documentation such as NIST SP800-30, DoDI 8500.1 and 8500.2.

h.   Graduates will analyze command and telemetry requirements and capabilities to support mission execution, vehicle operations and anomaly resolution.

i.   Graduates will analyze services for access, sharing, processing and external dissemination of information including data management and storage challenges such as "Big Data", open-source implementation and cloud technology applications for Ground Systems.

ESR-14. ARTIFICIAL INTELLIGENCE FOR SPACE SYSTEMS

a.   Graduates will examine the mathematical foundational principles of artificial intelligence and apply physics-informed machine learning techniques to optimize the design of space systems.

b.   Graduates will examine machine learning techniques to address hard problems in national space security.

ESR-15. CONDUCT AND REPORT INDEPENDENT RESEARCH

a.   Graduates will conduct independent research on a space systems problem, including resolution of the problem and presentation of the results and analysis in both written and oral form, via a Master's thesis.

Program Sponsor and ESR Approval Authority
Commander, Naval Warfare Systems Command

Commander NAVWAR Space Field Activity
Revised November 2021

Space Systems Fundamentals Certificate (SSF) - Curriculum 273 (DL)

Program Officer

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Brief Overview

The Space Systems Certificate program comprises four courses. Upon successful completion of the course work, students will be awarded a certificate of completion in keeping with standard practices of the Naval Postgraduate School as well as the 6206L subspecialty code. The Space Systems Certificate program supports Navy and DoD space educational needs and complements existing resident education by providing cross-disciplinary science and technical education. The Space Systems Certificate program is targeted primarily at enhancing the education and preparation for USN Space Cadre personnel. The Navy's Space Cadre represents a distinct body of expertise horizontally integrated within the Navy active duty, reserves, both officer and enlisted, and civilian employee communities organized to operationalize space.

Entry to the Space Cadre is met, in part, by completion of a Space PQS. The courses included in the certificate are designed to give a prospective Space Cadre member the knowledge required to meet the requirements of many portions of the PQS.

Completion of the Certificate will count toward satisfaction of the Information Professional Advanced Qualification Certification matrix (COMNAVCYBERFORINST 1520.1).

Requirements for Entry

Baccalaureate degree with completion of college level algebra, geometry, trigonometry, logarithms, and physics (including electricity and magnetism. (Physics 2).

Convenes

Fall, Spring

Program Length

4 Quarters

Graduate Certificate Requirements

Requirements for the certificate in Space Systems are met by successful completion of all four courses. Certificate credit is obtained by maintenance of a 3.0 grade point average on a 4.0 scale.

Upon completion of the Space Systems Fundamentals Certificate students should be able to:

- Demonstrate understanding of the Space Environment in which DOD satellites operate, including Remote Sensing, Space Environment, orbitology, satellite communications and satellite subsystems
- be able to advocate for USN/DoD interests in significant National Space Security Organizations
- be able to drive participation in joint processes for space systems architecture and requirements development
- be able to prioritize the resources necessary to formulate and defend operational requirements for space
- understand the major satellite systems used in ISR, PNT and communication

Navy students will:

- Gain knowledge required in corresponding fundamentals section of Space Cadre PQS
- Upon completion of the certificate, be awarded the 6206-L subspecialty code

Course Requirements

Course of Study

Course	Title	Lecture	Lab
SS3011	Space Technology and Applications	3	0
SS3613	Military Satellite Communications	3	0
	-or-		
SS3610	Space Communications Systems: Fundamentals and Analysis	4	2
PH3052	Physics of Space and Airborne Sensor Systems	4	0
	-or-		
MR3522	Remote Sensing of the Atmosphere and Ocean/Laboratory	4	2
PH2514	Introduction to the Space Environment	4	0
	-or-		
SS3051	Military Applications of DoD and Commercial Space Systems	3	2
	-or-		
SS3001	Military Applications of National Space Systems	4	1

Students unable to take SS3613 due to clearance issues

may take SS3610 as an approved substitute.

Students may choose between PH3052 and MR3522.

Students may choose between PH2514 and SS3051 and SS3001.

Space Nuclear Command, Control & Communications Certificate - Curriculum 298 (DL)

Program Officer

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Brief Overview

The Space Nuclear Command, Control & Communications (NC3) Certificate is comprised of four courses (SS3011, SS3613, SS3740 and SS3741). Upon successful completion of the course work, students will be awarded a certificate of completion in keeping with standard practices of the Naval Postgraduate School. The Space NC3 Certificate supports objectives corresponding to required space, ground and classified elements of USAF Global Strike Command's strategic Nuclear education components. This certificate is a distance learning, asynchronous education program that covers satellite technology and communication fundamentals relevant to U.S. strategic nuclear operations, deterrence and assurance.

Requirements for Entry

A baccalaureate degree with above-average grades, completion of college-level Algebra 2 and college-level physics with a C or better average, and a Secret clearance is required.

Convenes

Fall, Spring

Program Length

4 Quarters

Required Courses: Curriculum 298

Course	Title	Lecture	Lab
SS3011	Space Technology and Applications	3	0
SS3613	Military Satellite Communications	3	0
SS3740/AE3740	Nuclear Command, Control, and Communications Systems - Part I	3	0
SS3741/AE3741	Nuclear Command, Control, and Communications Systems - Part II	3	0

Nuclear Operations - Curriculum 738 (DL)

Program Officer

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Brief Overview

The Nuclear Operations curriculum is designed to be completed via distance learning and to provide students with knowledge of nuclear operations such as nuclear deterrence and assurance, nuclear weapons effects, nuclear command, control and communications (NC3), space-based systems used for early warning and communications, nuclear platforms, nuclear command and control (NC2), nuclear policy and nuclear non-proliferation. Students will complete the Space Nuclear Command, Control, and Communications (SNC3) certificate (Requirement #1), a nuclear deterrence and policy certificate (Requirement #2), which can be completed through the Naval Postgraduate School or an equivalent pre-approved certificate from another institution such as The Air Force Institute of Technology (AFIT), Harvard University Extension School, or Missouri State University. Students will then complete a pre-approved specialization track with a four-course certificate (Requirement #3). Finally, the Students will complete an approved thesis or capstone project (Requirement #4). Note: requirements #1, #2, and #3 can be completed in any order.

Requirements for Entry

The curriculum is open to US military officers and US federal government employees. Other nuclear enterprise or US government-affiliated applicants will generally be accepted if sponsored by a US military command or US

government federal agency. Applicants must be eligible for a Secret security clearance, which must be obtained before enrolling in the classified courses. Students will require access to SIPRNet while taking the classified courses. Applicants must have a bachelor's degree, with an APC of 255 (Bachelor's degree GPA of 2.6 or higher)

Convenes

Spring

Program Length

36 Months

1. Students will examine the strategy of Nuclear Deterrence historically and apply the concepts of Nuclear Deterrence to the present day. They will also examine US Nuclear Policy and Nuclear non-proliferation.

2. Students will analyze the nuclear strategy of the U.S.' two main nuclear rivals, China and Russia, including the broader topic of great power competition concerning these rivals.

3. Students will evaluate theories of escalation control and de-escalation and apply these concepts to US nuclear strategy.

4. Students will describe nuclear effects and understand how these effects impact U.S. NC3 systems and other military systems.

5. Students will explain the characteristics of the earth's atmosphere and the space environment as they relate to the systems used for Missile Early Warning and Nuclear Command and Control

6. Students will classify and explain wireless communications, including their expected operation of various communication types in a nuclear environment, with special emphasis on protected Satellite Communications.

7. Students will gain relevant specific knowledge in a specialization track (such as the Acquisition and Systems Engineering Track). Other specialization tracks may be added in the future with the approval of the Space Systems Academic Group Chair.

Core Requirements

Requirement #1: Space Nuclear Command, Control and Communications Certificate (SNC3 - Curriculum 298)

All students are required to complete the Space Nuclear Command, Control, and Communications (SNC3) Certificate (Curriculum 298)

Course	Title	Lecture	Lab
SS3011	Space Technology and Applications	3	0
SS3613	Military Satellite Communications	3	0
SS3740/AE3740	Nuclear Command, Control, and Communications Systems - Part I	3	0

Course	Title	Lecture	Lab
SS3741/AE3741	Nuclear Command, Control, and Communications Systems - Part II	3	0

Requirement #2: Complete a pre-approved nuclear strategy and policy certificate.

Students will complete one of the five options below:

Via distance learning or in residence:

1. Great Power Competition Certificate, Curriculum 255 (13 credit hours)

Via distance learning and transfer the credits to the Naval Postgraduate School:

2. Air Force Institute of Technology (AFIT) Nuclear Weapons Effects, Policy, and Proliferation (NWEPP) Certificate (12 credit hours)

3. Harvard Extension School Nuclear Deterrence Certificate (12 credit hours)

4. Missouri State Graduate Certificate in Countering Weapons of Mass Destruction (CWMD) (15 credit hours)

In residence:

5. Complete three courses from the following list:

a. NS3280: Nuclear Weapons and National Strategies

b. NS3030: American National Security Policy

c. NS4990: Seminar in Strategic Studies

d. NS4991: Seminar in United States Foreign Policy

e. NS4677: Space and International Security

f. DA3885: Proliferation and Counter-Proliferation

g. NS3450: The Russian Military: Past and Present

h. NS4620: Seminar on the People's Liberation Army

Requirement #3: Specialization Track

Complete one certificate as a specialization track from the following list:
1. Systems Engineering Fundaments (Curriculum 282)
2. Implementing Technological Change (Curriculum 231)

Other tracks are in development and will be approved by SSAG Chair.

Requirement #4: Thesis or Capstone Project

All students will complete a thesis or capstone project as approved by the academic group.

Space Systems Engineering PhD - Curriculum 597

Program Officer

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Brief Overview

Ph.D. degrees in Astronautical Engineering, Electrical Engineering and Physics are available.

Systems Engineering Analysis Curriculum and Program

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Overview

The Systems Engineering Analysis (SEA) curriculum and program at NPS provides a unique education bridging the knowledge bases of both Systems Engineering and Operations Analysis. The Chair of SEA, supported by the Academic Associate and Program Officer, manages execution of the program. The Vice Provost of Academic Leadership exercises overall executive responsibility, with the chairs of the Systems Engineering and Operations Research Departments being jointly responsible for ensuring the quality of the program. The Chair of SEA acts as a liaison point-of-contact for the collaborative efforts between the curriculum sponsor, OPNAV N9I and the SEA curriculum and program at NPS, and collaborates with the two department chairs in professional development, supports team-oriented research and analysis that links technical solutions to tactical problems, enhances understanding of the Navy's Requirements-Setting, Planning, Programming, Budgeting and Execution (PPBE) and acquisition processes, and the manner in which they impact warfighting acquisition programs.

The responsibilities of the faculty team are:

1. To maintain the military relevance and academic excellence of the SEA program;
2. To foster close relationships with the appropriate officers in OPNAV and the Fleet and with a curriculum sponsor, emphasizing the curriculum goal of improving the technical-tactical-operational prowess of the unrestricted line;
3. To draw on the best qualified and most knowledgeable faculty to serve as instructors and curriculum/course advisors;
4. To work through the Academic Associate, to ensure the interdisciplinary nature of the program is maintained, and that the best possible use is made of existing courses and faculty;
5. To enhance the availability of suitable student capstone projects, the professionalism of faculty advisors, and the quality of written project reports;
6. To foster the selection and matriculation of well-qualified students who have intellectual and professional promise of being future leaders of the Navy; and,
7. To advise the Chair in the management of SEA courses, administration of SEA students, and supervising the SEA Capstone project.

Degrees Awarded

The Systems Engineering and Operations Research Departments jointly award the Master of Science in Systems Engineering Analysis (MS SEA) degree. The SEA curriculum is designed for unrestricted line officers who aspire to command and seek a graduate degree tailored to enhance their value as combat officers. The hallmark of the curriculum is a strong scientific and technical content that offers a balanced blend and breadth in systems thinking and analysis of current and future military operations.

Candidates normally are expected to have studied mathematics and science in their undergraduate work. Undergraduate engineering study is advantageous, but not required.

The Master of Science degree in Systems Engineering Analysis requires:

1. A minimum of 48 quarter-hours of graduate-level work.
2. The candidate must take all courses in an approved study program, which must also satisfy the following

requirements:

    a. A minimum of 36 quarter-hours of credit in 3000 and 4000 level courses, including a minimum of 12 quarter-hours at the 4000 level.

3. Participation in a capstone project with a minimum of 12 credits is required for the degree. An acceptable thesis, for a minimum of 12 credits, may be substituted in lieu of a team project. The Academic Associate and the Program Officer must endorse such a request, which will be subject to final approval by the Chair Professor.

A student seeking the Master of Science in Systems Engineering Analysis must also demonstrate knowledge in systems design and integration, systems analysis and application, combat technology, and familiarity with professional military education in strategy and policy. This may be accomplished by completing all courses in an approved study program.

Systems Engineering Analysis Program – Curriculum 308

Program Officer

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Brief Overview

This interdisciplinary curriculum provides a foundation in systems thinking, technology, and operations analysis for warfighters. Graduates will be able to understand how to develop and fight new systems of combat systems, and have a more thorough understanding of current combat systems.

Students normally complete group projects in lieu of theses. These "capstone" projects are chosen to allow students to gain a thorough understanding of a critical warfare area and to provide the Navy and other services insights about future systems options to meet emerging needs.

The program is designed as a highly integrated graduate education. Lectures, team projects, and individual research are provided, as well as seminars from visiting experts. The length of this program is eight quarters.

Convenes

Summer

Program Length

24 Months

Subspecialty

Completion of this curriculum qualifies a naval officer as a Systems Engineering Subspecialist, with subspecialty code 6500P or 6501P (Navy Requirements Officer Program Track).

Requirements for Entry

For entry, the officer must have at least a C+ undergraduate grade point average, with at least one calculus course with a C or better and at least one calculus-based physics course with a C or better (APC 324). If an officer is an outstanding performer, but lacks the necessary academic preparation, waivers may be considered. In addition, distance learning courses in Calculus are available for candidates wishing to obtain higher math skills.

Degrees

Master of Science in Systems Engineering Analysis

This degree is proposed for all students completing the 308 curriculum. The Systems Engineering and Operations Research departments are the approving authority for the degree.

Master of Science in Systems Engineering

To be considered for this degree, a student must meet the degree requirements (including an ABET EAC accredited engineering BS degree or documented equivalent) and complete all the requirements of curriculum 308. The chair of the Department of Systems Engineering is the approving authority for the degree.

Master of Science in Systems Analysis

Selected students may elect to earn a degree in Systems Analysis from the Department of Operations Research. This involves a thesis in lieu of project and an extended analysis sequence. The chair of the Department of Operations Research is the approving authority for the degree.

Typical Course of Study

The first quarter of the SEA curriculum reflects a review of mathematics and physics, from a systems perspective. Subsequent quarters present a balance of courses in systems engineering, operations analysis, technology, joint professional military education, culminating in the capstone project-encompassed by the SE3201/2/3 sequence of courses. The students gain additional knowledge and insight through seminars and project related travel.

Quarter 1 (Accelerated)

Course	Title	Lecture	Lab
SE1001	Mathematics For SE I	4	2
SE1002	Mathematics For SE II	3	1
SE2003	Introduction to Mechanical Systems	4	2
SE2101	Introduction to Electromagnetic Systems	4	2

Quarter 2

Code	Course		
SE3000	Systems Engineering Colloquium	1	0
SE3100	Fundamentals of Systems Engineering	3	2
SE3112	Combat Systems Engineering I- Intro to Sensors	4	2
OS3180	Probability and Statistics for Systems Engineering	4	1
MN3301	Acquisition of Defense Systems	4	0

Quarter 3

Code	Course		
SI3400	Fundamentals of Engineering Project Management	3	2
SE4112	Combat Systems Engineering III	4	2
OS3211	Systems Optimization	4	0
SE3000	Systems Engineering Colloquium	1	0
OS3680	Naval Tactical Analysis	4	0

Quarter 4

Code	Course		
SE3113	Combat Systems Engineering II- Conventional Weapons	4	2
SE3302	System Suitability	3	2
SE3000	Systems Engineering Colloquium	1	0
OS4680	Naval Systems Analysis	4	0
OS3380	Combat Systems Simulation	3	1

Quarter 5

Code	Course		
SE4115	Combat Systems Integration	4	2
OA4602	Joint Campaign Analysis	4	0
OA4702	Cost Estimation	4	0
NW3230	Strategy & War	4	2
SE3000	Systems Engineering Colloquium	1	0

Quarter 6

Code	Course		
SE3121	C4ISR Systems	3	2
SE3201	Engineering Systems Conceptualization	2	4
SE4150	Systems Architecting and Design	3	2
NW3275	Joint Maritime Operations - part 1	4	0
SE3000	Systems Engineering Colloquium	1	0

NW3275: U.S. Navy URL only

Quarter 7

Code	Course		
ELECT	Elective		
OA4603	Test and Evaluation	4	0

Code	Course		
SE3202	Engineering Systems Design	2	4
NW3276	Joint Maritime Operations - part 2	2	2
SE3000	Systems Engineering Colloquium	1	0

NW3276: U.S. Navy URL only

Quarter 8

Code	Course		
ELECT	Elective		
SE3203	Engineering Systems Implementation & Operation	2	4
SI0810	Integrating Project -or-	0	8
ELECT	Elective		
NW3285	Theater Security Decision Making	4	0

Educational Skill Requirements

Systems Engineering Analysis Curriculum

Broad Objective

This curriculum teaches U.S. Navy Unrestricted Line Officers how the Navy builds and operates large combat systems of systems. The primary objective is to prepare officers to serve afloat and in key operational staff billets by giving them the technological and analytical understanding to fight the fleet today and in the future. The emphasis is on integration of complex warfare systems with compatible tactics. In addition, graduates with experience afloat will be prepared to serve ashore as program managers and in technical/analytical billets on headquarters staffs.

1. **Basics.** Introduction to the mathematics, physics, and computer skills needed to understand the technical aspects of combat, information, and decision systems.

2. **Systems Engineering.** Understand the systems engineering process and how to perform systems engineering studies, to include a knowledge of system design, development, and deployment; technical and cost trade-offs; human-in-the-loop issues and project management. Be able to integrate relevant technological disciplines that bear on weapons, sensor and information systems. Understand responsiveness to realistic military requirements, specifications and cost limitations. Study the linkage between strategic planning, requirements, project organization, and technology.

3. **Operations Analysis.** Learn how to apply advanced management and operations research ideas to defense problems, to include cost-benefit and cost-effectiveness analysis. Understand uncertainty and risk and their impact on military planning, decision making and operations. Become familiar with complexity and the modeling of competitive systems. Gain a basic

knowledge of modeling, simulation and gaming. Learn how Operations Research techniques, including experimental design, are applied to operational test and evaluation; planning and analyzing fleet battle experiments; and to military decision making.

4. **Sensor and Weapon Systems.** Gain a solid understanding of the scientific, mathematical and engineering principles behind existing and future military systems. Understand the elements that impact sensor system performance. Understand the principles behind existing and emerging sensor technologies, including radar, sonar, electro-optical sensors, and other sensors. Understand the technologies underlying weapons systems, and the principles that guide successful integration of weapons and sensors with platforms.

5. **Information Systems Technology.** Develop knowledge of information systems technology including computer systems; computer networks and communications systems; software engineering; and data base management. Demonstrate awareness of the capabilities, limitations, design and operation, and vulnerabilities of information systems. Understand the concepts of defensive and offensive Information Warfare.

6. **Independent Study.** Each student must demonstrate the ability to conduct independent and team oriented research and analysis on problems that link technical solutions to tactical problems, and to present the results in writing and oral briefings. A substantive project report or thesis will be required of all students.

7. **Department of Defense Resource Allocation.** Develop a working knowledge of resource allocation within the Department of Defense including the PPBE, JCIDS, and Acquisition processes. It is imperative that students understand key issues regarding the scheduling of budget delivery to, and the related interface with Congress, as well as the critical milestones involved in development of the President's Budget. In addition, a working knowledge of the interfaces between PPBE, JCIDS, and Acquisition is necessary to gain an appreciation for the synergies and disconnects between these two processes - and in particular to understanding the manner in which they impact warfighting acquisition programs.

Joint Professional Military Education

Completion of Joint Professional Military Education (JPME) is required for all USN officers enrolled in the 308 curriculum. Graduates will develop an understanding of warfighting within the context of operational art, to include: national military capabilities and command structure, joint and service doctrine, joint planning and execution, and joint and multinational forces and systems integration at the operational level of war.

Typical Course of Study Navy Requirements

Officer Program Track

The first quarter of the SEA curriculum reflects a review of mathematics and physics, from a systems perspective. Subsequent quarters present a balance of courses in systems engineering, operations analysis, technology, and program management topics culminating in the capstone project encompassed by the SE3201/2/3 sequence of courses. The students gain additional knowledge and insight through seminars and project related travel. This track satisfies the mandatory Defense Acquisition University (DAU) program management education required by the Defense Acquisition Work force Improvement Act (DAWIA) for Program Management through Level III.

Quarter 1 (Accelerated)

Course	Title	Lecture	Lab
SE1001	Mathematics For SE I	4	2
SE1002	Mathematics For SE II	3	1
SE2003	Introduction to Mechanical Systems	4	2
SE2101	Introduction to Electromagnetic Systems	4	2

Quarter 2

SE3000	Systems Engineering Colloquium	1	0
SE3100	Fundamentals of Systems Engineering	3	2
SE3112	Combat Systems Engineering I- Intro to Sensors	4	2
OS3180	Probability and Statistics for Systems Engineering	4	1
MN3331	Principles of Acquisition and Program Management	5	1

Quarter 3

SI3400	Fundamentals of Engineering Project Management	3	2
OS3211	Systems Optimization	4	0
SE3000	Systems Engineering Colloquium	1	0
SE4112	Combat Systems Engineering III	4	2
OS3680	Naval Tactical Analysis	4	0

Quarter 4

SE3113	Combat Systems Engineering II- Conventional Weapons	4	2
SE3302	System Suitability	3	2
SE3000	Systems Engineering Colloquium	1	0
OS4680	Naval Systems Analysis	4	0
OS3380	Combat Systems Simulation	3	1

Quarter 5

MN3303	Principles of Acquisition and Contract Management	4	0
SE4115	Combat Systems Integration	4	2
OA4602	Joint Campaign Analysis	4	0
OA4702	Cost Estimation	4	0
SE3000	Systems Engineering Colloquium	1	0

Quarter 6

MN3384	Acquisition Production, Quality and Manufacturing Decision Science	3	2
SE4150	Systems Architecting and Design	3	2
SE3121	C4ISR Systems	3	2
SE3201	Engineering Systems Conceptualization	2	4
SE3000	Systems Engineering Colloquium	1	0

Quarter 7

MN3309	Software Acquisition Management for Defense Systems	3	2
SE3202	Engineering Systems Design	2	4
MN4602	Acquisition Test and Evaluation Decision Science	3	2
SE3000	Systems Engineering Colloquium	1	0
GB4053	Defense Budget Policy and Financial Management Systems	4	0

Quarter 8

ELECT	Elective		
SE3203	Engineering Systems Implementation & Operation	2	4
MN4307	Defense Acquisition Program Management Case Studies	4	0
MN4470	Strategic Planning and Policy for the Acquisition Logistics Manager	4	0

Undersea Warfare Academic Group

Chair

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Chair Professor of Undersea Warfare

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Chair Professor of Mine and Expeditionary Warfare

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Executive Committee

Michael Atkinson, Associate Professor (2009); Ph.D., Stanford University, 2009.

Donald P. Brutzman, Associate Professor (1995); Ph.D., Naval Postgraduate School, 1994.

Roberto Cristi, Professor (1985); Ph.D., University of Massachusetts, 1983.

Oleg A. Godin, Professor (2016); Ph.D., Moscow Institute of Physics and Technology, 1984.

Douglas P. Horner, Research Assistant Professor (2005); Ph.D., Naval Postgraduate School, 2013.

John Joseph, CDR, USN (Ret.); Faculty Associate, Research (2006); M.S., Radford University, 1979, M.S., Naval Postgraduate School, 1991.

Phillip G. Sawyer, VADM, USN (Ret.); Chair Professor of Undersea Warfare (2022); Master's in Engineering Management, Old Dominion University, 1990.

Kevin B. Smith, Professor (1995); Ph.D., University of Miami, 1991.

Richard D. Williams III, RADM, USN (Ret.); Chair Professor of Mine and Expeditionary Warfare (2005); M.S., Naval Postgraduate School, 1972.

Hong Zhou, Professor (2004); Ph.D., University of California, Berkeley, 1996.

* The year of joining the Naval Postgraduate School faculty is indicated in parentheses.

Brief Overview

The Undersea Warfare Academic Group (USWAG) is an interdisciplinary association of faculty providing oversight for multiple Undersea Warfare (USW) related degree programs. The USWAG has administrative responsibility for the academic content of the overall USW curriculum. Teaching in this interdisciplinary program is carried out by faculty members attached to the following academic departments: Electrical and Computer Engineering, Applied Mathematics, Oceanography, Operations Research, Mechanical and Aerospace Engineering, and Physics. The Chair, USWAG approves thesis topics for students in the Undersea Warfare curricula.

Degrees

Most students in the USW curriculum pursue a degree through one of the associated academic departments. A list of degree options is found on the USW Curriculum

(525/526) page (p. **Error! Bookmark not defined.**). In special cases, students may pursue a Master of Science in Applied Science degree through the USWAG.

Students seeking the Master of Science in Applied Science degree under the cognizance of the Chair, Undersea Warfare Academic Group must successfully complete the following:

1. A minimum of 32 quarter-hours of graduate level courses relevant to undersea warfare, including at least 20 hours to satisfy a track in either the Physics Department (Acoustics), Oceanography Department (Physical Oceanography), or Electrical and Computer Engineering Department (Signal Processing).

2. A sequence of at least 12 hours of graduate level courses representing a specialization in some area other than that of the major.

3. At least 12 hours of coursework at the 4000 level.

4. An acceptable thesis advised or co-advised by a member of the respective department.

Undersea Warfare Course Descriptions

UW Courses (p. 517)

Undersea Warfare - Curriculum 525

Program Officer

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Brief Overview

The Undersea Warfare program is jointly sponsored by N97 and N95 to educate officers in the engineering fundamentals, physical principles and analytical concepts that govern operational employment of undersea warfare (USW) sensors and weapons. The USW program is interdisciplinary and integrates many subjects: mathematics, physics, oceanography, electrical and mechanical engineering, and operations analysis.

The program is designed to allow the US student to meet all of the requirements for Navy PME (as established by the Chief of Naval Operations) and for Joint Professional Military Education for Intermediate Level Professional Military Education (JPME Phase I) as established by the Chairman, Joint Chiefs of Staff.

A separate track modeled after the program is available for international students. The international version replaces U.S. PME courses with courses specifically developed for international students.

Requirements for Entry

A baccalaureate degree, or equivalent, from a program with a calculus sequence and a calculus-based physics sequence that results in an APC of 323 is required for direct input. Courses in the physical sciences and engineering are desirable. Officers not meeting the academic requirements for direct input may enter the program early for a one or two quarter refresher of math and/or physics as required.

Convenes

Fall, Spring

Program Length

24 Months

Degrees

Students in Undersea Warfare (525) may choose from a variety of technical degrees including:

Master of Science in Engineering Acoustics
(with emphasis on underwater acoustics, hardware design, and signal processing)

Master of Science in Physical Oceanography
(with emphasis on the prediction of the littoral environment, ocean acoustics and environmental effects on sonar performance)

Master of Science in Electrical Engineering
(with emphasis on communications or signal processing)

Master of Science in Mechanical Engineering
(with emphasis on autonomous systems)

Master of Science in Engineering Science
(with emphasis on autonomous systems)

Master of Science in Applied Mathematics
(with emphasis on autonomous systems or secure communications)

Master of Science in Applied Physics
(with emphasis on acoustics, weapons, or sensors)

Master of Science in Operations Research
(with emphasis on target search and detection)

Master of Science in Network Operations and Technology
(with emphasis on cyber resiliency)

Master of Science in Cyber Systems and Operations (U.S. students only)
(with emphasis on cyber resiliency)

In special circumstances students may pursue a Master of Science degree in Applied Science with emphasis on Signal Processing, Physical Oceanography, or Acoustics.

Subspecialty

Completion of this program qualifies an officer as an Undersea Warfare Subspecialist with a subspecialty code of 6301P. The curriculum sponsors are N97 (Submarine Warfare) and N95 (Expeditionary Warfare).

Typical Subspecialty Assignments

Naval Undersea Warfare Center COMINEWARCOM Naval

Air Warfare Center
Submarine Development Squadron Twelve
Program Executive Offices
Patrol Wing Staffs
Carrier Group Staffs
Naval Air Systems Command
Naval Surface Warfare Development Group
OPNAV
Destroyer Squadron Staffs
Fleet Mine Warfare Training Center
Operational Test and Evaluation Force

Typical Course of Study

Notes: Courses NW3230, NW3285, NW3275, and
NW3276, are Joint Professional Military Education courses
and are applicable to U.S. Navy students only. UW0001 (0-
1) Seminars on Undersea Warfare related topics are
offered approximately bi-weekly throughout the program.
USW students are expected to attend UW0001 seminars
as offered.

Quarter 1

Course	Title	Lecture	Lab
MA1115	Multi Variable Calculus	4	0
MA1116	Vector Calculus	3	0
OC2020	Computer Computations in Air-Ocean Sciences	2	2
PC3400	Survey of Underwater Acoustics	4	0

MA1115, MA1116: 6 week accelerated courses offered sequentially

Quarter 2

MA2121	Differential Equations	4	0
NW3230	Strategy & War	4	2
NW3275	Joint Maritime Operations - part 1	4	0
OC3230	Descriptive Physical Oceanography	3	1

Quarter 3

MA3132	Partial Differential Equations and Integral Transforms	4	0
NW3276	Joint Maritime Operations - part 2	2	2
PH3002	Non-Acoustic Sensor Systems	4	0
UW9999	Specialization Elective		

Quarter 4

ME3720	Introduction to Unmanned Systems	3	2
OS2103	Applied Probability for Systems Technology	4	1
UW9999	Specialization Elective		
UW9999	Specialization Elective		

Quarter 5

NW3285	Theater Security Decision Making	4	0
OA3602	Search Theory and Detection	4	0
OC3260	Fundamentals of Ocean Acoustics	4	1
UW9999	Specialization Elective		

Quarter 6

EO2402	Introduction to Linear Systems	4	1
UW2001	History of USW Part I, Mine Warfare	2	0
UW2003	Undersea Warfare – Yesterday, Today, Tomorrow	2	0
UW9999	Specialization Elective		
UW9999	Specialization Elective		

Quarter 7

OA4607	Tactical Decision Making	4	0
UW0810	Thesis Research/Group Project	0	8
UW0810	Thesis Research/Group Project	0	8
UW9999	Specialization Elective		

Quarter 8

EC3460	Introduction to Machine Learning for Signal Analytics	3	2
OC4270	Tactical Oceanography	3	4
UW0810	Thesis Research/Group Project	0	8
UW0810	Thesis Research/Group Project	0	8

Educational Skill Requirements (ESR)
Undersea Warfare Program
Subspecialty Code: 6301P

Maintaining superiority in Undersea Warfare is an
essential goal for our Navy and one of the CNO's top
priorities. Small, quiet targets, rising ambient noise levels,
technologically sophisticated asymmetric weapons, and
an emphasis on the littoral make conducting successful
offensive and defensive naval operations in the undersea
environment a most challenging task. The Undersea
Warfare curriculum at the Naval Postgraduate School
seeks to improve the performance of officers throughout
their careers in the operation, evaluation, development,
and acquisition of USW systems. To accomplish this
requires a broad, interdisciplinary education in the
fundamental principles of USW. The conceptual tools and
techniques provided by courses in mathematics, physics,
oceanography, operations research, signal processing, and
autonomous systems prepare the officer to understand
and solve new problems. In addition to the broad
education provided by the core courses of the curriculum,

each student will obtain their degree in a specific field such as Operations Research, Electrical Engineering, Engineering Acoustics, Applied Physics, Physical Oceanography, Mechanical Engineering, or Applied Mathematics. The combined breadth and depth of this education provide the Navy with a cadre of officers prepared to respond to future challenges in a wide variety of USW-related jobs. The specific ESRs include:

1. **Mathematics:** The officer will master the mathematical principles and techniques necessary to complete graduate level course work and research related to undersea warfare.
2. **Physics:** The officer will understand physical principles applicable to acoustic, non-acoustic Undersea Warfare (USW) systems.
3. **Acoustics:** The officer will understand acoustical phenomena affecting the design, performance, and operation of acoustic USW systems.
4. **Oceanography:** The officer will understand atmospheric and oceanographic processes influencing the performance and tactical use of USW systems.
5. **Signal Processing:** The officer will understand principles of signal processing and machine learning as they apply to signal and information processing in USW systems.
6. **Operations Research:** The officer will understand the principles of USW search, detection, and localization (in support of operational planning). The officer will understand principles of tactical decision aids and data analysis in the evaluation of USW systems.
7. **Unmanned Systems:** The officer will understand the fundamental technologies and capabilities of unmanned underwater systems and tactical robotics. This will include a physical understanding of autonomous vice remotely operated current and future technologies, such as artificial intelligence and machine learning, as well as concepts and limitations for unmanned systems as part of future undersea operating concepts.
8. **Programming and Simulation:** The officer will be able to program solutions to essential engineering problems. The officer will be able to assess models and perform simulations.
9. **Problem Solving and Practical Applicability:** The officer will demonstrate the ability to conduct independent analysis in Undersea Warfare and proficiency in written and oral presentations. Additionally, they will understand the history of USW and its implications to today's Navy.

Curriculum Sponsor and ESR Approval Authority

Director, Submarine Warfare Division (N97) Director, Expeditionary Warfare Division (N95)

Anti-Submarine Warfare Certificate - Curriculum 274

Academic Associate & Technical Point of Contact

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Brief Overview

The ASW Certificate consists of a sequence of four highly technical courses designed to provide our civilian and active-duty workforce with a learning experience which extends their general undergraduate education to include the essential concepts, equations, and skill sets needed to understand, design, and use ASW systems. The web-based courses are paced week-to-week by the instructors, but students have the flexibility to do coursework at times of their choosing during each week.

The total number of NPS credits obtained for the certificate is 11 graduate and 3 undergraduate.

Requirements for Entry

A Bachelor's degree from an accredited institution including a course in single-variable calculus, a course in calculus-based physics and calculus-based probability.

Convenes

Spring

Program Length

5 Quarters

At the completion of the certificate program:
- Students can define key concepts in geological, physical, and biological oceanography and evaluate their implications in naval operations.
- Students can evaluate the performance of a sonar system and design a basic sonar system to achieve given operational requirements.
- Students can analyze one dimensional acoustic signals.
- Students demonstrate proficiency in fundamental concepts of array processing.
- Students can apply logic, analytics, and mathematical modeling to quantitatively evaluate naval tactics against an adversary in search, patrol, and combat operations.

Graduate Certificate Requirements

The academic certificate program must be completed within three years of admission to the program. A student must maintain a 3.0 GQPR in the certificate courses to be awarded a certificate.

Required Courses

Course	Title	Lecture	Lab
PH3401	Introduction to the Sonar Equations	3	0
OC2930	Oceanography for Undersea Warfare	3	0
EO3404	Applied Digital Signal Processing	3	2
OS3680	Naval Tactical Analysis	4	0

The standard courses in the ASW Certificate are PH3401 Intro to Sonar Equations, OC2930 Intro to Oceanography for USW, OS3680 Naval Tactical Analysis, and EO3404 Applied Signal Processing. When resident students take the certificate, they may substitute equivalent or superior resident courses where possible.

Acceptable substitutes for PH3401 are PH3452 *Underwater Acoustics,* OC3260 *Sound in the Ocean,* or PC3400 *Survey of Underwater Acoustics.*
An acceptable substitute for OC2930 is OC3230 *Descriptive Physical Oceanography*.
Acceptable substitutes for EO3404 are EO3402 *Signals and Noise* or EC3400 *Digital Signal Processing.*
An acceptable substitute for OS3680 is OA3602 *Search Theory.*

Institutes and Centers

Center for Executive Education CEE

The Center for Executive Education (CEE) at NPS is a major component of the Navy Executive Development Program and is charged with preparing senior Naval leaders for positions of increased responsibility and leadership within DoD. CEE provides professional development opportunities to Naval senior leaders with an emphasis on maintaining warfighting effectiveness while optimizing resources and enhancing business discipline. All programs are designed to provide Naval senior leaders with the knowledge, skills, and abilities to manage and lead effectively within a dynamic geo-political environment and emerging cognitive age through the use of case studies, team exercises, practical applications, and interactive class discussions.

CEE courses are offered on campus, at the requesting command's location and online. CEE's periodic courses include:

- Navy Senior Leader Seminars (NSLS) - Captains/GS-15/CMDCM – Five days; offered five times each year
- Strategic Planning for Execution: Assessment and Risk (SPEAR) workshop - Flags/SES/O6/GS-15 and their teams – Four days; offered 3 times each year
- Strategic Communication Workshop (SCW) - Flags/SES/O6/GS-15 and their teams – Four days; offered 3 times each year
- Leadership and Communication for Senior Supervisors (LCSS) - O4-O5/GS-13-14/E7-E9 – Four days; offered 3 times each year
- Emerging Technology Awareness for the Warfighter (ETA-W) - O6-O4/GS15-GS13/E7-E9 – Three days; offered one time each year
- Emerging Technology Awareness for Senior Leaders (ETA-SL) – FLAG/GENERAL OFFICER/SES 2 days; offered one time each year
- Creating a Culture of Innovation (CCI) - O6-O4/GS15-GS13/E7-E9; Three days; offered one time each year
- Effective Leadership for DEI and High Performance - O6-O4/GS15-GS13/E7-E9; Three days; offered one time each year

CEE also develops and provides customized executive programs upon request.

For more information, please contact the CEE Registrar by calling (831) 656-3334 or by visiting our website www.nps.edu/cee.

Center for Regional Maritime Strategy (CRMS)

Website

http://my.nps.edu/web/center-for-regional-maritime-strategy

Director

Mike Malley, Ph.D.
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Overview

The center serves as the focal point for research and education in the NSA Department. Its purpose is to strengthen the U.S. Navy's awareness and understanding of political, economic, cultural, and strategic issues that affect naval operations, strategy, and policy in critical maritime regions around the world.

The center draws on the extensive regional studies expertise of the NSA Department's faculty to produce studies, analyses, and course material that inform senior Naval leaders and educate the Navy's next generation. NSA faculty have deep knowledge of regions ranging from the South China Sea to the South Atlantic and from the Mediterranean Sea to the Indian Ocean. The center will facilitate collaboration between NSA faculty and partners at other academic institutions, as well as foster closer relationships with sponsors in the Navy and throughout the U.S. government.

Point of Contact Information

Academic Programs

Questions about the academic content of NSA degree programs should be addressed to the cognizant Academic Associate or Program Committee Chair, as noted in the curriculum descriptions, above.

Administrative and Service Related Matters

Heather Eldridge
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Monterey, CA 93943

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Joint Professional Military Education

Questions about Joint Professional Military Education should be addressed to:

Professor Fred P. Drake
Chairman, Joint Professional Military Education
Naval Postgraduate School
1 University Circle, Halligan Hall, Room 239
Monterey, CA 93943

(831) 656-3003, DSN 756-3003
fpdrake@nps.edu

Admissions

Questions about admission to the Naval Postgraduate School should be addressed to:

Susan Dooley
Director of Admissions
Naval Postgraduate School
1 University Circle, Herrmann Hall, Room 022
Monterey, CA 93943

(831) 656-3093, DSN 756-3093
grad-ed@nps.edu

International Students

International students may also wish to contact the International Graduate Programs Office:

Danial Pick, COL, USA (Ret)
Director of International Graduate Programs
Naval Postgraduate School
1 University Circle, Herrmann Hall, Room 047D
Monterey, CA 93943

(831) 656-2186, DSN 756-2186, FAX (831) 656-3064
Website: https://nps.edu/web/igpo

Institute for Security Governance (ISG)

www.instituteforsecuritygovernance.org

Director: Steven Peterson

Institute For Security Governance

Naval Support Activity Monterey

1635 Cunningham Road (Bldg. 259)

Monterey, CA 93943-5011

Phone: +1 831.656.3171

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Overview:

The Institute for Security Governance — situated within the Defense Security Cooperation University's (DSCU) International School of Education and Advising (ISEA) — is the Department of Defense's Center of Excellence for Institutional Capacity Building (ICB). As a component of the Defense Security Cooperation Agency (DSCA), and one of its primary international Security Cooperation schoolhouses, ISG is charged with building partner institutional capacity and capability through tailored advising, education, and professional development programs grounded in American values and approaches.

Formerly Center for Civil-Military Relations (CCMR), ISG is a tenant activity at NPS.

Mission:

Advance national security and foreign policy objectives by building partner institutional capabilities and enhancing the approach and conduct of Institutional Capacity Building to address security challenges.

Vision:

Promote and advance American values, interests, and objectives through the development, integration, and advancement of the field and practice of Institutional Capacity Building.

Structure:

The ISG team is comprised of a civilian faculty and staff of over 90 personnel. ISG personnel are augmented by a contract support team, a robust group of adjunct faculty, and team of subject matter experts drawn from the military, government, industry, academia, and non-government organizations.

To learn more about our Team:
https://instituteforsecuritygovernance.org/team

Our Approach:

Advising Institutions to Build Capacity

Our long-term advising efforts enable partners to govern, manage, operate, maintain, and sustain defense capacity and capabilities. ISG's experienced teams work with specific partner institutions to cultivate security governance, defense management, operational planning, resources management, defense logistics, human capital and professional military education and many other critical tasks. Powered by detailed scoping and custom project design, ISG integrates innovative assessment, monitoring, and evaluation practices into each capacity building effort.

Educating Individuals to Build Capability

ISG designs and delivers short-format education and professional development courses that accelerate participant understanding of complex security and defense issues. Delivered in the U.S. or abroad, our offerings bring applied learning practices into bilateral or multilateral classroom environments. Participants are encouraged to engage in open, peer-to-peer learning and form lasting international and interagency networks.

Advancing the Field and Practice Of ICB

As the ICB Center of Excellence, ISG is charged with pushing the field and practice of ICB forward. We

contribute to research and development in emergent domains within the field and remain a key resource for ICB-related information; including best practices, common challenges, and lessons learned. ISG also serves as a space where ICB methodology is discussed, refined, and strengthened.

Enhancing ICB in Security Cooperation

ISG seeks to deepen understanding of ICB throughout the security cooperation community. This includes orienting and integrating existing capacity building efforts, offering opportunities to coordinate and collaborate, providing helpful tools and resources, and growing future ICB military and civilian leaders. To meet these objectives, ISG reports to the Defense Security Cooperation University (DSCU) and works closely with other security cooperation education and training bodies.

Focus Areas:

- Global Institutional Advising
  - Africa
  - Europe
  - Indo-Pacific
  - Middle East & Central Asia
  - Western Hemisphere
- Governance & Management Education
  - Security Governance
  - Civil-Military Relations
  - Strategy, Policy & Planning
  - Resource Management
  - Defense Acquisition
  - Logistics
  - Human Capital
  - Professional Education
- Capability Education & Development
  - Cyber Capability
  - Maritime Security
  - Peacekeeping & Exercises
  - Emergency Management & Resilience
  - Conflict, Terrorism, & Protection
- ICB Knowledge &
  - Practice Development
  - Doctrine & Methodology
  - Assessment & Integration
  - Research & Development
  - Outreach & Communications
  - Security Cooperation Education Integration
  - Communities of Practice and Interest

Activities:

All ISG projects are custom-designed to the individual conditions and requirements of the recipient country, and are in accordance with sponsor and stakeholder guidance.

Non-Resident Advising

Conducted both in Partner Nations and virtually several times a year – including continuous intersessional touchpoints – focusing on building adaptable Institutional Capacity Building programs to meet shared bilateral Security Cooperation objectives.

Resident Advising

Deploy to select Partner Nations for 12-24 months – with the option of extension – partnering senior Department of Defense civilian experts with allied counterparts to improve ministerial capacity in key areas.

Resident Education

Primarily conducted at ISG headquarters in Monterey, California in an adult-learning style with breakout groups, interactive exercises, student-led presentations, and related approaches – providing adaptable, scalable, and tailored education programs across a wide array of functional areas to address U.S. and Partner Nation security objectives.

Mobile/Virtual Education Teams

Conducted in bilateral or multilateral formats in Partner Nations – or in the case of Virtual/Hybrid, in a synchronous or combination synchronous/asynchronous formats – tailored to the bilateral and/or regional context, and designed in working group, workshop, and seminar formats. They too provide adaptable, scalable, and tailored education programs across a wide array of functional areas to address U.S. and Partner Nation security objectives.

Multinational Exercises

ISG provides customized support to unique exercises that challenge U.S. and multinational military staffs to function effectively and coordinate full-spectrum missions in complex operational spaces. Advising programs can be itinerate or placement of a resident advisor.

Course Titles:

For resources related to the Institute's educational programming offered in resident, mobile, virtual, and hybrid formats -- including the content and timing of these various
offerings: www.instituteforsecuritygovernance.org

MOVES Institute

www.movesinstitute.nps.edu

The Modeling, Virtual Environments, and Simulation Institute is the nation's Institute for Defense Modeling and Simulation focusing on enhancing the operational effectiveness of our joint forces and our allies by providing superior training and analysis products, education, and exemplary research. The Institute manages graduate degree programs in Modeling and Simulation in support of all the services and our allies. The Institute's research focus is in the areas of combat modeling, visual simulation, training and human systems, intelligent agents, and adaptive systems.

Naval War College Partnership & JPME

Chair

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James Adams, Associate Professor; COL USA (Ret.) M.S. National War College (2009); B.S. Business Administration, University of Tennessee, Martin (1984).

Yvonne Chiu, Associate Professor; Ph.D., University of California at Berkeley (2008); M.A. University of California at Berkeley (1999); A.B. Stanford University (1998).

Jonathan E. Czarnecki, Professor; COL USA, ARNG (Ret.); Ph.D., M.A., State University of New York at Buffalo (1979, 1976); B.S. Clarkson University (1970).

Richard B. Grahlman, Professor; CDR USN (Ret.); M.S., Naval Postgraduate School, B.S., Oregon State University.

Samuel Helfont Assistant Professor; Ph.D., Princeton University; M.A., Princeton University; M.A., Tel Aviv University (Israel); B.A., University of Maryland.

Michael W. Jones, Professor; CDR USNR; Ph.D., Florida State University (2004); M.S., B.A., University of New Orleans (1993).

J. Scott McPherson, Associate Professor; CAPT USN (Ret.); Ph.D., Salve Regina University (2009), M.A., Naval War College, (2000); B.A., University of Arkansas at Little Rock (1985).

Thomas P. Moore, Professor; COL USAR (Ret.); Ph.D., Virginia Tech (1986); M.S., Stanford University (1975); B.A., Northeastern University (1974).

Dayne E. Nix, Professor; CDR USN (Ret.) Ph.D., Salve Regina University (2007); M.A., Naval War College (2004); Th.M., Duke University (1993); M.Div., Denver Seminary (1983); B.A., University of Colorado (1974).

David F. Overton, Professor; LtCol USMC (Ret.); M.S., Naval Postgraduate School (2003); B.S., East Carolina University (1994).

Paul E. Rasmussen, Associate Professor; CDR USN (Ret.); M.A., U.S. Naval War College (2012); M.B.A., University of Nebraska (2009); B.S., University of California at San Diego(1993).

Gregory D. Reilly, Associate Professor; COL USA (Ret); M.A., U.S. Naval War College (2007); MMAS School of Advanced Military Studies (1997); MMAS Fort Leavenworth (1996); B.A. Economics, Sacramento State University (1984).

Joyce Sampson, Professor; Ph.D., M.A., Florida State University (2001); M.A., Kent State University (1992); B.A., Kent State University (1989).

John M. Sheehan, Associate Professor; CDR USN (Ret); Ph.D., Naval Postgraduate School (2013); M.A., George Mason University (2007); M.A., U.S. Naval War College (2004); M.B.A. Columbia College (2003); B.S. California State University, San Jose (1988).

Robert W. Tomlinson, Associate Professor; Col USAF (Ret), Ph.D., Claremont Graduate University (2012), MA, California State University Northridge (2003); MPA, Golden Gate University (1981); BA, College of the Holy Cross (1974).

Craig A. Whiteside, Associate Professor; LTC USA (Ret); Ph.D. (2014); M.A. (2011) Washington State University; C&GS College (2004); B.S., U.S. Military Academy (1991).

Professional Military Education (PME) and Joint Professional Military Education (JPME)

The U.S. Naval War College curricula offered at NPS fully meets the requirements for Navy PME as established by the Chief of Naval Operations and for JPME Phase I qualification as established by the Chairman, Joint Chiefs of Staff for Intermediate Level Professional Military Education.

In 1999, NPS partnered with the U.S. Naval War College in Newport, RI (NWC) to provide NPS students a tailored program leading to a Naval War College diploma and JPME phase I certification. From this beginning, the Naval War College JPME courses at NPS have been taught by highly qualified NWC-at-NPS faculty who reflect the high standards of NWC content, teaching methodology, and program management.

The NWC-at-NPS JPME curriculum mirrors the NWC resident program in Newport while tailoring it to the NPS program and constructs. It provides instruction in three core courses at NPS: Strategy and War (1 Quarter in length), Theatre Security Decision Making (1 Quarter in length), and Joint Maritime/Military Operations (one course covered over two quarters).

Of Note: Students should take the courses in the order listed above: Strategy and War; Theater Security Decision Making, then Joint Maritime Operations parts I and II (consecutively) in order to effectively participate in the final exercise that will demonstrate the holistic nature of

the three courses. Relatedly, only those students who complete the entire sequence (S&W, TSDM and JMO) will earn JPME phase I certification. Transcripts of those students who complete all NWC courses (S&W, TSDM and JMO) through other methodologies (i.e., Fleet Seminar, correspondence,) will be annotated to verify their JPME phase I certification.

Naval War Course Descriptions

NW Courses (p. 469)

Marine Corps Professional Military Education at NPS

Marine Corps officers selected to attend NPS through the Commandant's Career-Level Education Board (CCLEB) or the Commandant's Professional Intermediate-Level Education Board (CPIB) can participate in Marine Corps PME seminar programs for captains and majors. The Marine Corps' College of Distance Education and Training (CDET) designs, develops, and delivers both of the Marine Corps' officer distance education programs (DEP): the Expeditionary Warfare School (EWSDEP) and the Command & Staff College (CSCDEP). Interested officers may contact the CDET MCAS Miramar Campus at cdet_miramar@usmc.mil or call 858-307-1373.

NPS JPME Requirement. Resident DON students shall have the opportunity to participate in the strategy and naval warfare focused courses embedded within their respective curricula, as well as in Joint Professional Military Education (JPME) offered through the Naval War College program at NPS. JPME provides courses in strategy and war, theater security decision making, and joint maritime operations. Curriculum sponsors and community managers shall determine the requirement for JPME for DON students at NPS.

Naval War College C & S option. Marine Corps officers attending NPS may enroll in the Naval War College Command and Staff program in lieu of the Marine Corps Command and Staff DEP. The Naval War College courses needed to complete the Navy C & S requirement while at NPS are: NW3230 (Strategy and War - one quarter), NW3275 and NW3276 (Joint Maritime Operations - two consecutive quarters), and NW3285 (Theater Security Decision Making - one quarter).

Air Force Intermediate Development Education (IDE) at NPS

Air Force officers selected for IDE programs at the NPS are managed by the Air Force Institute of Technology, Civilian Institution Programs (AFIT/CI) office at Wright-Patterson AFB OH. Selected officers complete a master's degree program at NPS in a field of study appropriate to their careers.

Nonresident Education Opportunities (Distance Learning)

Nonresident Education Opportunities (Distance Learning)

While courses are available to students in Monterey at its main campus, NPS Distance Learning (DL) enables students to earn certificates or degrees at locations across the nation or around the globe.

- Mission-funded seats are available to eligible active duty naval officers (USN & USMC). Additional course fees may be required.
- All Military and DoD/government civilians are eligible to enroll in NPS Distance Learning programs.
- Select DoD Contractors are also eligible for enrollment in programs related to systems engineering and defense product development.
- Research associated with graduate studies may also include classified work.
- Although program length and costs vary, certificate programs are typically four courses (three to four credit hours each) while Master's degrees typically run 12 to 16 courses.

More information on tuition and admissions requirements for the NPS Distance Learning programs can be found at online.nps.edu.

Air Force Institute of Technology— Distance Learning

The Air Force Institute of Technology (AFIT), located at Wright-Patterson AFB, Ohio, is the Air Force's graduate school of engineering and management as well as its institution for technical professional continuing education. AFIT is developing distance learning programs for government students who cannot enroll in one of AFIT's resident programs. Detailed information about AFIT's nonresident programs can be found at www.afit.edu/en/dl/

The Naval Postgraduate School maintains a Strategic Alliance with the Air Force Institute of Technology. A memorandum of agreement between the Secretary of the Navy and the Secretary of the Air Force forms this alliance to ensure the two institutions continuously work together to meet the educational needs of the Armed Forces of the United States. NPS and AFIT will continue to reflect the heritage and character of their respective services, meeting Joint and service-unique needs, minimizing unnecessary redundancy, maintaining quality and realizing efficiencies and economies of scale.

Courses

AE

AE0810 - Thesis Research (0 - 8)

Every student conducting thesis research will enroll in this course.

AE2440 - Introduction to Scientific Programming (3 - 2)

This course offers an introduction to computer system operations and program development using NPS computer facilities. The main goal of the course is to provide an overview of different structured programming techniques, along with introduction to MATLAB/Simulink/GUIDE and to use modeling as a tool for scientific and engineering applications. The course discusses the accuracy of digital computations, ways to incorporate symbolic computations, and presents numerical methods in MATLAB functions. AE2440, EC2440, and SE2440 are the same course.

Prerequisite: Knowledge of single variable calculus and matrix algebra..

AE3740 - Nuclear Command, Control, and Communications Systems - Part I (3 - 0)

Same as SS3740 (p. 511). This course is the first of two courses that introduce nuclear command & control concepts as well as a comprehensive, technical view of the US Nuclear Command & Control & Communications (NC3) system. The first course will concentrate on deterrence theory, command & control theory and history behind the US NC3 system, as well as an introduction to NC3 support space systems.

Students will study international as well as domestic law & policy guidance in relation to nuclear weapon employment and proliferation. Nuclear close calls will be analyzed to identify failures in systems & procedures that must be avoided in the future. Students will study the state of nuclear weapons worldwide and understand the US strategy to counter the various nuclear threats. Students will begin a comprehensive study of the US NC3 system, which will continue in the second course.

Prerequisite: SS3011 (or experience with orbital mechanics), SS3613 (or experience with satellite communications and link budgets). Cross-Listed as: Same as SS3740. Security Clearance Required: Secret.

AE3741 - Nuclear Command, Control, and Communications Systems - Part II (3 - 0)

Same as SS3741 (p. 511). This course is the second of two courses that introduce nuclear command & control concepts as well as a comprehensive, technical view of the US Nuclear Command & Control & Communications (NC3) system. There will be a large emphasis on future trends and vulnerabilities, which must be considered for future systems.

Students will understand theory of Command & Control (C2) and operation of highly reliable systems, methods used protect and secure these systems in the extreme adverse environments and ensure their reliability.

Prerequisite: SS3740 (NC^3 Systems Part I). Cross-Listed as: Same as SS3741. Security Clearance Required: Secret.

AE3804 - Thermal Control of Spacecraft (3 - 2)

A solid foundation in heat transfer is the basis for design, testing, operation and evaluation of spacecraft thermal control systems. Therefore, the course examines the three fundamental modes of heat transfer (conduction, convection and radiation) singly and in combination in one and two dimensions, in unsteady conditions, and involving phase changes, with emphasis on applications to spacecraft design. The course examines thermal environments, thermal design, thermal testing, thermal operation, and integration of thermal design into the overall spacecraft systems. Also considered are unique problems and solutions in spacecraft design integration of thermal control systems. PREREQUISITES: None.

AE3811 - Space Systems Laboratory (2 - 2)

This course covers principles of spacecraft test programs, test philosophies and requirements of commercial, NASA, military programs, and evaluation as a team of a given spacecraft program test requirements .It covers component, subsystem, and system level tests. Environmental tests cover static, sinusoidal, acoustic, random, shock, modal, thermal balance and thermal vacuum tests. The course covers experiments in Fltsatcom Laboratory on satellite performance and other spacecraft test beds. The course also covers test effectiveness and history of on-orbit failures.

Prerequisite: AE3840.

AE3815 - Spacecraft Rotational Mechanics (3 - 2)

Fundamentals of vector and tensor algebra. Rigid shape orientation and its parametrization, Euler's theorem, Direction Cosine Matrix and Rotation Matrix, Orientation Quaternion, Modified Rodriguez Parameters. Change of coordinates for vector and tensors. Rigid shape orientation differential kinematics, angular velocity, Darboux equation. Rigid body spacecraft rotational dynamics: angular momentum, inertia tensor and its transformations, Euler's rotational motion equations, solutions of the Euler's equation in significant cases, spin stabilization, energy-sink analysis. Modeling of environmental torque acting on an orbiting spacecraft: gravity gradient, aerodynamic torque, solar pressure torque. During the two hours per week of laboratory as

well as the homework's the students build up sequentially a full software simulator of spacecraft rotational mechanics to be used in subsequent classes.

Prerequisite: MA2121.

AE3818 - Spacecraft Attitude Dynamics and Control (3 - 2)

Definition of reference frames for spacecraft attitude determination and control systems (ADCS). Attitude parameterizations and transformation of vectors between two reference frames. Block diagrams for spacecraft ADCS. Overview of common spacecraft attitude sensors and actuators. Attitude determination algorithms. Rigid body orientation differential kinematics and spacecraft rotational dynamics. Review of linear feedback control, and application of feedback control to spacecraft pointing. ADCS considerations for spacecraft design. Discussion of cyber-security in relation to ADCS. Laboratory projects include simulation and analysis of spacecraft attitude dynamics, pointing, control, and practical challenges.

Prerequisite: ME2801 or EC2300.

AE3820 - Advanced Mechanics and Orbital Robotics (3 - 2)

This course is an intermediate level analysis of the dynamics of space systems, including: ascent and descent of rockets, tethers, yo-yo despin, spinning hubs with flexible appendages, single stage to orbit, and various problems in spacecraft attitude dynamics such as nutation dampers. The analysis will include developing the equation of motion, equilibrium and stability analysis, solutions of nonlinear systems using perturbation methods and numerical techniques. Computational and symbolic manipulator packages will be used extensively.

Prerequisite: MA2121.

AE3830 - Aerospace Guidance and Control (3 - 2)

Overview and fundamental components of Guidance, Navigation and Control Systems. State-space representation of dynamical systems. Simulation of nonlinear dynamical systems. Sources and effects of navigation and modeling errors on guidance and control systems. Error propagation techniques and Monte Carlo simulations. Review of PID controllers. Introduction to basic optimal control theory. Linear quadratic double-integrator problems and foundations of real-time optimal control (RTOC). Guidance theory via RTOC. Class project on a two-degree of freedom Guidance-Control System architecture.

Prerequisite: ME2801 or EC2300, MA2121 or equivalent.. Cross-Listed as: Cross-list AE3830 as both AE3830 and ME3830 to support AE and ME curricula.

AE3840 - Analysis of Spacecraft Structures (3 - 2)

Students will be introduced to solid mechanics and dynamics. The fundamentals of strength of materials and beam theory, along with stress analysis, buckling, and vibration theory, will be applied to perform structural analysis of spacecraft structures. Students will learn the finite element method and use standard aerospace industry analysis tools. Design considerations specific to spacecraft structures will be presented to examine the engineering of space structures.

Corequisite: MA2121, or consent of instructor..

AE3851 - Spacecraft Propulsion (3 - 2)

Introduces concepts and devices in spacecraft propulsion. It reviews fundamental compressible fluid mechanics, thermodynamics with combustion analysis, and cycle analysis for liquid rocket engines. Conventional monopropellants, bipropellants, and solid propellants are discussed. Electric propulsion schemes (resistojets, arcjets, ion, magneto-plasma-dynamic, etc.) are introduced and their performances contrasted with chemical schemes. Characteristics of more advanced concepts (laser, solar, nuclear, etc.) are also considered.

Prerequisite: MA2121.

AE3852 - Propulsion for Launch Vehicles (4 - 0)

Introduction to propulsion for launch vehicles, beginning with mission energy requirements and an overview of current and proposed launch propulsion devices. Performance analysis, operating characteristics and propellant selection criteria are considered for air breathing and solid, liquid and nuclear rocket motor propulsion systems. Advanced cycles and concepts are presented.   Design of components and subsystems.

Prerequisite: ME3201.

AE3870 - Computational Tool for Spacecraft Design (2 - 4)

In this course, the students become familiar with the use of computer aided design tools for spacecraft subsystems and system design. The tools are for conceptual spacecraft design trade-offs and detailed subsystem design, such as for structures, thermal, attitude control, and communications.

Prerequisite: Consent of instructor.

AE4362 - Astrodynamics (3 - 0)

Review of the two-body problem. The effects of a third point mass and a distributed mass. Expansion of the disturbing potential in series of Legendre functions. Variation of parameter equations for osculating orbital elements. Perturbation and numerical solution techniques. Statistical orbit determination. Codes used by the military to maintain the catalog of artificial satellites and space debris.

Prerequisite: SS3500 or equivalent or by consent of instructor.

AE4452 - Advanced Missile Propulsion (4 - 1)

Analysis and design of solid propellant rockets, ramjets, dual-combustion ramjets, ducted rockets, and detonation-based propulsion systems. Propellant selection criteria and characteristics, combustion models and behavior,

performance analysis, combustor design, combustion instabilities and damping, mission and flight envelope effects on design requirements and technology requirements. Use of chemical equilibrium analysis software, performance, and grain design codes.   Laboratory test firings for comparison with measured performance.

Prerequisite: AE3851 or consent of instructor.

AE4500 - Advanced Space Flight Mechanics and Orbital Robotics (3 - 2)

This course covers advanced topics in Space Flight Mechanics and Orbital Robotics. The class is designed to provide fundamental engineering and mathematical tools necessary to analyze and design emerging advanced Space Flight missions, such as: Distributed Space Systems, Constellations and Swarms, On-orbit Assembly, Servicing and Manufacturing (ASAM), Space Debris Remediation. Focus of the course is given to modeling the relative orbital and attitude mechanics and advanced guidance and control aspects of co-orbiting artificial satellites. Topics include relative orbital mechanics and orbital perturbations; linear and non-linear proximity maneuver dynamics and control in SE(3); formulation of relative motion using orbital elements; low-thrust propulsion for formation flying; untraditional space flight maneuvers such as those exploiting differential drag. The course teaches rigorous mathematical analysis methods. Numerical simulation experiments will be used to reinforce the learning and enable to case-study realistic mission scenarios. This course covers recent advances of Astronautical Engineering and emphasizing contemporary issues of high interest to DoD, NASA and US Space community at large.

Prerequisite: Orbital Mechanics SS3500, OR Classical Physics OR Engineering Mechanics OR Approval by Course Coordinator. Corequisite: None. Cross-Listed as: ME4500.

AE4502 - Supersonic and Hypersonic Flows (4 - 0)

One-dimensional, compressible flow is reviewed. Two-dimensional and axis-symmetric supersonic flow of ideal gases. Oblique shocks and expansion waves. General compressible flow equations including Fanno and Rayleigh flow analysis. Potential supersonic and conical flows. Compressible scaling and transonic area ruling. Effects of very high velocity and low density. Hypersonic flow. Mach number independence and equivalence principles. Newtonian method. Blunt and slender body solutions. Real gas behavior and effect on shock and boundary layers. Applications are presented to satellite parasitic drag and re-entry flows.

Prerequisite: ME3201 or consent of instructor.

AE4506 - Rarefied Gas Dynamics (4 - 0)

Topics include advanced thermodynamics with molecular structure, kinetic theory, distribution functions, Boltzmann equation and transport phenomena from a kinetic theory point of view. Types of flow range from free-molecule to transition, to high temperature continuum. Numerical approaches are discussed. Applications to space problems and hypersonics are treated.

Prerequisite: ME3201 or equivalent..

AE4800 - Machine Learning for Autonomous Operations (3 - 2)

This course covers the theory, computation and practical implementation of machine learning concepts for the design and autonomous operations of aerospace and marine engineering systems. Specific machine learning topics covered are: construction of meta-models using three- and six-degree-of-freedom Newtonian dynamical equations, design of experiments for end-to-end dynamical systems, generation of labeled training data, neural networks, and deep learning. These topics will be covered alongside the development of specific meta-models using physics-based simulations of aerospace and marine engineering systems. Examples will be drawn from a sample of DoD problems such as range prediction for a ballistic missile and predicting the damage from a simulated attack on an airfield. Relevant concepts from optimization theory will also be covered as part of the foundations of machine learning. MATLAB-based assignments will form the core of a student's learning experience. This course may also be used as part of the allowable electives for the Robotics Certificate program.

Prerequisite: ME3420 OR AE3830 or by consent of instructor. Cross-Listed as: Cross-listed with ME4800.

AE4816 - Dynamics and Control of Space Structures (4 - 0)

Review of dynamics, finite element method, structural natural frequencies, mode shapes, and control of flexible structures. Smart sensors, actuators and applications to active vibration control, shape control, vibration isolation and fine beam pointing. Equation of motion of spacecraft with flexible structures, and control of spacecraft and flexible structures. The interaction of flexibility and control. Impact of flexibility on the performance of military spacecraft and future trends.

Prerequisite: AE3830, ME3521, and EC2300 or equivalent or by consent of instructor.

AE4818 - Acquisition, Tracking, and Pointing of Military Spacecraft (3 - 2)

This course covers acquisition, tracking, and pointing (ATP) design for military systems, such as spacecraft and laser beam control systems. It covers effects of structural flexibility and jitter on ATP performance, jitter control, acquisition system, tracking algorithms, laser beam control, laser beam aberration due to atmosphere and its correction by using adaptive optics, and spacecraft attitude control. The course will also cover laboratory examples of ATP designs for military systems.

Prerequisite: Knowledge of dynamics and control or

consent of instructor.

AE4820 - Robotic Multibody Systems (3 - 2)

This course focuses on the analytical modeling, numerical simulations and laboratory experimentation of dynamics and control of the autonomous maneuvering of robotic multibody systems. Systems of one or more robotic manipulators that are either on a fixed base or mounted on a moving base are considered the mechanics, guidance and control of these robotic manipulators are studied and their modeling analyzed in detail. Emphasis is given for the case of an open-tree robotic manipulator mounted on a drifting base. Applications are considered for orbiting spacecraft, underwater, surface, ground and airborne vehicles. The course laboratories focuses on analytical and numerical simulations as well as hands-on experimentation on hardware-in-the loop test bed. The Robotic Operating System as well as the Gazebo development environment is extensively used together with Matlab/Simulink and the in house developed Space Robotics Toolbox (SPART).

Prerequisite: AE3818, ME3801or by consent of instructor.

AE4824 - Applications of Deep Learning for Military Systems (3 - 2)

This course covers the applications of deep learning for military systems including satellite imagery processing and target detection, classification and aimpoint tracking for high energy laser beams. The coverage begins with introduction to computer vision, machine learning, and "shallow" neural networks. Then it expands to deep neural networks, Convolutional Neural Networks (CNN), network architecture design, training and validation, neural network databases, transfer learning, and CNN frameworks including TensorFlow. Laboratory sessions include network design, training, and inference for shallow and deep neural networks using Python programming language. Tailoring various existing CNN network structures for transfer learning will be included as well for satellite imagery processing and target object detection, classification, and tracking.

Prerequisite: Knowledge of controls and basic programming or consent of instructor. Cross-Listed as: Cross-listed with ME4824.

AE4830 - Spacecraft Systems I (3 - 2)

This course emphasizes the systems analysis of geosynchronous spacecraft and covers the analysis of GNC (orbit and attitude control), structures, propulsion, thermal and electrical power subsystems. Basic mathematical equations will be used in the preliminary design of the subsystems and the tradeoff studies involved. The differences and similarities between dual-spin and three-axis stabilized spacecraft will be covered in detail. Systems aspect of a typical mission profile will be illustrated. Throughout, emphasis will be on the spacecraft bus. Students will be engaged in problem solving during most of the laboratory period.

Prerequisite: Completion of Space Operations core-curriculum.

AE4831 - Spacecraft Systems II (3 - 2)

In this course, students will be involved in a group project to design a spacecraft to meet mission requirements. Material presented in AE4830 as well as AE4831 will be utilized. In parallel, this course covers some or all of the following aspects of spacecraft systems: spacecraft testing, TT&C subsystem, and design of observation payloads. Differences and similarities between geosynchronous spacecraft and LEO/HEO spacecraft will be discussed. Topics include gravitational perturbation (J2 effects), gravity-gradient stabilization, and atmospheric drag effects.

Prerequisite: AE4830.

AE4850 - Dynamic Optimization (3 - 2)

This course develops basic measures of performance of a dynamic system with methods to target a set of conditions and optimize the performance. Topics include an overview of the Guidance, Navigation and Control System, state-space models, performance measures, problem of Bolza, the Maximum Principle, and transversality conditions. A significant focus of the course will be in practical methods and numerical techniques for solving boundary value problems. Computational methods will be used to solve a wide range of problems in dynamic optimization arising in combat systems such as rapid vehicle reorientation and targeting problems. Applications include UxVs, autonomous systems, aerospace vehicles and robotic systems. Where appropriate, the course will illustrate systems aspects of mission design and operations.

Prerequisite: MA2121, SS3500, AE3815 or by consent of instructor.

AE4860 - Space Control (2 - 2)

This course covers the fundamentals of Space Domain Awareness, Offensive Space Operations, and Defensive Space Operations. As Naval Officers must be able to affect the Space domain from the Maritime domain while also leveraging effects from the Space domain to the Maritime environment, this course offers an in-depth understanding of the history, policies, doctrine, organizations, technical systems, techniques and operations for Space Domain Awareness, Offensive Space Operations, and Defensive Space Operations terrestrially, in Earth orbit, and in the cislunar orbital environment.

Prerequisite: SS3400 or SS3500 or Consent of Instructor. . Security Clearance Required: Top Secret SCI.

AE4870 - Spacecraft Design and Integration I (2 - 4)

Principles of spacecraft design considerations, spacecraft configurations, design of spacecraft subsystems, interdependency of designs of spacecraft subsystems, launch vehicles, mass power estimation, and trade-offs between performance, cost, and reliability. The emphasis

is on military geosynchronous communications satellites. The course includes an individual design project.

Prerequisite: SS3861, AE3804, AE3840, and AE3851; or by consent of instructor.

AE4871 - Spacecraft Design and Integration II (2 - 4)

A team project-oriented course on design of non-geosynchronous spacecraft systems. Provides understanding of the principles of space system design, integration, and systems engineering, and their application to an overall spacecraft mission. Considerations are given to cost, performance, and test plan. Several DoD/NASA organizations, such as Naval Research Laboratory and Jet Propulsion Laboratory, provide support in the definition of the mission requirements for the project, spacecraft design, and design reviews.

Prerequisite: AE4870 or by consent of instructor.

AE4881 - Aerospace Trajectory Planning and Guidance (2 - 4)

Same as ME4881. This course covers the theory, computation and practical implementation of integrated trajectory planning and guidance algorithms for aerospace vehicles. The theory is based on the next generation of dynamical systems in mechanical and aerospace engineering. Examples will be drawn from a sample of DoD problems in space systems, missile engineering and small munitions. After a review of the state of practice, a unified theoretical framework for solving practically constrained trajectory problems will be developed. The Karush-Kuhn-Tucker conditions will form the foundations of constraint violation and validating optimality conditions. Multiplier theory and its use in solving practical problems will be covered from a real-time computational viewpoint. No-fly zones and engineering requirements will be formulated as a mathematical mixture of state and decision-variable constraints. Extensive MATLAB-based mini-projects will form the core of the laboratory experience. These projects are designed for students to learn the process of constructing a flyable trajectory planning algorithm from first principles to an integrated guidance system.

Prerequisite: AE4850 or ME4703 or ME4822 or Consent of Instructor..

AE4901 - Advanced Topics in Mechanical (Aerospace) Engineering (V - V)

Same as ME4901. Advanced study in Mechanical (Aerospace) Engineering generally on a subject not covered in existing courses. May be repeated for credit with a different topic. This course number should be used to initiate new advanced courses. This course may not be taken on a Pass/Fail Basis.

Prerequisite: Permission of Department Chairman and instructor.

AE4902 - Advanced Study in Astronautical Engineering (V - V)

Directed advanced study in Astronautical Engineering on a subject of mutual interest to student and staff member after most of a student's electives have already been taken. May be repeated for credit with a different topic. Graded on Pass/Fail basis only.

Prerequisite: Permission of Department Chairman.

AE5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

AE5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council.

Prerequisite: Advancement to Candidacy.

CC

CC0001 - Seminar Series in C4I (0 - 2)

Seminars (consisting of guest lectures, video teleconferences, and field trips) are scheduled to provide background information on specific Joint C4I systems and activities.

CC0810 - Thesis Research for C4I Students (0 - 8)

Thesis research for JC4I students

CC3000 - Command and Control (4 - 0)

No single activity in military operations is more important than C2! This course focuses on the fundamental theories of both command and control as they apply in current and emerging operational environments including but not limited to the nuances of cross domain C2 involving cyber, information, and kinetic operations. Emphasis is placed on understanding established theories associated with control of forces and systems and how application of these theories varies according to changing forces and systems and how application of these theories varies according to changing and evolving environments, technologies and organizations. Theoretical concepts may include but are not limited to decision making, organizational design, control, motivation, and information theories. Additionally, the course will explore the evolution of information systems to include current enterprise and cloud architectures and how they impact control processes and the ability to command. Cases involving US national security and military events are

studied as a means of identifying successes and failures in the application of these theories. Prerequisites: none.

CC3102 - Combat Modeling and Analysis for Command and Control (3 - 2)

Emphasis is on the use of mathematical and computer models to help solve operational problems or improve the efficiency and effectiveness of control. Topics include but are not limited to the evolution of computer based experimentation and modeling, fundamental mathematical modeling techniques, examination and evaluation of current modeling software, and the interpretation and application of model outputs to real-world situations. The course is the basis for later courses on the use of modeling techniques to conduct detailed analysis and evaluation of command and control processes and systems.

Prerequisite: CC3000 and OS3105 (may be concurrent). Security Clearance Required: Secret.

CC3250 - Command, Control and Communications (C3) (4 - 0)

CC3250 is designed to introduce technical curriculum students to command and control theory and processes as well as the first principles associated with modern electronic communication systems of interest to military operations. Specific course topics include command and control (C2) elements and concepts, the technology influence on C2 as well as fundamental communications principles and concepts to include: signal representations, noise considerations, link analysis, analog/digital modulations and Defense Department systems within the Global Information Grid concept.

Prerequisite: SE1001.

CC3900 - Special Topics in Command, Control, Communications, Computer and Intelligence Systems (V - 0)

Supervised study in selected areas of command, control and communications to meet the needs of individual students. May be repeated for credit if course content changes. Graded on Pass/Fail basis only.

Prerequisite: Consent of Academic Associate. .

CC4101 - Systems Engineering for Joint C4I Systems (4 - 2)

Provide an introduction to systems engineering by performing systems engineering activities, using the tools that a systems engineer uses, analyzing the procedures a systems engineer follows, and performing an actual systems design on a joint C4I system element. The course will use practical examples to explain the fundamental principles, while maximizing the hands-on practical systems design activities. A required course for the 365 curriculum.

Prerequisite: CC3000 and OS3604.

CC4103 - C4I Systems Evaluation (2 - 4)

Experiments in determining C4I system effectiveness using war gaming and simulation. Design of experiments. Survey of current C4I systems evaluation techniques.

Prerequisite: CC4101.

CC4221 - Joint C4ISR Systems (4 - 0)

Synthesis course that deals with adaptation of internet technology to military situations including security, quality of service, survivability and reach to mobile platforms (radio-WAN) issues. Course deals with general interoperability issues in information systems, including communications interoperability, modularity and coupling, and related issues. Course also deals with what the next generation information technology training requirements are likely to be and how to prepare for them. Prerequisites: None.

CC4250 - Enterprise Architecture (4 - 0)

The focus of the course is the DoD enterprise and extended enterprise in terms of its information architecture. The course will look at Enterprise Architecture at the strategic, tactical and operational levels. The activities will include analysis of state of the art architectures, modeling enterprises, viewpoints and communications requirements. The student will analyze existing architectures, learn the relevance and limitations of enterprise architectures and to learn to appreciate the strengths and limitations of various approaches. The student will also become familiar with Service oriented architecture, the Information Technology Infrastructure Library and the role of components in the delivery of infrastructure products and standards.

Prerequisite: CC3000, IS3502.

CC4900 - Advanced Study in C4ISR (V - 0)

Supervised study in selected areas of command, control, and communications to meet the needs of individual students. May be repeated for credit if course content changes. Graded on a Pass/Fail basis only.

Prerequisite: Consent of Academic Associate.

CC4913 - Policies and Problems in C2 (4 - 0)

Study of the fundamental role C2 systems fulfill in operational military situations, including the full range of military operations. Analysis of the changing role of organizational structures and processes as well as technologies and impacts on C2 systems requirements and designs. Consideration of the complexities imposed on C2 systems as the force structure becomes more heterogeneous, as in the case of NATO and NGOs. Case study of selected incidents and systems with a focus on current problems. This course is specifically for students in the 365 curriculum.

Prerequisite: CC4103.

CC4920 - Multi-Criteria Analysis (4 - 0)

The major goal of this course is to learn where and how to search for the best solutions for problems with contradictory criteria. This course will introduce methodology for correct statement and solution of engineering optimization problems, called the Parameter Space Investigation (PSI) method. This technique has been widely integrated into various fields of industry, science, and technology. The PSI method is implemented in the comprehensive software system MOVI (Multicriteria Optimization and Vector Identification) that will be used and distributed during the course. Prerequisites: None.

CS

CS0001 - Colloquium (0 - 1)

(No credit) Departmental lecture series. Attendance is required by students in their fourth quarter. Graded on Pass/Fail.

CS0809 - Capstone Project in Computing (0 - V)

For degree programs that require a capstone project. Every student in degree programs for which a capstone project is required will register for this course during each quarter of study. This course is intended to provide a set of incremental activities, reports, and presentations that will ensure student progress toward the completion of the capstone project within the timeframe of the standard degree program. This course may be repeated for credit.

CS0810 - Thesis Research (0 - 8)

Every student conducting thesis research will enroll in this course.

CS0820 - Integrated Project (0 - 12)

The Naval Postgraduate School provides many opportunities for students to participate in campus-wide interdisciplinary projects. These projects encourage students to conceptualize systems which respond to current and future operational requirements. An integral part of the project involves working with other groups to understand and resolve issues involved with system integration. This course is available to Computer Science students who are participating in a campus-wide integrated project. Course is graded on a pass/fail basis.

CS2000 - Introduction to Computer Systems (6 - 6)

The objective of this course is to introduce foundational concepts from computing systems by constructing a general-purpose computer system from the ground up. By integrating algorithms, computer architecture, operating systems, and compilers through hands-on projects, the course will explore hardware and software design techniques and balancing tradeoffs between competing design constraints. Students will learn about the engineering of systems across many levels of abstraction, from digital logic to software design.

Corequisite: CS2020 (may be enrolled concurrently.).

CS2001 - Fundamentals of Computing Systems (3 - Current: 3; New: 2)

The objective of this course is to teach basic CS concepts by constructing a general-purpose computer system from the ground up. By introducing computer architecture, compilers, operating systems, and algorithms through hands-on projects, students will explore the interdependency of hardware and software design techniques and balance tradeoffs between competing design constraints. Students will learn about the engineering of computer systems across many levels of abstraction, from digital logic to software design.

Corequisite: CS2020 and MA2025..

CS2011 - Computing Systems Principles (4 - 0)

Designed to provide computer science majors with a basic understanding of computer systems hardware. The course includes the following topics. Basic computer concepts, number systems and data representation, digital logic and Boolean algebra, storage devices and organization, basic computer organization and control, and instruction formats, addressing modes and the assembler process. No previous background in computer hardware is assumed. PREREQUISITE: None.

CS2020 - Introduction to Programming (3 - 2)

This course teaches the fundamental programming concepts. Topics covered include data types, variables, expressions, parameter passing, control structures, strings, arrays, exception handling, software development, and testing techniques. Python is used in the course, but the focus of the course is not to teach any specific features of Python. The primary focus of the course is to teach core programming concepts that are universally available in modern programming languages. Prerequisite: None.

CS2071 - Fundamental Object-Oriented Programming in C++ (4 - 2)

This course is an introductory course in program development techniques and the structured and object-oriented programming paradigms using C++. The topics covered include: problem solving, documentation, C++ Integrated Programming Environment (IDE), control flow, native types and statements, operators, structures, functions, pointers, arrays, object-oriented programming, encapsulation (class and objects), and I/O. Weekly programming or written assignments will be assigned.

PREREQUISITE: None.

CS2072 - Fundamental Object Oriented Programming in JavaScript (4 - 1)

This course is an introductory course in program development techniques and the structured and object-oriented programming paradigms using JavaScript. The topics covered include: problem-solving, documentation, control flow, native types and statements, operators, structures, functions, arrays, object-oriented programming, encapsulation, and VO. Weekly programming or written assignments will be assigned. Prerequisite: None.

CS2073 - Fundamental Object-Oriented Programming in Java (4 - 2)

This course is an introductory course in program development techniques and the structured and object-oriented programming paradigms using Java. The topics covered include: problem solving, documentation, Java Integrated Programming Environment (IDE), control flow, native types and statements, operators, structures, functions, pointers, arrays, object-oriented programming, encapsulation (class and objects), and I/O. Weekly programming or written assignments will be assigned. PREREQUISITE: None.

CS2121 - Fundamentals of Automata and Algorithms (4 - 0)

This course presents the basic concepts in automata and algorithms that are essential to computer professionals. Practical examples are used to illustrate course material. Topics covered include finite state automata, pushdown automata, regular and context free languages, limits of what can be solved on a computer (undecidability), the Halting Problem, algorithms for sorting and searching, binary search trees, hash tables, graph algorithms for shortest paths and minimum spanning trees, as well as measures of algorithm complexities (big-O notation and intractability).

CS2171 - C++ as a Second Language (4 - 2)

A first course in C++ for students experienced in another programming language. Students learn to implement problem solutions using the procedural and object-oriented language features of C++. The procedural programming topics include: data types, operators, input/output, control structures, repetition structures, functions, arrays and pointers. The object-oriented topics include: data abstraction and encapsulation, classes, objects, operator overloading, inheritance, polymorphism, templates and reusable class libraries. Weekly programming projects provide students the opportunity to implement techniques covered in class.

Prerequisite: Recent completion of the complete series in another programming language course, or programming experience in another programming language..

CS2173 - Java as a Second Language (4 - 1)

A first course in Java for students experienced in another programming language. Students learn to implement problem solutions using the procedural and object-oriented language features of Java. Topics include: program structures and environment, arrays, exceptions, constructors and finalizers, class extension, visibility and casting, overriding vs overloading, abstract classes and interfaces, files and streams, class loaders, threads and sockets. Programming projects provide students the opportunity to implement techniques covered in class.

Prerequisite: Recent completion of the complete series in another programming language course, or programming experience in another programming language..

CS3000 - Great Principles of Computing Technology (4 - 1)

An introduction to computing technology that underlies all of information technology (IT). Offers a holistic view of the computing field and its connections with other fields in science, business, and philosophy. Covers deep principles of information technology in the areas of computation, communication, coordination, storage, and automation. Emphasizes the historical development of these principles, why they have stood the tests of time, how they relate to one another, and how they relate to issues in other fields. Prepares students for graduate study in computing-related fields. Prerequisites: None.

CS3001 - Foundations of Computer Science (3 - 2)

This course covers core computing concepts and data structures needed to formally represent and analyze computational problems and algorithms relevant to the Navy's mission with precision. Emphasis is on rigorous specification of problems and solutions so that one can more effectively measure and reason about the suitability of technologies developed for areas important to the Navy such as computer security, machine learning, computer networking and autonomous systems.

Prerequisite: CS2001 and CS2020 and MA 2025, or consent of the instructor.

CS3004 - Human-Computer Interaction (3 - 2)

This course studies the design and assessment of modern human-computer interfaces. Students will execute a complete design-prototype cycle that includes needs analysis, requirement analysis, task analysis, conceptual design, scenario development, and then prototyping a functional mock-up suitable for supporting a user study. Students will then conduct a study using their prototype with real users, collect data, and produce a report that presents their data with a final user experience (UX) specification suitable for implementation. Students will

understand how UX fits within the overall product development context and within new emerging paradigms such as mobile computing, wearables, pure voice (AI) interfaces, and others.

CS3021 - Introduction to Data Structures and Intermediate Programming (4 - 1)

This second course in the programming practices sequence builds upon the topics covered in CS2020. The first objective of the course is the teaching of data structures and abstract data types. The second objective is the teaching of object-oriented programming concepts such as inheritance and polymorphism. Topics covered include recursion, file input and output, dynamic memory allocation, lists, binary search trees, balanced binary search trees, and hashing techniques. C++ is used in the course.

Prerequisite: CS2020.

CS3022 - Programming Paradigms (4 - 2)

This is the third course in the programming practice sequence. Based on the knowledge of Java, this course introduces students to other programming paradigms. Many concepts are illustrated using C++ and ADA. Functional programming using Lisp and Haskell and logic programming using Prolog are also introduced in the course.

Prerequisite: CS3021.

CS3023 - Intermediate Programming (3 - 4)

This second course in the programming practices sequence builds upon the topics covered in CS2020. The main objective of the course is the teaching of software techniques and practices for building intermediate level programs. Topics covered include object-oriented principles, recursion, file input and output, dynamic memory allocation, exception-handling, and event-driven programming. A limited amount of functional programming is also covered. The main programming language for this course is Python, with occasional discourses into C++.

Prerequisite: CS2020, or previous Undergraduate experience.

CS3024 - Data Structures (3 - 2)

Abstract data types and data structures are key elements in computer programming. The objective of the course is the teaching of data structures and abstract data types, programming techniques for their development and their use in problem solving. Topics covered include dynamic memory allocation, lists, stacks, queues, binary search trees, priority queues, hash tables and hashing techniques, maps, and graphs.

Prerequisite: CS2020.

CS3030 - Fundamentals of Computer Architecture and Operating Systems (4 - 0)

(For Non-MS CS students, and for entering CS students in the Refresher quarter.) This course, designed for non-computer science majors, provides an overview of basic computer hardware concepts and operating systems software. The following topics are covered: basic computer concepts; data representation; elements of computer architecture and operation; processor and process management; multiprogramming; memory management; and file management. Future trends in computer hardware and operating systems will be discussed.

Prerequisite: CS2020 or Consent of Instructor.

CS3040 - Low Level Programming (3 - 2)

This course is an accelerated survey of the C programming language for computer scientists. It introduces students to programming practices using the C language, and the tools needed to effectively write and debug C programs. The class illustrates the design decisions associated with the low-level operations not implemented in other modern programming languages, demonstrating C's performance and control capabilities. Topics include function calling convention, dynamic memory allocation, recursion, file input/output, kernel management of files, searching/sorting, data types, data structures using C (arrays, hash tables, doubly linked lists, etc), and secure programming in C. Prerequisites: Students are expected to know how to program in at least one language, or exempted by permission of the instructor. Familiarity with Linux or another UNIX-like operating system will be helpful.

Prerequisite: CS2020.

CS3060 - Database Systems (3 - 1)

This course presents an up-to-date introduction to database systems including database system architectures, physical file organizations, data models, query languages, and design of relational and non-relational databases.

Prerequisite: CS3023 or Consent of Instructor.

CS3070 - Operating Systems (3 - 2)

A theoretical and practical treatment of operating concepts. Major course topics include concurrency, Ada tasking, virtual memory including demand paging and segmentation, dynamic linking and loading, file structures and information security. The laboratory portion of the class will give students the opportunity to write and test components of a modern operating system.

Prerequisite: CS2020, CS3021, and CS2011..

CS3071 - Advanced Object-Oriented Programming in C++ (4 - 2)

This is a course in advanced object-oriented programming using C++ for students having an intermediate-level

experience with C++. Students will learn guidelines for using C++ effectively through general design strategies and language specific features to make C++ programs and object-oriented designs more efficient, robust, maintainable and portable. Topics include: Memory management; Constructor and Assignment Operator Issues; Classes and Functions; Inheritance and Object-Oriented Design; Standard Template Library; Exceptions; Efficiency.

Prerequisite: CS2171 or Consent of Instructor.

CS3101 - Theory of Formal Languages and Automata (5 - 0)

This course will cover the Chomsky hierarchy of Formal Languages (regular sets, context-free languages, context-sensitive languages, and recursively enumerable languages) and the types of grammars and automata associated with each class in the hierarchy. Emphasis is placed on the major results of the theory as they apply to language and compiler design. In addition, the major results involving the concept of in decidability are covered.

Prerequisite: CS3001.

CS3111 - Principles of Programming Languages (4 - 0)

This course is an introduction to the design, evaluation and implementation of programming languages. Imperative, functional, logic, and concurrent programming methodologies are investigated, with an emphasis on practical issues. Tradeoffs in choosing different programming languages for a given task are discussed and principles on which an objective assessment of programming language design can be made are presented.

Prerequisite: CS2020 or Consent of Instructor..

CS3113 - Compilers and Translation (3 - 2)

This course is intended to explore the basics of modern compiler design and construction techniques. The fundamentals of scanning, parsing and compiler semantics are developed in the framework of modern compiler-compiler and translator-writing systems technology. The laboratory periods will be used to develop a small model compiler/assembler.

Prerequisite: CS3022, CS3101.

CS3130 - Software Design for Mobile Computers (3 - 2)

This course introduces the student to rapid application development environments, programming languages, and operating systems used by commercial off-the-shelf handheld computers running operating systems such as Newton Intelligence, Magic Cap, GEOS, and PalmOS. The course includes a survey of devices, architectures, operating systems, and programming languages. Laboratory programming exercises will be required for at least one PDA-class operating system platform.

Prerequisite: CS3021.

CS3140 - Low-level Programming II (3 - 2)

Assembly language is used as the vehicle to introduce students to the principles of program construction at the machine code and assembly language levels. Students will be exposed to assembly languages as formally documented by CPU designers. By studying real-world processors, the differences between complex and reduced instruction set are illustrated. Students will study the use of assemblers, linkers, and loaders in the program creation process. Common executable file formats are studied as well as standard calling conventions used to interface assembly language functions with high order languages, viz. C, functions and operating system services. The theory of disassembly and tools for disassembling executable files are covered for the purpose of analyzing binary programs.

Prerequisite: CS3040 or Consent of Instructor..

CS3150 - Design and Analysis of Algorithms (5 - 0)

This course focuses on the design and analysis of efficient algorithms. Techniques for analyzing algorithms in order to measure their efficiency are presented. Control structure abstractions, such as divide and conquer, greedy, dynamic programming, backtrack (branch and bound), and local search methods are studied. The theory of NP-completeness is presented along with current approaches to NP-hard problems.

Prerequisite: CS3021 and MA2025.

CS3200 - Computer Architecture (3 - 2)

This course examines the organization of computer and processor architectures. Instruction set design alternatives, processor implementation, memory system hierarchy, and I/O systems are the main topics of study. A quantitative approach is taken in which different design alternatives are evaluated and compared through analysis and/or experimentation. The course is accompanied by a set of labs which reinforce and extend the lecture subject matter.

Prerequisite: CS2011 and either CS2020 or permission of the instructor.

CS3250 - Introduction to Cyber Physical Systems (3 - 2)

This course introduces the technology, architecture, and applications of Cyber Physical Systems (CPS) including ICS/SCADA, and the issues of security for these systems, to achieve Naval mission objectives. The course covers building blocks (system topologies and architectures), enabling technologies (devices, networking, management), threats and vulnerabilities, reliability, safety, availability, resilience, performance, and real-time constraints. Relevant case studies and hands-on lab exercises are included.

Prerequisite: Undergraduate level understanding of Networking (CS3502), Computer Security (CS3600), and Operating Systems (CS3070) is required for this course..

CS3310 - Artificial Intelligence (4 - 1)

Survey of topics and methods of Artificial Intelligence. Methods include rule-based systems, heuristic search and exploitation of natural constraints, means-ends analysis, semantic networks, and frames. Emphasis is placed on solving problems that seem to require intelligence rather than attempting to simulate or study natural intelligence. Projects to illustrate basic concepts are assigned.

Prerequisite: One college-level course in programming..

CS3315 - Introduction to Machine Learning and Big Data (3 - 1)

A survey of methods for process large amounts of data and classifying and analyzing it using machine-learning methods. Big-data topics examine the obstacles to processing including managerial obstacles, problems of data consistency, problems of data accuracy, data-reduction methods, and big-data distributed processing methods. Topics on machine learning include concept learning, decision trees, Bayesian models, linear models, neural networks, case-based reasoning, genetic algorithms, sequence learning, and assessment techniques. Students will do projects with software tools on military data..

Prerequisite: CS3310 or consent of instructor..

CS3331 - Basics of Applied Artificial Intelligence (4 - 0)

Basics of artificial-intelligence concepts illustrated with military examples. Topics include knowledge representation, logical reasoning, probabilistic reasoning, heuristic search, agent-based systems, and social artificial intelligence. The course is designed for students who are not computer-science majors.

Prerequisite: CS4000.

CS3332 - Applied Machine Learning (4 - 0)

Survey of machine-learning techniques of artificial intelligence with a particular focus on military applications. Topics include types of machine learning, training and testing of machine learning, data preparation, decision trees, Bayesian reasoning, linear models, neural networks, case-based reasoning, and reinforcement learning. Each method will be related to important military and government applications. This course is intended for students who are not computer-science majors.

Prerequisite: CS3331.

CS3502 - Computer Communications and Networks (3 - 2)

This course covers basic computer networking concepts and technology through the study of protocols at each layer of the Internet architecture. Materials taught in class are reinforced through laboratory projects.
Prerequisite: a solid background in Computer Architecture, Algorithm and Data Structures, and programming experience with C/C++ or Java are important for success in this class.

Prerequisite: CS2011 or CS3030 or EC2700.

CS3505 - Introductory Computer Communications (3 - 2)

This introductory course in computer networking focuses on high-level core internetworking concepts and the relative merits of different architectures in relation to security, performance, economic, and reliability objectives. Students will develop a deeper understanding of the Internet and Internet applications, and in particular how the end-to-end arguments, robustness principle, layering, naming, and hierarchy have enabled the Internet to scale through orders of magnitude in size and speed while accommodating widespread heterogeneity. It introduces principles of reliable communication, wireless channels, naming and directory services, content distribution networks, networks for cloud computing, overlays, and peer-to-peer communication models. This course is intended for all graduate students. Prerequisites: None.

CS3600 - Introduction to Cybersecurity (4 - 1)

This course provides a comprehensive overview of cybersecurity terminology, concepts, software, hardware, and policies. It covers information threats, vulnerabilities, risks and safeguards and shows how these safeguards establish the confidentiality, integrity, authenticity, availability and non-repudiation of information. It addresses the protection of information using a combination of software and hardware mechanisms, while it is being processed and stored on computing platforms and transmitted across networks. This is the entry point (prerequisite) for all other Cybersecurity and Defense Track courses.

Prerequisite: CS2011, CS3030, or EC2700..

CS3606 - An Introduction to Information System Security (4 - 0)

Due to the rapid development and ubiquitous deployment of computer and information systems, and the very nature of insecurities they may hold, professionals involved with the design, development, deployment, and management of these systems now require a familiarity with information assurance and security. This course will introduce topics relevant to information assurance (IA) and computer security necessary to create a foundation of knowledge for the information management professional. The domains of knowledge to be introduced during the course include: access control systems and methodology; telecommunications and network security; security management practices; application and systems development security; cryptography; security architecture and models; operations security; business continuity and disaster recovery planning; laws, investigations, and ethics; and physical security. This course is meant to introduce the topics and will lay the foundations for

further studies in any of the domains listed. Prerequisites: None.

CS3610 - Information Ethics, Crime, and Law (4 - 0)

This class examines the major controversies affecting today's Internet resulting from the interplay of policy, law, technology and human nature. Topics include computer crime; intellectual property; privacy; encryption; free speech; identity; data mining and additional DoD specific issues. Readings include laws, judicial opinions, popular articles, and academic computer science articles. Assignments include written exercises, a midterm quiz analyzing a public policy problem, and term paper. Prerequisites: None.

CS3621 - Applications Project and Research for Identity Management and Cyber Security Students (0 - V)

This program requires either an Application project or a Thesis. Every student conducting an Applications Project or Thesis research in the Identity Management and Cyber Security degree program will register for this course during each quarter of study. This course is intended to provide a set of incremental activities, reports, and presentations that will ensure student progress toward the completion of the Applications Project or thesis research within the timeframe of the standard degree program. This course may be repeated for credit.

Corequisite: Enrollment in the MA in Identity Management and Cyber Security degree program..

CS3633 - Data Security (3 - 2)

Where is my data and how is it being protected? This course examines the major technologies, procedures, and controversies affecting the secure storage and use of data. Historical context; access controls vs. encryption algorithms; computer forensics and media exploitation; privacy and data recovery; security for data-at-rest vs. data-in-flight vs. data-in-computation; translucent databases; private information retrieval; data mining; cloud computing.

Prerequisite: CS3600, CS3502.

CS3636 - Data Fusion with Online Information Systems (3 - 0)

Explores data fusion as applied to personal information in both the online and offline world. Topics include credit and criminal databases, Information Surveillance, GSP, Satellite imagery, online search, text mining, anonymization, re-identification, and privacy policy. Familiarity with statistics useful but not mandatory. Prerequisites: None.

CS3640 - Analysis of DoD Critical Infrastructure Protection (3 - 1)

The DoD relies on the correct functioning of an extensive information and control infrastructure to accomplish its mission. To assist in ensuring the survivability of assets that comprise this infrastructure, the DoD has formulated a CIP lifecycle, which includes: Analysis & Assessment, Remediation, Indicators & Warnings, Mitigation, Incident Response, and Reconstitution. This course introduces students to this lifecycle, and how the criticality and survivability of mission-critical infrastructures within the DoD are assessed.

Prerequisite: CS3600.

CS3645 - Cyber Threats and Mitigation (3 - 0)

This course will cover threats to information systems within the enterprise and will provide students with options for their mitigation. An objective of the course is to allow the student to understand the potential losses associated with today's major threats in terms of data disclosure, alteration or disruption of data, and the costs associated with mitigation techniques. Topics include: current state of the art in virus, worm and Trojan technology; botnets and their uses; common attack vectors and mitigations; data exfiltration techniques; intrusion detection and prevention systems; application log analysis. Security Clearance Required. Classified and unclassified versions available.

Prerequisite: CS3600.

CS3660 - Critical Infrastructure Protection (4 - 0)

Critical infrastructure is one of the cornerstones of Homeland Security in the United States. While we intuitively understand the importance of our infrastructure, we understand far less about what is critical and what we can do to make infrastructure more resilient. The purpose of this course is to give you a framework for understanding and the tools to analyze critical infrastructures. We take a "system of systems" approach that involves understanding the basics of how infrastructures function and how complexity theory and related policies influence their structure. We study risk and its applications to critical infrastructures. Finally, we provide a framework that will allow you to scope, model, and then analyze an infrastructure from both the attacker and defender points of view resulting in recommendations based on risk and considering the return on investment in terms of risk reduction.

Prerequisite: NS3180.

CS3670 - Secure Management of Systems (3 - 2)

This course provides students with a security manager's view of the diverse management concerns associated with administering and operating an automated information system facility with minimized risk. Students will learn how to operate a computer facility securely, legally and efficiently, with emphasis on DOD policies. This course is one of a set of courses that can earn a student the Cyber Security Fundamentals academic certificate.

Prerequisite: CS3600.

CS3686 - Identity Management Infrastructure (3 - 0)

This course covers a broad range of topics related to the standards, protocols, technology, and management infrastructure necessary to field an enterprise-level identity management (IdM) solution. Lecture and reading assignments span the gamut of IdM issues: from low-level authentication protocol mechanics, to high-level identity federal initiatives. This course is one of several that will collectively compose the requirements for Identity Management specialization tracks in the Information Science and Computer Science degree programs. Completion of four courses: CS3686, CS3699, IS3710, and IS3720, will meet the requirements for earning the Federal/DoD Identity Management Certificate offered by NPS. Prerequisites: None.

CS3690 - Network Security (4 - 1)

This course covers the concepts and technologies used to achieve confidentiality, integrity, and authenticity for information processed across networks. Topics include: fundamentals of TCP/IP-based networking, core network security principles, traffic filtering types and methodology, packet-level traffic analysis, employment of cryptography, tunneling/encapsulation, Public Key Infrastructure (PKI), remote authentication protocols, and virtual private networks based upon the IPSec, L2TP, and SSL protocols.

Prerequisite: CS3600 or consent of instructor..

CS3695 - Network Vulnerability Assessment and Risk Mitigation (3 - 2)

This course provides a basis for understanding the potential vulnerabilities and their mitigation in networked systems by studying methods to: (1) obtain information about a remote network, (2) to possibly exploit or subvert systems residing on that network and (3) techniques to mitigate risks to networked systems. Labs provide practical experience with current network attack and vulnerability assessment tools, as well as tools and methodologies for a systematic approach to reducing vulnerabilities. A final project that demonstrates skill and knowledge is required.

Prerequisite: CS3502 or IS3502 or CS3690 or permission of the instructor..

CS3697 - Secure Management of Operational Technology Systems (3 - 1)

This course provides students with a security manager's view of the diverse management concerns associated with administering and operating an industrial control system (ICS) with minimized risk. Students will learn how to manage operational technology (OT) systems in a DoD/DoN facility securely, legally and efficiently.

Prerequisite: CS3600 and CS3690, or consent of the instructor..

CS3699 - Biometrics (3 - 0)

This course reviews the technical details of biometric identification and verification. The major biometric approaches (fingerprints, irises, etc.) are covered in detail with respect to acquisition of biometric data, matching techniques, anti-spooking techniques, and current standards. The uses and limitations of biometrics are covered, as well as some of the legal, ethical, and privacy concerns of maintaining and using biometric data. This course is one of several that will collectively comprise the requirements for Identity Management specialization tracks in both the Information Science and Computer Science degree programs. Completion of four courses, CS3686, CS3699, IS3710, and IS3720, will meet the requirements for earning the Federal DoD Identity Management Certificate offered by NPS. Prerequisites: None.

CS3800 - Directed Study in Computer Sciences (0 - V)

(Variable hours 0-2 to 0-8.) Individual research and study by the student under the supervision of a member of the faculty. The course is intended primarily to permit interested students to pursue in depth subjects not fully covered in formal class work. Graded on Pass/Fail basis only.

Prerequisite: Consent of Instructor.

CS3802 - Computational Methods for Data Analytics (4 - 0)

(Same as OA3802.) This course introduces several tools for analysts to acquire, store, access, clean, and merge relevant data, so as to produce a dataset that can be analyzed with necessary tools. The topics include binary data, popular text formats, bash command interpreter, relational and NoSQL databases, web scraping methods, parallel processing, and geographic data. Students will be introduced to high-performance computation facility, such as NPS Hamming and Grace clusters.

Prerequisite: OA2801 or Consent of Instructor.

CS3910 - Science of Computer Programming (3 - 2)

Introduction to computational thinking and basic concepts related to systematic problem solving assisted by computers. Imperative, functional and concurrent programming. Identifying languages for problem modeling and solving. Software analysis and generation using design structures, embedded knowledge, systematic reasoning for computer systems and software applications using computational thinking, machine learning and big data. Implications for agile/reliable software systems and military applications of AI.

Prerequisite: Prerequisites: Automata Theory CS3101, Algorithms C3150 and Software methodology SW3460.

CS3920 - Topics in Computer Science (V - V)

(Variable hours 2-4 to 4-1.) Designed to support subject

matter of special interest, dependent upon faculty availability. Topics will either be drawn from areas not covered by core courses, or be focused treatments of subjects of limited scope. This course may be lecture-or lab-oriented, with prerequisites determined by the instructor. Students may repeat this course for credit with a different topic.

Prerequisite: Consent of Instructor.

CS3921 - Topics in Computer Science (V - V)

Designed to support subject matter of special interest, dependent upon faculty availability. Topics will either be drawn from areas not covered by core courses, or be focused treatments of subjects of limited scope. This course may be lecture- or lab-oriented, with prerequisites determined by the instructor. Students may repeat this course for credit with a different topic.

Prerequisite: Consent of the instructor.

CS4000 - Harnessing Artificial Intelligence (0 - 2)

An introduction for non-CS-majors to the structure of the AI field and the kinds of hardware-software systems available to perform classification, data mining, decision support, discovery, speech understanding, vision, inference, and deduction. Students will be exposed to the major areas of concern, research, and application of AI, including the history and foundations, the kinds of learning machines, the critical domains of AI application, and the directions in which the field is advancing.

Prerequisite: None.

CS4112 - Distributed Systems (3 - 2)

An advanced treatment of distributed systems. Major course topics include models of distributed computing; design and assessment of distributed algorithms, including clocks, mutual exclusion, resolution of conflicts for resources, control and termination of distributed computations, leader election, message ordering, synchronizers, slicers, distributed shared memory, consensus, self-stabilization, and fault tolerance; and current topics in distributed systems, such as distributed operating systems, distributed multimedia systems, sensor and peer-to-peer networks, and web services.

Prerequisite: CS3070 or equivalent.

CS4182 - Capstones in Computer Science (4 - 0)

This is the capstone course for the CS curriculum. It surveys the transforming effects of seminal papers on ten subject areas within Computer Science. Each paper illustrates how the introduction of an organizing framework, a suitable form of analysis, or a set of supporting principles was able to change the way problems within the subject area were approached, a change that led to integrated and lasting solutions. Students will be responsible for reading and evaluating key papers that have helped to shape modern Computer Science.

Prerequisite: CS3000.

CS4310 - Sensory Artificial Intelligence (4 - 1)

A study of methods of computational simulation in natural-language processing, computer vision, and sensor networks. Issues in natural-language processing include modeling of syntax, semantics, morphology, discourse, phonetics, and stochastic phenomena. Issues in computer vision include low-level processing, segmentation, shape inference, and object identification. Issues in sensor networks include deployment, local inference, and communications.

Prerequisite: CS3310.

CS4312 - Advanced Database Systems (3 - 1)

This course is a sequel to CS3320, Database Systems. The course will provide an in-depth coverage of relational database theory, distributed database systems, semantic data models, query processing and optimization, transaction management, recovery, security and other advanced topics. Topics will be illustrated using both commercial and prototype database systems.

Prerequisite: CS3060 or Consent of Instructor.

CS4313 - Advanced Robotic Systems (3 - 2)

AI methods for robots and unmanned vehicles. The first part of the course will discuss generic sensing and control mechanisms, including reactive and hierarchical control. The second part of the course will focus on specialized areas of robotics, including biologically inspired robotics, developmental robotics, swarm robotics, and unmanned autonomous vehicles.

Prerequisite: CS3310.

CS4315 - Introduction to Machine Learning and Data Mining (3 - 1)

A survey of methods by which software and hardware can improve their performance over time. Topics include data manipulation, concept learning, association rules, decision trees, Bayesian models, simple linear models, case-based reasoning, genetic algorithms, and finite-state sequence learning. Students will do projects with software tools. Prerequisites: One college-level course in programming.

Prerequisite: CY3650 and one college-level course in programming.

CS4317 - Language Systems (3 - 2)

This course introduces the computational aspects of processing language. Topics include: lexicography, morphology, grammars, parsing, semantics, stochastic grammars, hidden Markov models, speech understanding, language generation, and language translation systems.

Prerequisite: CS3310, CS3150 and CS3101.

CS4321 - Deep Learning (3 - 2)

Core and advanced deep learning methods including end-to-end production development in support of naval

mission objectives. The course covers both Deterministic and Bayesian Deep Learning with in-depth review of the core concepts (math, architectures (e.g. MLP, CNN, Sequences etc..), optimization for deep learning, training methodology and DL project organization). This course builds on the core fundamentals to develop complex concepts such as Bayesian Deep Learning, Generative Adversarial Networks (GAN), dense predictions (e.g. U-Nets), Active Learning, Self-Supervised Learning and Continuous Learning algorithms with neural networks. The course will utilize contemporary popular Python frameworks (e.g. Tensorflow/PyTorch).

Prerequisite: CS3021 and CS3315; or consent of instructor..

CS4322 - Internet Information Systems Technology (3 - 2)

A course exploring the implementation of recent Internet tools for supporting databases, intelligent systems, and information retrieval. Topics include browsers, server technology including servlets, XML, data mining, and data warehousing. Students will do programming to build their own tools.

Prerequisite: CS2020 and either CS3310 or consent of instructor..

CS4323 - Bayesian Methods for Neural Networks (3 - 2)

Probabilistic methods, particularly Bayesian methods, are fundamental for many machine learning techniques, including deep learning. Bayesian methods focus on modeling uncertainty, which is key in many real-world applications with noisy data. This class will focus on the theory, the implementation (in Python), and the real-world application of Bayesian methods (e.g. Variational Inference) for neural networks. It will build on the Python programming knowledge taught in CS 2020 and the probability and statistics knowledge taught in OS 3307.

Prerequisite: CS2020, OS3307.

CS4330 - Introduction to Computer Vision (3 - 2)

This course introduces students to the main concepts that allow computers to "see" and understand visual information. It teaches methods and skills in image processing, pattern recognition, statistical analysis, classification, and learning. These are exemplified on applications such as military intelligence, surveillance, object tracking, robotic navigation, human-computer interfaces, and visual effects. Students complete a small class project that demonstrates the use of computer vision for an application of their interest. In laboratory activities, students get hands-on experience with the most important tools for building practical vision systems.

Prerequisite: Students must be familiar with basic programming (Matlab, Python, Java, C or C++ etc.), and have fundamental knowledge of (or an aptitude for) linear algebra, probability theory and statistics..

CS4333 - Current Directions in Artificial Intelligence (4 - 0)

A survey of current important topics in artificial intelligence for students who are not computer-science majors. Topics include big-data management, advanced topics in neural networks, adversarial machine learning, explainability, testing and verification of artificial-intelligence systems, privacy issues in artificial intelligence, and other legal issues in artificial intelligence.

Prerequisite: CS4000, CS3331 and CS3332.

CS4340 - Trustworthy and Responsible Artificial Intelligence (4 - 0)

More and more critical activities are performed by or with the help of automation under the banner of "artificial intelligence". Finance, housing, medicine, communication, criminal justice, and combat systems all have been or stand to be revolutionized by this change. But such systems have often been the subject of significant failures, having unanticipated, undesired, or unfair effects. These technologies are not subject to the same level of safety and reliability engineering as other engineered systems. This course examines the need for and approaches to developing and sustaining automated systems in trustworthy, responsible, and ethical ways for use in everyday and national security applications. The course frames these technologies as complex sociotechnical systems with trustworthiness affected by technical capabilities, interaction with both users and subjects of the system's behaviors, and context such as operative law, policy, and doctrine. Specific focus is given to tools, techniques, and processes which can define assurance within such systems and the ways in which assurance does and does not support inquiry into ethical dimensions of the system's behaviors. In turn, these methods and tools support the development of systems consistent with ethical principles and core values, such as the DoD AI Principles.

The course uses a combination of lectures, discussions of readings, a quarter-long course project, and detailed analysis of failure and success cases to demonstrate the current capabilities and limitations of engineering computational automation. Students will be exposed to the cutting edge of research and practice around creating trustworthy and responsible AI.

Prerequisite: Familiarity with programming at the level of CS2020 and the basics of artificial intelligence/machine learning at the level of CS3310 or CS3315, or permission of the instructor..

CS4450 - Advanced Computer Architecture (4 - 0)

This course covers advanced topics in computer architecture and the application of concepts in computer architecture to the design and use of computers. The topics discussed include classes of computer architecture, application oriented architecture and high performance architecture.

Prerequisite: CS2011 or equivalent and CS3200 or equivalent..

CS4533 - Wireless Mobile Computing (3 - 2)

This course will focus on a new paradigm in computing: wireless mobile computing. Portable, handheld, computing devices are now being used for many applications previously accomplished by larger desktop computers or dedicated small devices. Some of these devices contain powerful RISC CPUs, user-accessible flash RAM storage, networking and peripheral connectivity, handwriting recognition, and built-in infrared networking capabilities. The goal of this course is to provide a fundamental understanding of the devices, communications, and design and implementation issues in building such mobile networked applications. Students will be required to research, design, and/or implement a project that integrates multiple technologies to solve a real-world problem requiring mobile computing.

Prerequisite: CS2020.

CS4535 - Mobile Devices (3 - 2)

There is a large number of mobile devices, including cellular phones, personal digital assistants (PDAs), PDA/cellular phone combinations, pagers, badges and other wearable devices, in use today in a variety of applications. The number and variety of such devices keeps growing at a fast pace as new processing, display, battery and wireless technologies are invented and as new applications for these devices are envisioned. This is a practical, hands-on course that covers the architecture, usability and applications of mobile devices. From an application perspective, this course will discuss mobile devices as tools to support homeland security applications, military applications for capability enhancement, and communications and computing needs of mobile professionals. The study of principles is combined with hands-on laboratory exercises to develop applications on mobile devices.

Prerequisite: CS2020.

CS4537 - Wireless Data Services (3 - 2)

Tremendous progress has been made in mobile device and wireless networking technologies. Many different PDAs, cell phones, smartphones and specialized devices have been introduced in the market place, and been enthusiastically adopted by millions of people around the world. Wireless networking technology development and adoption has moved even faster! The combination of mobile devices and wireless networking lends itself to data applications that can make a significant difference in a wide variety of application areas. The aim of this course is to provide an understanding of the issues, technologies and applications related to wireless data services. In addition to other topics, this course will cover wireless internet, SMS, MMS, WAP, iMODE, J2ME, and BREW.

Prerequisite: CS4535.

CS4538 - Mobile Device and Wireless Security (3 - 1)

The application of Mobile and Wireless devices has grown rapidly in military and commercial environments. The functionality and reliability of these devices has grown tremendously. The mobile and wireless nature of these devices raise new and important security challenges not usually present in static environments. This course will address these questions including the security functionality, protocol and assurance issues associated with this emerging technology.

Prerequisite: CS3600, CS3690, CS4537.

CS4550 - Computer Networks II (4 - 0)

This course covers advanced and emerging topics in computer networking. Some topics taught in CS3502 will be reviewed and studied in more detail. Other course subjects may vary from instructor to instructor and they include: multimedia networking, wireless networks, multicasting, peer-to-peer networks, quality of service, network management, network architecture, and security.

Prerequisite: CS3502.

CS4552 - Robust and Secure Network Design (3 - 2)

A hands-on, projects-based, exploration of network layer design choices that directly impact the robustness and security a computer network. The course is intended for CS and non-CS majors. Students will develop research and troubleshooting skills through experiments performed on realistic network configurations. The network technologies covered include traditional networks based on distributed routing protocols such as OSPF, RIP and BGP, as well as software defined networks that employ centralized control.

Prerequisite: An advanced programming course, CS3502 or equivalent with consent of the instructor..

CS4554 - Network Modeling and Analysis (4 - 0)

The purpose of this class is to learn to formally specify and analyze network protocols, emphasizing wireless protocols, and in the process acquire a thorough understanding of these protocols. Formal protocol models such as communicating finite state machines and systems of communicating machines will be used as a tool for this purpose. Some protocols other than wireless protocols may also be covered. Several research papers from recent years will be assigned reading. Cellular networking, IEEE 802.11, Bluetooth, and wireless local loop networks will be covered as well. The class will study these protocols in the context of the network architectures and physical environments they are intended to perform in. Students should acquire an increased knowledge of formal tools, experience in protocol and system analysis, and a better understanding of protocols and networks.   At the discretion of the professor, other advanced topics such as simulation and statistical analysis of networks and network protocols may be added and/or substituted for some of the topics above. The emphasis is on application

of mathematical rigor to the analysis and description of networking protocols.

Prerequisite: CS3502.

CS4558 - Network Traffic Analysis (3 - 2)

Explores fundamentals of packet-switched network traffic analysis at the network layer and above as applied to problems in traffic engineering, economics, security, etc. Explores the design and integration of analytic tools and techniques into the fabric of the network including: spatial and temporal anomaly detection, origin-destination matrix estimation, application mix determination, deep-packet inspection, fingerprinting, intrusion detection and insider threat mitigation. Finally, the course covers active defense and offensive methods reliant on traffic analysis.

Prerequisite: CS3502 and CS4550 or equivalent.

CS4600 - Secure System Principles (3 - 2)

An advanced course that focuses on key principles of a constructive approach to secure systems. A brief review of operating systems and computer architecture is provided. Major topics include threat characterization and subversion; confinement; fundamental abstractions, principles, and mechanisms, such as reduced complexity, hierarchical relationships, least privilege, hardware protection, resource management and virtualization, software security, secure system composition, mutual suspicion, synchronization, covert and side-channel analysis, secure metadata, secure operational states, usability, and life cycle assurance. Current developments will include advances in security hardware, components, and systems.

Prerequisite: CS3600, CS3070, CS3502.

CS4603 - Database Security (3 - 1)

Course topics include: policies for information integrity and confidentiality of database (DB) systems, modeling of secure DB systems, security in statistical DBs, security approaches for object-oriented DBs, multi-tier architecture security issues, privacy, aggregation and inference, military applications of secure DBs, and other important implementation issues; such as, atomicity, serialization, and view-based controls.

Prerequisite: CS3600, CS3060 and CS3070.

CS4605 - Security Policies, Models and Formal Methods (3 - 1)

This course covers the methods used to specify, model and verify the access control mechanisms of computational systems. The identification of the security policy and its interpretation in terms of a technical policy is covered. Several security policy and access-control models are explored.

Prerequisite: CS3150, CS3600, CS3101.

CS4610 - Information Ethics (3 - 0)

Rapid and revolutionary advances in IT confront society with novel choices and opportunities. This course attempts to identify the kinds of ethical choices that may arise from its use. While a few may be clear choices, most will be between the greater of goods or the lesser of evils. These choices will be difficult because the values are difficult to identify, the right choices are more difficult than the wrong, and their consequences are neither certain nor easily predicted. Prerequisites: None.

CS4614 - Advanced Topics in Computer Security (3 - 1)

This course applies graduate level knowledge and reasoning skills in written essays and verbal discussion of current topics in computer security. Students read academic papers regarding Information Assurance topics, and discuss issues that they derive from the readings. This pedagogical approach is constructivist, in encouraging the students to develop their own viewpoints and conclusions.

Prerequisite: CS3600.

CS4615 - Cryptographic Protocol Design and Attacks (3 - 1)

Cryptographic protocols (such as key-exchange and mutual-authentication protocols) are essential to the security of all distributed computer networks. Such protocols are often simple, but they also often fall victim to various attacks, including structural attacks. This course considers the 'protocol analysis problem': finding attacks against a protocol (if they exist) or proving their absence (if they do not). We will examine protocol design and protocol-analysis techniques, and compare their strengths and weaknesses. Advanced topics include (as time permits) protocol-design heuristics, trust-management and higher-level protocol goals, interactions between protocols, computational soundness, and decidability results.

Prerequisite: CS3600 or permission of instructor.

CS4648 - Software Reverse Engineering and Malware Analysis (3 - 2)

This course will explore how malware is constructed through reverse engineering and analysis of malicious code. Techniques to perform dynamic behavioral analysis and static examination of program control flow and properties will be discussed. Malware analysis topics include: obfuscation, stealth, persistence, propagation, network communications for command & control, anti-analysis (anti-debugging, anti-disassembly, anti-virtualization), code injection, and process hollowing. Reverse engineering involves disassembling and analyzing binary executables to determine the techniques used by the malware to achieve its mission. Attack campaigns by known advanced persistent threats. (APTs) will be used in case studies.

Prerequisite: CS3070 and CS3140 or Consent of the Instructor.

CS4650 - Fundamentals of Information Systems Security Engineering (3 - 1)

This course presents the fundamental principles and processes of information systems security engineering (ISSE). The ISSE life cycle model consists of five stages: requirements definition, design, implementation, testing and deployment. The processes involved in these stages are explained in the context of a Defense-in-Depth protection strategy, with an emphasis on the role of security requirements engineering (SRE) in the construction of a secure system. This course covers the concepts and techniques needed to systematically elicit, derive and validate security requirements. It introduces how these techniques can be used in practice, and addresses the relationship between SRE and secure system design. Course work will be a combination of lectures, case studies and a team-based SRE project.

Prerequisite: CS4600.

CS4652 - Applied Information Systems Security Engineering (3 - 2)

This course focuses on the key concepts and practices of information systems security engineering from a system life cycle perspective. Core topics include security architecture and design analysis, system implementation assessment, requirements/implementation traceability correspondence, security test and evaluation strategy, certification and accreditation (C&A) requirements analysis, and risk management. The Systems Thinking approach is introduced for assessing system security behaviors based on dependencies, interactions and emergent properties of its components in the context of functionality, scalability, interoperability and maintainability. Case studies and laboratory projects will demonstrate security engineering practices through the life cycle of a secure system.

Prerequisite: CS4650.

CS4670 - Quantum Computing (4 - 0)

Same as PH4670. This interdisciplinary survey course explores the evolution and direction of quantum computing technology. Topics include quantum circuits, quantum algorithms (including factoring and search), and quantum key distribution. Prerequisites: familiarity with basic notions of computing, quantum theory, and linear algebra, consistent with the material covered in any of CS3000, PH2652, MA3042 or PH3991.

Prerequisite: Familiarity with basic notions of computing, quantum theory, and linear algebra, consistent with the material covered in CS3000, PH2652, MA3042 or PH3991..

CS4675 - Intrusion Detection and Response (3 - 1)

This is an introduction to methods of intrusion detection in computer systems and networks and the possible methods of automatic responses to those events. It will cover types of intrusion detection, inference of suspicion, implementation, and management, and will examine at least one specific product. A special focus in response management will be the use of deliberate deception in defense of systems, including the psychology and ethics of deception in general.

Prerequisite: CS3600.

CS4677 - Computer Forensics (3 - 2)

This course covers the fundamentals of computer forensics in the context of DoN/DOD information operations. Students examine how information is stored and how it may be deliberately hidden and/or subverted. Coverage includes: practical forensic examination and analysis, techniques of evidence recovery, legal preparation of evidence, common forensic tools, the principle of original integrity, disk examination, and logging.

Prerequisite: CS3600.

CS4678 - Advanced Cyber Vulnerability Assessment (4 - 1)

This course provides a basis for understanding the potential vulnerabilities in networked systems by applying a problem-solving approach to: 1) obtaining information about a remote network, 2) possibly exploiting or subverting systems residing on that network, 3) understanding the theory of operation of existing tools and libraries along with how to measure the effectiveness of those tools, and 4) understanding tools and techniques available for vulnerability discovery and mitigation. Labs provide practical experience with current network attack and vulnerability assessment tools as well as development of new tools. Foot printing, scanning, enumeration and escalation are addressed from the attacker's perspective. A final project that demonstrates skill and knowledge is required.

Prerequisite: CS3690, CS3070, CS3140.

CS4679 - Advances in Cyber Security Operations (4 - 1)

Unfettered by rules, ethics, or government acquisition politics, the cyber underground has created sophisticated and innovative mechanisms for digital crime. Spanning all layers from hardware and firmware to human-computer interfaces, these command and control systems are both clandestine and dynamic. Using case studies, this course explores the techniques, tactics and procedures of cyber security operations used to identify and track emerging adversarial behavior. By addressing computer network attack, defense, and exploitation topics associated with disruptive technologies, students will gain an understanding of the threats, vulnerabilities, and appropriate mitigating security controls. Sample topics include: supply chain attacks; driving forces of the cyber underground; operations involving a variety of cyber technologies and infrastructures; tracking, location, and identification: security implications of new hardware and firmware interfaces; and covert and side channels.

Prerequisite: CS3502, CS3600, CS3070, or consent of

instructor. In addition, programming experience through courses such as CS3040 and CS3140 is recommended..

CS4680 - Introduction to Risk Management Framework (3 - 2)

This course provides an in-depth instruction on the Risk Management Framework (RMF) and the DoD/DoN security assessment process. It includes an introduction to the Risk Management Framework as applied to procurement and lifecycle management of DoD and federal government information systems, with a focus on the role of the Security Controls Assessor. Topics include the principal roles in the process, functional components, and the authorization package required of the Assess and Authorize (A&A) process. Also included is a discussion of the DoD/DoN A&A process specifications currently in use (RMF with tailoring guidance from the DoD and Committee for National Security Systems) and the continuing effort by the Joint Transformation Working Group aimed at producing federated guidance. In the laboratory portion of the course, students will do 2 or 3 case studies of information systems that have been evaluated under the current DoD criteria in preparation for authorization to carry sensitive information. The students will study each system from concept through final system assessment and authorization. They will look at and evaluate such things as the security policies, system and security architecture, design, implementation, deployment, management, evolution, assurances, etc. through available documentation and other evidence, to determine whether the systems will be secure enough to process or transmit information at the appropriate levels of assurance. The case studies will be based on information available about deployed systems and is therefore restricted to U.S. students only.

Prerequisite: CS3670 or Consent of Instructor.

CS4684 - Cyber Security Incident Response and Recovery (3 - 2)

This course defines the nature and scope of cyber security incident handling services, including intrusion/incident detection, damage control, service continuity, forensic analysis, service/data restoration, and incident reporting. Material covers policy, planning, operations, and technology issues involved in related cyber incident handling plans; i.e., Business Continuity, Disaster Recovery, and Continuity of Operations. Specific incident types addressed include, natural disasters, denial of service, malicious code, malicious misuse of hardware and firmware, unauthorized access, data compromise and inappropriate use, including insider attacks. Emphasis is given to the detection and analysis of infiltration and exfiltration techniques employed during cyber attacks, thus enabling the incident handler to detect low noise attacks, and to deconstruct particularly insidious attacks. Based upon the choice of case studies, this course will be taught at either the unclassified or TS/SCI levels.

Prerequisite: CS3690 or Consent of Instructor.

CS4690 - Security for Cyber-Physical Systems (3 - 1)

This course considers threats and vulnerabilities in embedded and operational technologies employed in critical infrastructure, including industrial control systems, transportation networks, the power grid and other cyber-physical systems. In these systems, communication, computation and control are tightly related, allowing cyber- attacks to have devastating kinetic effects. The class examines the security of cyber- physical systems, emphasizing the variety of potential attack vectors and attacker motivations, through reviewing sector-specific vulnerability case studies and security in initiatives.

Prerequisite: CS3690, CS3070, CS3040.

CS4800 - Directed Study in Advanced Computer Science (0 - V)

Advanced group studies in computer science on a subject of mutual interest to student and faculty member. Intended primarily to permit students to pursue in-depth subjects not fully covered in formal class work or thesis research. May be repeated for credit with a different topic. Graded on Pass/Fail basis only.

Prerequisite: Consent of Instructor.

CS4900 - Technology and Transformation I (2 - 0)

CS4900/4901 is a two-quarter course that supports students in the selection of thesis topics with potential for transformation. The thesis process is a microcosm of transformation processes. Topics include: meaning of transformation and innovation, innovation process, skills of innovation, election of thesis topic, design of an effective thesis document, organizing an effective writing process. Frequent faculty guest speakers will discuss different research areas and current problems under study. The emphasis in the first quarter is on the range of possible research and in the second on the transformation process as it applies to thesis. Includes weekly readings and exercises. Prerequisites: None.

CS4901 - Technology and Transformation II (2 - 0)

CS4900/4901 is a two-quarter course that supports students in the selection of thesis topics with potential for transformation. The thesis process is a microcosm of transformation processes. Topics include: meaning of transformation and innovation, innovation process, skills of innovation, selection of thesis topic, design of an effective thesis document, organizing an effective writing process. Frequent faculty guest speakers will discuss different research areas and current problems under study. The emphasis in the first quarter is on the range of possible research and in the second on the transformation process as it applies to thesis. Includes weekly readings and exercises.

Prerequisite: CS4900.

CS4902 - Practices of Transformation (0 - 2)

This course will examine the current and planned research of Computer Science faculty in multiple fields of study. The course is designed to support Computer Science students in their third quarter of study in the selection of an emphasis track and an area for thesis research. Completion of this course requires submission of an approved thesis proposal during finals week.

Prerequisite: Computer Science students in third quarter or consent of Department Chairman.

CS4903 - Research Methods in Computer Science (2 - 0)

This course introduces students to research design and execution in computer science, a field that combines science, engineering, and mathematics. Topics include a review of quantitative, qualitative, and heterogeneous research methods. Framing research questions and hypotheses; collection of background material and literature review; the use of models and experimentation as part of a research process; testing and analysis; and the determination of well-grounded conclusions will be covered. The development of the thesis, writing techniques and thesis management will be discussed. Students are expected to register for this course in the fourth quarter of their studies. A completed thesis proposal is an expected product.

Prerequisite: This course requires prior completion or validation of CS4900, or consent of instructor..

CS4910 - Advanced Readings in Computer Science (0 - V)

(Variable hours 0-2 to 0-8.) Directed readings in computer science on a subject of mutual interest to student and faculty member. The course allows in-depth study of advanced topics not fully covered in formal class work or thesis research. May be repeated for credit with a different topic.

Prerequisite: Consent of Instructor.

CS4920 - Advanced Topics in Computer Science (V - V)

(Variable hours 2-4 to 4-1.) Designed to support advanced group study of subject matter of special interest, dependent upon faculty availability. Topics will be drawn from areas not covered by other advanced courses, or be focused treatments of subject of limited scope. This course may be lecture or lab oriented, with prerequisites determined by the instructor. Students may repeat this course for credit with a different topic.

CS4921 - Advanced Topics in Computer Science I (V - V)

(Variable hours 2-4 to 4-1.) Designed to support advanced group study of subject matter of special interest, dependent upon faculty availability. Topics will be drawn from areas not covered by other advanced courses, or be focused treatments of subject of limited scope. This course may be lecture or lab oriented, with prerequisites determined by the instructor. Students may repeat this

course for credit with a different topic.

CS4922 - Advanced Topics in Computer Science II (V - V)

(Variable hours 2-4 to 4-1.) Designed to support advanced group study of subject matter of special interest, dependent upon faculty availability. Topics will be drawn from areas not covered by other advanced courses, or be focused treatments of subject of limited scope. This course may be lecture or lab oriented, with prerequisites determined by the instructor. Students may repeat this course for credit with a different topic.

CS4923 - Advanced Topics in Computer Science III (V - V)

(Variable hours 2-4 to 4-1.) Designed to support advanced group study of subject matter of special interest, dependent upon faculty availability. Topics will be drawn from areas not covered by other advanced courses, or be focused treatments of subject of limited scope. This course may be lecture or lab oriented, with prerequisites determined by the instructor. Students may repeat this course for credit with a different topic.

CS4924 - Seminar Series in Computer Science and Cyber Systems and Operations (1 - 0)

Seminars (consisting of guest lectures and video teleconferences) are scheduled to provide information on emerging topics in Computer Science, and Cyber Systems and operations. This course can be repeated for credit. Prerequisites: None.

CS4925 - Innovation Leadership (3 - 2)

Accelerating the pace of innovation in a world of accelerating change driven by accelerating digital technology is a DOD priority. Starting from the premise that innovation is adoption of new practice in a community, this course teaches the essential practices of innovation leaders who successfully produce technology adoption. The course covers the foundational practices of communication that support the leadership practices. The course teaches advanced practices for navigation through contingencies and surprises, and for mobilizing communities around new practices. Students will complete a project to produce an adopted innovation. Prerequisites: None.

CS4926 - Advocating Emerging Technologies (4 - 1)

In a world of ever-changing technological developments, leaders are faced with the challenge of communicating highly specialized knowledge, technological needs, and impacts to a wide audience – both up and down the decision-making ladder. This course offers cyberspace and other technology professionals strategic skills for communicating specialized technical concepts and subject

matter expertise. Students will be challenged to transform subject matter expertise in a technical arena into communication that is immediately accessible to a non-technical audience. This course will cover how to engage effectively with a skeptical audience to communicate technological content, need, and impact succinctly, using written, oral, visual, electronic and nonverbal (WOVEN) rhetorical skills. The learning outcomes of this course serve as a bridge for innovators to commands and leadership, enabling force technological readiness and agility in adoption through effective communication of specialized capabilities.

Prerequisite: Completion of departmental thesis or capstone proposal, or approval of instructor..

CS4927 - Coaching for Innovation Projects (0 - 2)

This course provides regular coaching for students working on innovation projects that aim to impact communities outside NPS. It also teaches how to facilitate projects of others. Open to all students who are working on innovation projects defined for execution at the 4000 level.

CS5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

CS5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council.

Prerequisite: Advancement to Candidacy.

R000

CSR100 - Refresher for Beginning Programming (2 - 2)

(No credit) An introduction to computer algorithms, programs and hardware. Using structured programming and stepwise refinement techniques, students receive classroom instruction plus design and test programs in the laboratory. Computer projects of increasing difficulty are assigned. This course is not graded.

CSR101 - Refresher for Laboratory Systems (2 - 1)

Intended for computer science majors, to provide an introduction to computer science and computing laboratory facilities. Both Unix and the MS-DOS operating systems are introduced from a user perspective, as well as operation of corresponding workstation and personal computer hardware. Each system's user interface, text processing, programming environment, network and

communication facilities are surveyed. Students are exposed to basic principles and procedures for productive software and document development through both lecture and hands-on tutorials. Should be taken concurrently with CS0100. Not graded. No credit.

CY

CY0809 - Capstone Project (0 - 8)

Every student engaged in a curriculum capstone project will enroll in this course.

CY0810 - Thesis Research (0 - 8)

Every student conducting thesis research will enroll in this course.

CY3000 - Introduction to Cyber Systems and Operations (3 - 0)

This course provides an overview of policies, organizations, and systems affecting the conduct of military cyberspace operations. Topics include operational authorities and command relationships, cyber lines of operation, legal and ethical considerations, adversary actor motivations and capabilities, and cyberspace risk management. Real-world examples, case studies, and guest speakers are utilized to address salient topics from an operationally relevant perspective.

Security Clearance Required: Top Secret SCI.

CY3100 - Introduction to Communications Networks (4 - 1)

The purpose of this course is to develop literacy and familiarity with the technologies, techniques, and systems that provide the physical communications and point-to-point communications control upon which all communications networks are based. Physical layer topics include concepts in signals, information, analog and digital signals, signal corruption, signal reception, binary and non-binary data communications, communications channels, and radio communications concepts, IEEE standards 802.11 and 802.16, network interface controllers, switches, repeaters, multiplexers, antennas, A/D & D/A converters, and vocoders. Datalink layer concepts include connection vs. connectionless oriented, packet vs. circuit mode, error control, flow control, synchronization, framing, logical link control, media access control, Ethernet, Point-to-Point Protocol (PPP), and High-level Data Link Control (HDLC). Emphasis is on military communications systems to include Link 16, DSCS, Milstar, and WNW. Prerequisites: None.

CY3110 - Internet Protocols (3 - 1)

This course covers basic device (computers, smart-phones

and PDAs) communications and networking through the study of the fundamental principles and technologies employed to implement the upper three layers of the TCP/IP protocol stack. The lower two-physical (1) and link (2)-layers are addressed only insofar as to provide a complete bit-level to message-level overview regarding each layer's role in supporting end-to-end communications. For the three upper layers, the course delves into analysis of the dominant protocols employed (e.g., IP, DNS, ICMP, HTTP, DHCP, TCP, UDP, RIP, OSPF, BGP, MobileIP, VoIP, and MPLS). In addition to understanding the basic operation, each protocol is also considered in the context of basic security challenges (confidentiality, integrity, availability) encountered in a distributed, internetworked environment. Prerequisites: None.

CY3200 - Cyberspace Operations Fundamentals (4 - 2)

This course explores the fundamentals of cyberspace operations. The broad goals of the course are to cover the three main domains of cyber – science and technology, computation and data analytics, and strategy, policy and ethics. Conceptually cyberspace operations are the employment of cyber capabilities to achieve objectives in or through cyberspace. Nation state militaries, agencies or proxies use these operations as a component of conflict or warfare for political utility or competitive advantage. This course analyzes the offensive and defensive dimensions of cyberspace operations based on actual campaigns and incidents. It examines network architectures, technical methods, and emerging innovations for the conduct of cyberspace operations. The course debates policy and legal precedents to counter malicious actors operating in the domain. The hands-on lab exercises provide students with opportunities to employ cyber tools and techniques used by actors and to engage in war game decisions. The course concludes by proposing novel strategies to mitigate risk and prevail in cyber enabled military affairs.

Prerequisite: None. Corequisite: None. Cross-Listed as: Cross-listed with NS3200.

CY3201 - Foundations of Cyberspace Operations (3 - 0)

This distance learning course explores the foundations of cyberspace operations. The broad goals of the course are to cover the three main domains of cyber – science and technology, computation and data analytics, and strategy, policy and ethics. Conceptually cyberspace operations are the employment of cyber capabilities to achieve objectives in, or, through cyberspace. Nation state militaries, agencies or proxies use these operations as a component of conflict or warfare for political utility or competitive advantage. This course analyzes the offensive and defensive dimensions of cyberspace operations based on actual campaigns and incidents. It examines network architectures, technical methods, and emerging innovations for the conduct of cyberspace operations. The

course debates policy and legal precedents to counter malicious actors operating in the domain. It gives students periodic opportunities for interactive analysis of the three main domains of cyber. The course concludes by proposing novel strategies to mitigate risk and prevail in cyber enabled military affairs. This course is open only to students enrolled in DL certificate programs.

Prerequisite: None. Corequisite: None.

CY3300 - Cyber Communications Architectures (4 - 0)

The purpose of this course is to develop literacy and familiarity with Navy, DoD, and allied enterprise information systems and emerging technology trends. It presents basic concepts in conventional and military telephony and telecommunication networks; examines DoN implementations from intra-ship, ship-to-ship and long haul; and discusses architectures and components of the GIG including both classified and unclassified networks. It discusses interoperability of diverse network architectures and the impact of mobile platforms on operations.

Prerequisite: CY3100, CY3110, CS3030 or Consent of Instructor.

CY3520 - Practical Network Operations (3 - 3)

This course develops fluency in applying computer security principles in the context of deploying and configuring network services and architectures. Emphasis is placed on utilizing an understanding of network protocols and their vulnerabilities to defend and construct a network. Students will gain hands-on experience building a network, analyzing the interaction of network and host based security mechanisms, and maintaining continuous awareness of security relevant events. Prerequisites: None.

CY3602 - Network Operations II (3 - 2)

This course is a sequel to Network Operations I, with a focus on how to deal with network attacks and compromises. The goal is a resilient network that can meet operational and mission needs even in the face of attacks. Students will learn how to detect and respond to attacks and compromises while keeping the network operational to the extent possible. Topics covered include self-assessment through vulnerability and penetration testing, using firewalls and intrusion detection and prevention systems to monitor network traffic and system activity; and an introduction to established processes for cyber forensics and attribution, incident response, and recovery.

Prerequisite: IS3502 or CS3600 or Consent of the Instructor. Corequisite: CY4700 required for students in Curriculum 326.

CY3650 - Foundations in Data Science (3 - 1)

This course surveys the use of information technologies and data analytics, with emphasis on case studies relevant

to cyber operations and to the DoD. Topics include technologies and trends for Big Data management (e.g., distributed cloud file systems, NoSQL data stores); major themes and technologies in cloud computing (SaaS, PaaS, IaaS), distributed computation frameworks (MapReduce); and case studies focusing on how cloud infrastructure is used to enable services and analytics (e.g., mining, matching filtering and translating data).

Prerequisite: CS2020 or equivalent introductory programming experience..

CY3800 - Topics in Signals Operations (3 - 0)

Students will be introduced to concepts and systems for managing and ensuring effective employment of the electromagnetic spectrum (EMS). Topics include DoD, other government and Intelligence Community systems for communications; Signals Intelligence (SIGINT), Radio Frequency (RF) exploitation, electronic counter measures, electronic counter-counter measures, Precision Navigation and Timing (PNT), and EMS management. Students will better understand the role of these in building to and ensuring Naval Information Dominance and a US strategic and operational electronic advantage.

Prerequisite: CY3100, CY3300, or Consent of Instructor.

CY4000 - Cyberspace and Military Operations (0 - 2)

The cyber domain is one of force and action, and their far-reaching implications. This course is an introduction to the big ideas and constructs of cyberspace, and how military operations are conducted in and through it. Using the context of great power competition as a backdrop, students will be introduced to the cyber enterprise, technologies that undergird cyberspace, cyberspace as a domain of operation, and how military operations in the cyber domain affect strategy, power, and policy.

Prerequisite: No prerequisites.

CY4400 - Cyber Mission Planning (3 - 0)

This course details the process of mission planning in the cyber warfare domain and its integration of cyber with other warfare domains. All phases of mission planning and execution for cyber missions in both direct and supporting roles are covered. Topics include requirements development/ solicitation, managing expectations, targeting considerations, munitions development and selection, preparation of the environment, mission de-confliction in the cyber battlefield, balancing the needs of offensive and defensive stakeholders, and cyber battle damage assessment.

Prerequisite: CY4700 or Consent of Instructor. Security Clearance Required: Top Secret SCI.

CY4410 - Cyber Policy and Strategy (3 - 0)

This course explores the emerging strategies, policies and doctrine associated with cyber operations and military operations affected by cyberspace. The student will review the latest guidance provided by the US government at the national, interagency, DOD, and naval levels and relate these materials to the national strategy of the US. Special emphasis is provided for the products of US Cyber Command and Fleet Cyber Command/Tenth Fleet. These materials are compared to the emerging strategies and doctrine of other countries.

Prerequisite: DA3105, CY3000, or Consent of the Instructor. Security Clearance Required: Top Secret SCI.

CY4600 - Network Operations in a Contested Environment (3 - 2)

This is a course in offensive cyber operations and effects achievable by cyber means in a contested environment. It examines the network environment as a domain under contention and related information operations. Existing architectures and infrastructures for conducting offensive operations are studied. This course develops the literacy and competencies necessary to understand potential problems and realistic solutions for critical non-kinetic, cyber-related warfare issues for the United States.

Prerequisite: CY3520. Corequisite: CY4400 or Consent of the Instructor. Security Clearance Required: Top Secret SCI.

CY4650 - Cyber Data Management and Analytics (4 - 0)

This course surveys the use of information technologies and data analytics, with emphasis on case studies relevant to cyber operations and to the DoD. Topics include technologies and trends for Big Data management (e.g., distributed cloud file systems, NoSQL data stores); major themes and technologies in cloud computing (SaaS, PaaS, IaaS), distributed computation frameworks (MapReduce); and case studies focusing on how cloud infrastructure is used to enable services and analytics (e.g., mining, matching filtering and translating data).

Prerequisite: CY3520.

CY4700 - Defensive Cyberspace Operations (3 - 3)

This course explores methods to discover adversarial presence on a network and defend against adversarial TTPs (tactics, techniques, and procedures). Topics include, but are not limited to: the cyber kill chain, techniques the adversary uses to remain hidden within a compromised network, adversarial command and control, malware triage, mitigation of malware and eviction of an adversary from an operational network.   Labs assignments will reinforce material taught in class.

Prerequisite: CY3000 and CS3690; or consent of the instructor.

CY4710 - Adversarial Cyberspace Operations (3 - 2)

This course explores the underlying principles and TTPs (tactics, tools and procedures) of offensive cyberspace operations, and considers the campaign-level advantages achievable through delivery of cyber effects. It examines the use of cyber capabilities against target networks, based on a methodology of cyber reconnaissance of network defenses and vulnerabilities, analysis of viable options for exploitations, preparation and delivery of

cyber effects, and post-delivery impact assessment. Students will gain experience using the latest tools and techniques for penetration-testing against target networks.

Prerequisite: CY3000 and CS3690; or consent of the instructor.

CY4750 - Advanced Cyber Systems and Operations (3 - 1)

This course serves as a capstone experience in which the students are immersed in a current operational or policy challenges related provided by the Information Dominance Corps community stakeholders. The assigned task will involve proposed cyber operations in support of an existing or anticipated operational plan. Student teams will develop courses of action (COA) that address legal, ethical, political, technical, tactical, operational and strategic implications. The recommended COA will be presented to the stakeholders.

Prerequisite: CY4100, CY4400, CY4600.

CY4900 - Research Topics in Cyber Systems and Operations (1 - 0)

This course is designed to help students determine, shape and explore the foundational research for their theses and to introduce them to advances in cyber technologies and research. Students are expected to register for this course in the second quarter of their course of study. Prerequisites: None.

CY4901 - Cyber Systems and Operations Research Methods (1 - 0)

The objective of this course is to introduce students to research design and execution in the context of cyber systems and operations. Topics include a review of quantitative, qualitative, and heterogeneous research methods. Framing a hypothesis, collection of background material and literature review, the use of models and experimentation as part of a scientific process, testing and analysis, and the determination of well-grounded conclusions will be covered. The development of the thesis, writing techniques and thesis management will be covered. Students are expected to register for this course in the third quarter of their studies.

DA

DA0810 - Thesis Research (0 - 8)

This is a thesis research block.

DA0812 - MIIS Exchange (0 - 0)

(NO CREDIT) Students participating in the exchange program with the Middlebury Institute of International Studies (MIIS) will enroll in this course.

Cross-Listed as: NS0812.

DA2010 - Technical Writing and Composition (4 - 0)

This course provides a review of the rhetorical and grammatical principles necessary for successful academic writing. Course content emphasizes standard English grammar and syntax, as well as mastery of two rhetorical modes: comparison and contrast and persuasion. Emphasis is also placed on the correct use of both parenthetical and footnote notation and documentation for traditional and electronic sources. Prerequisites: None.

DA2410 - Modeling for Military Decision Making, I (4 - 0)

This course introduces mathematical modeling processes and concepts. Deterministic models in a graphical setting will be emphasized, including experimental modeling, curve fit-ting, and optimization. Applications include arms race models, Lanchester combat models, exponential growth and decay models, the Logistic model for social diffusion, supply/demand economic models, and inventory models. The computer is used as a tool with emphasis on the Excel spreadsheet package.

Prerequisite: Prerequisite: College algebra..

DA3010 - Technical Writing and Composition, II (4 - 0)

This course provides an in-depth analysis of the rhetorical principles applied in effective academic writing. Course content emphasizes rhetorical analysis, research, formal academic documentation, and a further review of English grammar and syntax. This course is writing intensive and intended to further the principles introduced in DA2010.

Prerequisite: DA2010.

DA3101 - Conflict in the Information Age (4 - 0)

With the advent of Big Data, Artificial Intelligence, and Autonomous Robotics, the "Information Age" has entered a new phase. These changes demand rethinking future military and security policy and the subsequent war fighting and competition strategies that are required for a successful national security. While significant attention is focused upon information technologies, the principal emphasis in this course lies in an endeavor to understand the ways in which new technologies affect military strategy, doctrine, and organization. In particular the rise of networked organizations, non-linear military operations, and irregular warfare conducted by both Special Operations Forces and Conventional Forces. Prerequisites: None.

DA3102 - Psychological Warfare and Deception (4 - 0)

This DA 3102 course will examine: What constitutes psychological operations? What constitutes military deception? How do PSYOP and MILDEC relate to each other? What are the necessary and/or sufficient conditions for successful PSYOP and MILDEC? How can PSYOP and MILDEC influence the outcome of a war, or contribute to the resolution of a crisis? Prerequisites:

None.

DA3104 - Computer Network Attack and Defense (4 - 1)

This course introduces the basic principles of attacking and defending computer networks. On the attack side, it covers system intrusions, denial of service attacks, viruses, worms, and Trojan horses. On the defense side, it covers security policies and objectives, access control, authentication, firewalls, intrusion detection, cryptography, security management, and incident response. Basic networking concepts, including TCP/IP, are also covered. No background in computer science or networking is required. The course includes some hands-on work with hacking and security technologies. Prerequisites: None.

DA3105 - Conflict and Cyberspace (4 - 1)

This course examines how cyberspace, particularly the Internet, can serve as a tool of conflict in the hands of both state and non-state actors. Topics include: characteristics of cyberspace, technology trends, power in cyberspace, cyber-based information operations (IO), cyber surveillance, domestic and international laws governing cyber operations, cyber crime, cyber activism and hacktivism, cyber terrorism, cyber warfare, and cyber defense. Prerequisite: None.

DA3110 - Sovereignty, Resilience and Resistance (4 - 0)

This course will examine the theories and research of the use of resilience and resistance by nations to defend territorial, cultural, and information sovereignty and deter aggressive states from invasion. This course will examine the three phases of conflict; pre-crisis, onset of crisis, and the loss of sovereignty, and study the implications of resilience and resistance on local communities as well as their aggressors. Throughout the course, we will dissect the role, responsibilities, and authorities of special operations tasked to support these activities.

Prerequisite: DA3882.

DA3120 - Jihadi Information Operations (4 - 0)

This course traces the rise and evolution of the Jihadi movement since its birth in the 1960s; analyzes the symbols, discourses, and media Jihadist use in their own information operations, primarily vis-à-vis the larger Muslim community; and examines the impacts on and receptiveness of the broader Muslim community to these information operations. The focus of the course is on the transnational Jihadi movement, but some examples of local Jihadism will be discussed as well. Prerequisites: None.

DA3180 - Warfare in the Electromagnetic Spectrum: Principles and Applications (4 - 0)

This course provides students an introduction to the electromagnetic spectrum (EMS) and how we operate and conduct warfare within it. The class will include information up to and including SECRET-US ONLY; Clearance is required. No other courses are required as a prerequisite.

Security Clearance Required: Secret.

DA3201 - Strategic Decision Making for Special Operations (4 - 0)

This course examines the unique relationships and associated risks between strategic, operational, and tactical decision makers during the conduct of unconventional warfare (with emphasis on military special operations). The course begins by surveying popular models and theories of U.S. Government decision making and bureaucracy, while using selected case studies to improve the student's diagnostic skills. Roles and relationships between key strategic and political stakeholders in this decision-making process are examined to better understand the practical environment. Lastly, students will develop alternative methods of high risk/high payoff decision making based on the course subject matter. Prerequisites: None.

DA3260 - Human Intelligence in Irregular Warfare (4 - 0)

The course examines human intelligence operations in irregular warfare. It covers espionage, various source operations, counterintelligence, and covert action. It also briefly discusses the intelligence community and issues of coordinating the various human intelligence activities of the U.S. government. A central purpose of the course is to understand what changes may be necessary to human intelligence operations in order to increase their effectiveness in irregular warfare. Prerequisites: None

DA3270 - Intelligence in the Information Age (4 - 0)

The course examines intelligence in light of the information revolution. It examines collection, analysis, covert action and counterintelligence. It also discusses the intelligence community and issues of coordinating the various intelligence activities of the U.S. government. A central purpose of the course is to increase understanding of the relationship between intelligence and information operations.

Prerequisite: DA3101.

DA3301 - Principles of Strategic Design (4 - 0)

Military and security affairs are profoundly shaped by the design choices made regarding what types and which specific weapons, transport, and information systems to develop and sustain. Their alignment with the appropriate organizational designs and doctrinal concepts

of operations is an essential element in the innovation process so critical to maintaining and improving military effectiveness. This course surveys principles of design, as practiced by commercial and industrial enterprises and in their military historical context, and examines how strategic design can be applied to current and future innovation and force modernization initiatives. Offered as required.

DA3302 - Navigating Innovation Ecosystems (4 -)

The older institutions of military innovation are being outpaced by rapid technological change and the increasing importance of non-traditional actors and communities. This course is designed to prepare students for understanding, navigating, and successfully leveraging the ecosystems relevant for innovation. The content of the course is designed to (a) map the most current innovation landscape, (b) prepare students to understand the varying incentive structures, cultures, and norms across the landscape, and (c) provide the intellectual tools for successfully traversing this space. Offered as required.

DA3304 - Rapid Prototyping for the Warfighter (3 - 2)

The proliferation of new, inexpensive, easy-to-use technologies has dramatically lowered the barrier to technology exploration. This new frontier allows the user an unprecedented ability to design new solutions to wicked problems and to quickly iterate over new and exciting alternatives. Rapid prototyping leverages low-cost, low-resolution models of potential solutions to drive the processes of design and innovation. This course introduces a prototyping methodology for this exploration, requires hands-on active engagement with rapid prototyping, investigates other labs on and off campus that are engaged in prototyping efforts, and explores how this alternative approach might impact students' future military engagements.

DA3410 - Modeling for Special Operations II (4 - 0)

This course continues the mathematical modeling process and concepts introduced in DA2410. Students will use statistical software to create probabilistic and statistical models to analyze data in the context of special operations, irregular warfare, defense innovation, information operations, and political warfare. Students will apply these models to military decision-making under risk and uncertainty.

DA3450 - Open Source Data Analysis (4 - 0)

In this course, students will learn to use "Big Data" to answer "Big Questions." The course focuses on the use of open source data and open source software, and walks students through writing computer commands which will allow them to automate the formatting, merging, and analysis of large datasets, with the goal of allowing students to tap into the global explosion of data resources which are increasingly available through online media, using freely available tools that can be employed in diverse environments that may lack access to expensive proprietary software.

Prerequisite: DA3410 or Consent of Instructor.

DA3460 - Wargaming the Great Campaigns of History (4 - 0)

This course is designed to provide the student with the opportunity to develop a deeper understanding of the fundamental dynamics and principles underlying combat operations. Students will develop an understanding of the fundamentals of both campaign analysis and wargame Design Mechanics allowing them to develop their own games. The course utilizes a mixture of commercial and private wargames to develop a practical understanding of the principles of wargame design. The course consists of a mixture of interactive seminar discussions and practical exercises designed to provide the principles and Design Mechanics of wargame design allowing students to critically examine a historical campaign and design, develop, and play their own comparative dynamic model of their selected campaign.

Prerequisite: DA2410, DA3410.

DA3600 - Geographical and Temporal Dimensions of Dark Networks (4 - 0)

This course is the first of a two-course series that focuses on the spatial, temporal, and relational dimensions of dark networks. Dark networks involve covert and illegal activity such as drug-trafficking and terrorist networks. Using a task-based approach, the first course introduces a terrorist network that students analyze using Google Earth, ArcGIS, and software tools that elicit temporal and geospatial aspects of terrorist network activity. This ability to anchor data to both location and time is of primary importance to our students and is invaluable to their ability to analyze trends of current and past activity in their AOR. This class will teach students to think critically and creatively about how different forms of spatial data can be integrated into their research. While the class will briefly cover fundamentals of remote sensing and coordinate systems, this lab-intensive course primarily focuses on real-world situations that students will face in the field. No prerequisite.

DA3610 - Visual Analytics (4 - 0)

Visual Analytics is the first course in the CORE Lab sequence. It addresses a common problem we all face-the collection of data at a faster rate than our ability to analyze it. The course's purpose is to introduce methods to examine and analyze massive, multidimensional, multi-source, time-varying data. It offers new tools and technology to integrate and fuse data to support the

analytical process so we are better prepared to make decisions in a time-critical manner. Ultimately, the course opens the door to what some consider a new multidisciplinary field: Visual representations and interaction techniques that enable us to see, explore, and understand large amounts of information at once; Data representations and transformations that convert all massive, multidimensional, multi-source, and time varying information in ways that support visualization and analysis; Analytical reasoning techniques that enable us to obtain deep insights that directly support assessment, planning, and decision making; Techniques that support the production, presentation, and dissemination of analytical results and the communication of information to a variety of audiences (Thomas and Cook, 2005:4). Prerequisites: None.

DA3701 - Seminar in Stoic Ethics (4 - 0)

This seminar offers an introduction to Stoic ethical thought. Stoicism was an influential philosophical system that developed in the Western world between the Hellenistic period (which is generally said to begin with the death of Alexander the Great in 323 BCE), and the Imperial Roman period into the mid to late second century CE. A group of students as practically minded as yourselves might reasonably ask the question: "So what? What does any of this have to do with me? What possible value can I gain from studying a body of thought that 1) has not been systematically observed for over the past eighteen hundred years and 2) was grounded in a cosmology and a set of physical and metaphysical beliefs that have long since been supplanted by the progress of science?" Prerequisites: None.

DA3720 - The Rise of Religious Violence (4 - 0)

This course aims to explore the conditions under which religious groups engage in violent activity as a means of achieving various political, social and religious goals. The ultimate purpose of the course is to a) investigate how religion influences conflict, violence and war b) compare the rise and fall of religious groups engaging in violent activity with the intent of better understanding the conditions under which religious groups resort to and abandon violence c) consider ways in which religiously motivated violence can be mitigated and d) investigate how the United States and the U.S. military can address religiously motivated violence directed at its government, military, citizens and other interests.

Prerequisite: Student completed at least one full quarter.

DA3721 - Networks and Religion (4 - 0)

This course explores the interplay of social networks and religion. Social scientists have long been aware of the interaction of social networks and religious behavior, but there are few, if any, systematic analyses of the topic. This course seeks to remedy this gap. It is divided into six sections. The first provides an overview of the history of, as well as current trends in, the social scientific study of religion and social network analysis. The next four sections focus on different ways that social network ties affect religious behavior: those that bind people of faith together (i.e., ties that bind), those through which religious ideas diffuse across time and space (i.e., ties that loose), those that contribute to the health and well-being of people and communities of faith (i.e., ties that build up), and those that lead to conflict and violence (i.e., ties that tear down). The final section consists of student presentations of their papers, as well as a review of the course.

Prerequisite: Student completed two quarters of coursework.

DA3750 - Anthropology of Conflict (4 - 0)

The focus of this course is cross-cultural conflict and violent confrontation with a view to considering how anthropology might be better used to study modern warfare and large-scale ethnic conflict. For instance, military historians, political scientists, and foreign policy analysts increasingly refer to 'culture' and religion, identity politics, and ideology to help explain the new world disorder. From an anthropological perspective, are they using these social science concepts correctly? This course is designed to not only expose students to anthropological concepts useful for understanding the motivations of combatants from other cultures and the nature of warfare as fought by different people(s), but the extent to which cross-cultural miscommunication can complicate the role of U.S. military personnel abroad. Prerequisites: None.

DA3760 - Soul of the Sword: The History of Weapons (4 - 0)

This course examines the evolution of weapons primarily from a cultural and anthropological perspective, the aim being to provide military professionals with a more basic insight into how and why arms are and were chosen; how the use of weaponry and the concept of courage have manifested themselves over time, and the manner in which the institution of war has been influenced by the nature of the armaments extant at the time conflict took place. The course will place special emphasis on not only the roots of weaponry very early in human existence, but also the characteristics and use of "weapons" (i.e., teeth, claws, antlers etc.) by other species. This course will cover a vast sweep of history; expect to cover rocks and rockets along with everything in between. Prerequisites: None.

DA3800 - Theory and Practice of Social Revolution (4 - 0)

This course is intended to examine various forms and dynamics of social revolution and theoretical debates in the study of social movements. We will be particularly concerned with the social and political context of

insurgency, focusing on basic questions, such as: Under what circumstances are grievances or political dissents more likely to evolve into an insurgency? How do dissidents frame their agendas to acquire support and to recruit others? In addition, how do insurgency movements become transnational? 1) Theoretical Synthesis: this course provides an overview of insurgency from the conceptual framework of social movement theory. Rather than treating social revolution as a self-contained phenomenon, this course will introduce alternative frameworks and explanatory models generated from social movement theory in order to isolate the types of factors that are most pertinent to understanding the causes and processes of insurgency. 2) Empirical Application: Based on the theoretical models this course introduces, we will focus on a small number of empirical cases and identify underlying factors to explain how and why certain groups use different political, military, and social methods to pursue their goals. Students will be asked to evaluate which theoretical models are most applicable under particular circumstances in each case. Prerequisites: None.

DA3801 - International Terrorism (4 - 0)

This course provides an in-depth examination of the origins, nature, and political/military roles of contemporary international terrorism. It briefly examines the early history of terrorism, the contending theories that purport to explain the sources of terrorist behavior, the different types of terrorism and terrorist actions, and the challenge international terrorism poses for American interests and foreign policy. Functional topics, such as the special problems posed by state-sponsored terrorism, the relationship between terrorism and the media, and the range of possible military responses to terrorism are also examined. The course will conclude by comparing and contrasting different national responses to the problem of international terrorism, and examining the difficulties faced by the United States in its efforts to find and effective policy response. Prerequisites: None.

DA3802 - Seminar in Guerrilla Warfare (4 - 0)

Have you ever wanted to seize state power from below? Have you ever been responsible for keeping others from doing so? This reading seminar is designed to examine the strategy and operational art of substate conflict. It examines the problems of social mobilization; underground organization, command and control, and security; alternate strategies of internal war, and competing theories of counterinsurgency. These and related issues are examined analytically and historically. Comparative cases are discussed and evaluated. Throughout the course, attention is also given to the manner in which such wars are conducted in the future. Prerequisite: None.

DA3880 - History of Special Operations (4 - 0)

What constitutes a "special" operation? This course considers special operations in a historical context, with emphasis given to their impact on war outcomes, the necessary conditions for their success, and the patterns of civil-military relations that emerge when elite forces are formed. Successes and failures in air, ground, and naval actions are equally considered. Historical studies from World War II to the present will provide the principle means of analysis to gain insights into the theory, practice, and effects of special operations and irregular warfare. Prerequisite: None.

DA3882 - Coercion and Competition in World Politics (4 - 0)

This course teaches students the strategic context surrounding military and special operations and is the basic building block for the understanding of the use of military force. Students will gain an in-depth knowledge of deterrence and international relations. Prerequisites: None.

DA3883 - The Rise, Transformation and Future of the Nation-State System (4 - 0)

This course provides students with a broad overview of the rise, proliferation, and possible fall of the major international organizing tool of the modern era: the nation-state. The course examines the rise of the nation-state in Europe, focusing on the specific political and economic factors that shaped the nation-state; the adoption of the nation-state system around the world, where it did not emerge organically; and the possible decline of the nation-state in the age of globalization. Does globalization mean the end of the nation-state, and if so, what kinds of organizational arrangements are likely to compete with and perhaps replace the nation-state? Prerequisite: None.

DA3885 - Proliferation and Counter-proliferation (4 - 0)

This course provides students in the special operations community and related fields with the analytic tools to understand proliferation strategy and devise effective counter-proliferation measures. The course focuses on (1) why actors pursue or forego nuclear, chemical, and biological (NCB) weapons; (2) how actors go about developing these unique capabilities in the face of security risks and resource constraints; and (3) when various political-military options are most and least effective at inhibiting the spread of NCB weapons, especially amid an era of rapidly emerging technology. The course pairs traditional seminars and written assignments with interactive exercises to simulate strategic decision making by foreign actors over NCB-weapons programs. Students

are equipped to identify over-the-horizon proliferation challenges, exploit specific opportunities, and formulate options for engaging with partners in the counter-proliferation arena.

Prerequisite: DA3882 or consent of instructor.

DA3900 - Command and Leadership (4 - 0)

This graduate-level elective course focuses on command and staff leadership at the tactical, operational, and strategic levels. This course is run as a seminar. Students will examine/gain appreciation of best-practice command and staff leadership in multi-domain operations, though the lens of regular forces, irregular forces, interagency elements, coalitions, and alliances. Students will consider differing leadership paradigms and examine the strengths and limitations of these constructs and their techniques as applied in practice. The course will include sessions with prominent American and international guest lecturers with broad experience in command and leadership of the military, inter-agency organizations, politics, business, coalitions and alliances, academics, and other fields. Prerequisites: None.

DA4038 - SOF Support to Governance (4 - 0)

A class to prepare future ARSOF senior leaders with a comprehensive understanding of transitional governance. The course applies theories, methods, and practices to governance-based support activities in competition and conflict, across contested, austere, denied, and politically sensitive environments. Readings constitute historical examples in military governance of WWII reconstruction to regional case studies in transitional governance apparatuses and counter proxy influence.

DA4280 - Intelligence and Counter-Proliferation (4 - 0)

This course examines the role of intelligence in countering the proliferation of weapons of mass destruction (CP/CWMD). It provides a holistic look at the Intelligence Community and various capabilities used to collect, analyze, and disrupt proliferation networks. The course will also cover the vital role intelligence plays in diplomacy, including negotiations, sanctions, and support to international nonproliferation regimes. The instructor will use case studies, guest speakers, site visits, and draws on a decade of CP/CWMD experience to illustrate key concepts.

Prerequisite: Students should take DA3882 and are recommended, but not required, to take DA3885 prior to taking this course.. Security Clearance Required: .

DA4101 - Concepts in Information Operations (4 - 0)

The emergence of information operations (IO) signaled a broadening of the original concept of information warfare (IW) beyond its early emphasis on electronic warfare and/or cyberspace-based attack and defense, to include also such notions as managing others' perceptions, public diplomacy, and the media. This broadening implied a new emphasis on content-based concepts of information operations as opposed to conduit-oriented issues of attack and defense of communications. This course surveys the entire scope of IO, keeping in mind the critical importance of IW, but also emphasizing the more conceptual issues having to do with strategy, doctrine and organization. Applied issues are also examined, including such topics as the methods for sharing sensitive data with semi-trusted allies, and the impact of information attack and defense on the future of force projection. Prerequisites: None.

DA4102 - Special Information Operations (4 - 0)

This course serves as a project-oriented culmination of the studies of those specializing in the SOLIC "IO track." Students are given a specific, real-world problem and challenged to find the place for IO in developing solutions. The goal is both to mobilize the knowledge amassed from previous study and to use practical experience to gain insight into the issues of how IO can support special operations, and how special operations can support IO. Another key element of the course is the requirement that the students work as a team, employing either organizational concepts they have learned about, or developing new ones that may be most suitable to the particular problem at hand. The course concludes with briefings to the sponsors of the given project undertaken. The course is conducted at a Top Secret level. Prerequisites: None.

Security Clearance Required: Top Secret.

DA4104 - Militaries and Technological Change (4 - 0)

Technological advances have always influenced developments in military affairs, particularly fighting doctrines and forms of organization. This course surveys the major technological changes that accompanied industrialization: including advances in weapons, transportation, and communications systems; and examines the ways in which professional militaries adapted to these developments. Special attention is given to advances in information systems, as the goal of the course is to derive insights into how militaries might respond, doctrinally and organizationally, to an extended period of information-technology-driven changes in military affairs. Prerequisites: None.

DA4105 - Special Topics in Information Operations (4 - 0)

This course will focus on special topics in information and special operations. The list of topics to be analyzed for the seminar is announced at least one quarter prior to the offering of the seminar. Advanced study and research is conducted on topics not covered in other seminars. A major, graded research paper is required.

DA4106 - Trust, Influence and Networks (4 - 0)

This course examines the underlying nature of trust and influence, especially as they shape and are shaped by social networks. Students will acquire a theoretical foundation for these concepts and how they apply to a broad spectrum of activity, including work processes, military operations, underground movements, information and intelligence operations, governance, and the media; how trust and influence are established, maintained, exploited, and lost; and the functions they serve for individuals, organizations, and societies. Concepts will be illustrated with examples drawn from a variety of contexts. The course is aimed especially at students concerned with unconventional warfare, information operations, network-centric warfare, nation building, civil and military affairs, public affairs, terrorism, and intelligence. Prerequisites: None.

DA4107 - Psychological Influence (4 - 0)

This course examines a range of both public and covert efforts (hostile and friendly) to achieve influence through information and communication. Drawing from social and political psychological theories and research, we will examine the conditions under which influence in the information environment is most likely to succeed or fail. Prerequisites: None.

DA4108 - Deception, Denial, Surprise, and Counterdeception (4 - 0)

An impression about the threats a nation faces shapes its policies and actions in both war and peacetime. Consequently, information has a vital role in understanding threats and creating impressions. At the same time, it is uncertain whether the proliferation of communications technologies and the dissemination of vast amounts of information will keep senior leaders better informed or simply create more confusion. This course aims to stimulate serious thought about how deception, denial and counter-deception can influence the outcome of a war or contribute to the favorable resolution of an international crisis. Topics include: the theory and process of deception; the role of intelligence; the process of protecting information that could be used by opponents to uncover some truth; and detecting deception. Case studies will be used throughout the course to reinforce important concepts. Prerequisites: None.

DA4110 - Applied Influence (4 - 0)

This course expands upon the foundational principles taught in DA4107 *Psychological Influence*. In part one of the course, we will examine a wide variety of influence products across defense and private sectors, discuss the psychological forces at play, and evaluate their effectiveness. Part two of the course focuses on *applying* these concepts. In doing so, students will develop an influence campaign to include messaging products designed to change the thinking or behavior of a target audience. The third and final part of the course is dedicated to student presentations to the class and wider audience.

Prerequisite: DA4107.

DA4120 - Seminar on Jihadi Information Operations (4 - 0)

This advanced seminar is designed as a follow-on course to DA 3120 for students pursuing theses or advanced research projects relevant to the field of Jihadi information operations. Course material will provide a more robust examination of the nature and types of IO campaigns used by both local and transnational Jihadi groups, but will also allow students to pursue and present specialized research on the topic.

Prerequisite: DA3120 and a one-page statement of research.

DA4250 - Covert Action (4 - 0)

This course examines the role and conduct of Covert Action in the United States. The course will cover historical cases, and various types of covert action employed by US Presidents to further US policy goals. The class will also look at the role of congressional oversight, legal authorities, policy considerations, and ethical issues, and is relevant to DoD/DoN to further interagency collaboration and engagement in Title 10/Title 50 deconfliction of operations in today's battle space. This class will include information up to the SECRET level but most course material and student papers/presentations are expected to be kept UNCLASSIFIED. Prerequisites: None.

Security Clearance Required: Secret.

DA4285 - Counterproliferation (4 - 0)

This course will prepare students to counter nuclear, biological, and chemical (NBC) weapons threats in future operational or staff assignments by improving their understanding of the causes and consequences of NBC weapons proliferation and use and the strategies and capabilities available to counter these threats. Prerequisites: None.

Cross-Listed as: Cross-listed with NS4285.

DA4301 - Fighting Undeclared Wars: American Approaches (4 - 0)

FIGHTING UNDECLARED WARS: AMERICAN APPROACHES examines the aspects of American culture that affect the United States' ability to conduct special operations and engage in undeclared wars. By understanding American strategic culture, both U.S. and allied students should be able to plan more effective operations. The course builds on a historical review, from pre-Revolutionary wars and the Constitutional basis of the Armed Forces, through the

undeclared wars and warfighting theories of the 19th and 20th centuries, including recent special operations. From the historical studies, the students consider aspects of modern warfighting, including strategy formulation, civil-military affairs, use of force, covert action and policymaking. This course exposes U. S. and allied students to "FIGHTING UNDECLARED WARS," and also reveals the political, societal, economic, military and intellectual underpinnings of undeclared wars as a tool of United States national security and policy. Prerequisites: None.

DA4302 - Coping with Wicked Problems (4 - 0)

This interdisciplinary seminar focuses on a new class of problems-"wicked problems" or "messes." Evidence of wicked problems comes from experts in many quarters-product designers, software engineers, planners, program managers and policy makers. All warn that traditional methods of problem solving are not working and no apparent alternatives are in sight.   Wicked problems have the following characteristics: 1) there is no agreement about "the problem." In fact, the formulation of the problem IS the problem. 2) There is no agreement on a solution. In actuality, stakeholders put forward many competing "solutions" none of which have stopping rules to determine when the problem is solved.   3) The problem solving process is complex because constraints, such as resources and political ramifications, are constantly changing. 4) Constraints also change because they are generated by numerous interested parties who come and go, change their minds, fail to communicate, or otherwise change the rules by which the problem must be solved. Using case studies, readings and actual dilemmas confronting military officers and government officials, students learn to recognize when they are in wicked problem territory and what coping strategies and tactics might be useful in this problem-solving context. Prerequisites: None.

DA4303 - The Scientific Study of War (4 - 0)

This course is designed to treat the 'scientific study of war' as a debate. Can we study war and warfare using science as a model? If so, why is there such seeming reticence to doing so among policy circles, significant portions of the military community, and general public? What are the strengths and weaknesses of various scientific tools and what do we risk by eschewing science altogether? The course proceeds in two parts. In the first part of the class we examine the history of military thought as it pertains to the question of 'scientism'. In the second part of the course we look at various methodological approaches to understanding organized conflict and assess their strengths and limitations. These will include theory building (both rhetorical and formal), hypothesis testing using quantitative and qualitative approaches, as well as various forms of simulation. The substantive issues

covered include the outbreak of war, the conduct of war, the termination of war, and the relationships between war, civil society, and economics.

Prerequisite: Student completed at least two full quarters.

DA4410 - Models of Conflict (4 - 0)

This course deals with the problems faced by a rational decision-maker, trying to maximize some payoff in a social setting. A distinction will be made between Type I behavior (optimization in a game against nature), Type II (optimization when faced with agents who react against the decision-maker's perceived behavior), Type III (optimizations against strategic agents), and Type IV (cooperation with other agents). Applications include arms race models, treaty inspections problems, monopolistic behavior, coalition formation, and pursuit games. The computer is used as a modeling tool.

DA4460 - Alternate Research Methods and Defense Analysis (4 - 0)

This course is the first in a two-quarter sequence intended to familiarize students with a range of methodological approaches applicable to graduate research across the spectrum of topics included within the concept of defense analysis. Both qualitative and quantitative methods are considered in this course, with equal emphasis given to case studies, heuristics, sociological approaches, statistical analyses and formal modeling and game theory. More esoteric approaches will also be briefly considered, as will the blending of methodologies, with the degree of attention given to these approaches being dependent upon specific student interest and need. Beyond the conceptual study of research methods, students will also be exposed to many examples of scholarly works that employ one or more of the methods being studied. The course, though focused on methods, also introduces the concept of research design to help prepare students for the second course in the sequence. Graded on Pass/Fail basis only. Prerequisites: None.

DA4470 - Designing Operationally Oriented Research Studies (4 - 0)

Decision-makers need tabletop exercises, crisis simulations, and wargames to help them visualize and describe modern strategy, operations, and campaigns. Good strategies start by first visualizing and describing competition, then developing ideas to increase your chances of winning and analyzing your ideas in a competitive environment. Any research — from historical cases to trend analysis and quantitative models — that helps decision-makers recreate this competitive clash of wills provides a simulation against which to develop strategy and operational campaigns. The course aims to help students understand how to use wargaming, focused on contemporary operational concepts and threats, to create and analyze relevant operational campaigns to

achieve strategic objectives. The course provides a wide range of research design concepts enabling students to develop a wargame to support research on critical issues. Students will develop an understanding of the links between strategy and operational campaigns, how operational concepts flow from an individual's definition of competition and victory, and how the choices of others influence these concepts in a competitive environment. In applying research design to operational planning, students will understand the unique features of the various design methods and how they can best use them for operational/campaign planning analysis. During the course, students will be able to demonstrate knowledge of strategic planning, operational theory, and wargaming methodology - including the research, design, development, execution, and analysis of their own designed operationally oriented effort.

Prerequisite: DA4460.

DA4480 - System Sciences for Strategic Analysis and Planning (4 - 0)

This course is intended to provide an introduction to the Philosophy of Science and concepts of General Systems Theory, complexity and chaos theories, cybernetics, social network analysis, stakeholder analysis, systems approach to net assessment, Complex Adaptive Systems, and system dynamics as they apply to analysis and strategic planning. Some basic algebraic functions and calculus concepts and graphs that relate to system dynamics modeling and cybernetic systems will be discussed as they underlie system dynamics (and cybernetics), network theory, chaos theory, and cause and effect relationships that inform or contribute to a better understanding of systemic behavior over time. The focus will be on concepts rather than specific mathematic calculations.

Prerequisite: DA 2410.

DA4481 - System Dynamics Modeling for Planning and Design (3 - 2)

This course will teach the basic concepts of system dynamics and modeling/simulation of dynamic systems. Real world applications and military case studies will be used to illustrate the value of system dynamics and students will be given the opportunity to model various real world problems of particular interest for the DoD/DoN .

Prerequisite: DA4480.

DA4500 - Special Topics in Strategic Analysis (4 - 0)

This course will focus on special topics in special operations and low intensity conflict. The list of topics to be analyzed for the seminar is announced at least one quarter prior to the offering of the seminar. Advanced study and research is conducted on topics not covered in other seminars. A major, graded research paper is required.

DA4600 - Dark Networks (4 - 0)

This course focuses on dark networks-covert and illegal networks such as drug-trafficking and terror networks. The course's first objective is to teach students how to identify and describe these networks and their dynamics. We use various software packages (e.g. Inflow, e.g. Analyst Notebook) to aid in the identification and description effort. The second objective is to design intervention strategies to disrupt, destabilize and possibly destroy dark networks once they have been identified and described. Students are expected to focus their interventions at the tactical and operational levels, although some attention is given to the strategic and policy levels as well. Prerequisites: None.

DA4601 - Terrorist Financing (4 - 0)

This course will examine how terrorists fund their activities and how they can be tracked and thwarted through their financial networks and footprints. It will cover sources and methods of terrorist financing, including the role of charities, legitimate businesses, and crime; the use of both formal banking systems and informal hawala systems to transfer funds; and money laundering. It will also cover national and international structures, regulations, tools, and efforts to identify, track, capture, and eliminate terrorists and their financial support through their financial transactions. Concepts will be illustrated with case studies of terrorist groups and regions where terrorism is present. Prerequisites: None.

DA4610 - Dynamic Network Analysis (4 - 0)

This course builds on DA4600 (Dark Networks) by offering additional substantive and methodological tools for analyzing relational networks. The course is pragmatically oriented in that it pays particular attention to issues concerning the collection and preparation of relational data in software programs such as Palantir, Analysts Notebook, Microsoft Excel and Microsoft Access and moving to traditional social network analysis tools such as UCINET, Pajek and ORA (Organizational Risk Analyzer). This course will also explore what is being called dynamic network analysis where users not only examine the effects of actual ties (e.g., friendship, kinship) but also "virtual" ties (e.g., shared ideology, skills, knowledge, etc.) Finally, the course will introduce students to techniques using social network data (regression) and geospatial data (geospatial statistics) that will help students tease out which variables (e.g., centrality, education level) are causally related from those that are not.

Prerequisite: DA4600 and permission from the instructor.

DA4620 - Network Design (4 - 0)

In 21st century operational and policy environments, more and more people operate in networks to get things done-community networks, policy networks, inter-agency

networks, business networks, international networks etc. Defined as sustained relations between two or more social actors (e.g. individuals, groups, organizations, or nations), networks can be formal or informal and serve a range of purposes. Reliant on readings and cases, this course helps students develop a basic understanding of networks and the skill set to operate effectively within them. Primary networks of interest are those whose members come from different cultural, ethnic, organizational, and national backgrounds.

Prerequisite: Must be two quarters into a program..

DA4710 - Critical Thinking and Ethical Decision Making (4 - 0)

This course explores both the contemporary and classical frameworks used to define effective ethical leadership and decision making. Emphasis is placed on the development of critical thinking and decision making skills, the recognition of logical fallacies, and the analysis of both civilian and military case studies, and the exploration of current ethical issues. Readings for this course span classical selections from such writers as Plato, Rousseau, Kant and Mill through contemporary papers from the 1996-'97 Joint Services Conferences on Professional Ethics. Prerequisite: None.

DA4711 - Ethical Analysis of War (4 - 0)

This course will focus on the contemporary philosophical debate over the moral justification for states engaging in war and for individuals killing in war. The foundations and history of just war theory, as well as alternative accounts such as political realism and pacifism, will first be covered to provide a general starting point for the broader moral justification for going to war. From that foundation, debates regarding ethical conduct within war and competing theories over the moral justification for killing will be examined. Topics to be covered also include: recent, contemporary revisionist just war theory models, the moral equality of combatants thesis and its rejection, the moral obligations of a soldier serving for both just and unjust causes, and unique ethical considerations for special forces and irregular war operations. Finally, attention will also be given to the unique ethical challenges raised by newly emerging military technology, such as drones and cyber weapons. This is a graduate philosophy seminar where we wrestle over many of the current issues on the cutting edge of the ethics of war debate in contemporary analytic philosophy.

Prerequisite: DA4710 or Consent of Instructor.

DA4760 - The Military Advisor (4 - 0)

This course examines the many roles of the military advisor-as leader, trainer, liaison-in a wide variety of settings, among very different groups of people, and under significantly different conditions. Lessons will be drawn from first-person accounts. What field craft lessons can be learned from past endeavors? What challenges might advisors expect to encounter in the future? This course is open to Department of Defense Analysis students only or by consent of the instructor.

DA4770 - Ethnic Conflict (4 - 0)

The Ethnic Conflict course poses a series of questions, such as 'what is a state?', 'what is a nation?' in order to better understand when and why ethnic conflict erupts and persists. Often cited as the most prevalent form of warfare today, 'ethnic conflict' as a term may conceal more that its reveals. For instance, strife in Northern Ireland and in Israel is often explained away as ethnonationalist and ethnoreligious in nature. On the face of it, both cases would seem to have much in common. However, once local histories and regional politics are considered, the two represent radically different models of (and for) ethnic conflict. This course will examine a series of such examples in order to better understand the origins, trajectory, and virulence of ethnic conflict. Prerequisites: None.

DA4780 - Political Anthropology: War and Society (4 - 0)

War is a generative force in world politics and culture. Events at the frontline can affect life back at the home front. This course explores how cultural narratives of war (war stories) are affected by the events of war and how national/group identities respond to war—especially when things don't go as expected. This class appropriates the globalization concept and redefines it as a general property of the "international," as relations of interconnection and mutual constitution. It looks at armed force and war through the lens of globalization, arguing that by means of the interconnections it occasions, war is transformative of world politics and of the people and places it reaches out and touches. Throughout, it underlies the interconnection and the play of relations across often widely divergent spaces and populations. In these ways, the course opens up the international as a distinct social space of connection and constitution and anatomizes the place of war and the military in this space. Students will present material on particular regional examples as developed in the course of the class. Prerequisites: None.

DA4810 - Countering International Terrorism (4 - 0)

The course examines the U.S. government's response to international terrorism. It examines policy, strategy, bureaucracy, the role of intelligence, and the media and information campaigns, as well as specific responses to terrorism, such as military force, covert operations, policing, economic sanctions, and diplomacy. The purpose of the course is to provide students a sound basis for developing and evaluating responses to terrorism. Prerequisites: None.

DA4820 - Low Intensity Conflict Seminar: Africa (4 - 0)

This course teaches students how to analyze the nature of conflict in sub-Saharan Africa – who is likely to fight, where, why, and when, with special attention paid to the significance of regional complexities and local particularities. Eight cases are presented with two aims: to present a history of post-colonial conflict and to achieve regional balance. Students are specifically taught how to compare and contrast among different sets of factors which tend to feed conflict in Africa. Students also learn about sources of information to which they can turn in the future should conflict flare up in places with which they are unfamiliar.

Prerequisite: Student completed at least two quarters of instruction in the Defense Analysis Department or NSA or permission of instructor.

DA4830 - Irregular War in the Middle East and South Asia (4 - 0)

This course examines irregular warfare in the Middle East and South Asia. It is focused upon the wars in Iraq, Afghanistan, and Syria. Those conflicts contained new tactics, procedures, and strategies for both adversaries and US forces. The lessons of the wars are contested. The course will delve into detailed assessment of them so that students walk away with a rigorous understanding of what applies to future operations. Furthermore, the course will provide an in-depth understanding of social, political, and religious factors that shape operations in the Middle East and South Asia.

DA4831 - Flashpoints (4 - 0)

Flash points is a course designed to analyze countries and issues of immediate concern to the Special Operations community. Recent courses have focused on the Syrian civil war, the rise of the Islamic State, Iran, and Yemen -- all pressing issues to the USG that do or could directly involve Special Operators. The evolution and nature of state structures and socio-political cleavages in the country of interest are of primary concern.

Prerequisite: DA3882 or an International Relations course..

DA4832 - Anthropology, Media, and War (4 - 0)

This class explores the ways in which culture forms the various foundations and narratives of war, how the media reflects, but also shapes narrative, and also how individual perspectives act on the story. To help focus our readings, regionally we will focus on material, mainly from 1991 onwards--but we need not be limited to any one side's narrative.

Prerequisite: DA3750 and DA4780.

DA4840 - Regional Seminar in Low Intensity Conflict: Europe and the Transcaucasus (4 - 0)

As part of the regional seminar series, this course examines low intensity conflict issues in Europe and the Caucasus. The seminar reviews the theoretical literature on political violence and analyzes the recent history of European and Caucasus-based terrorism and insurgency. It offers a series of detailed case studies of local organizations and conflict, and focuses on functional issues in Europe and the Caucasus. Prerequisites: None.

DA4850 - Regional Seminar in Low-Intensity Conflict: Latin America (4 - 0)

As part of the regional seminar series, this course examines insurgencies in Latin America. The seminar reviews the history of the continent and the Caribbean from colonial times to the present; examines theoretical literature on political violence; and analyzes the recent history of Latin American-based terrorism and insurgency. It offers a series of detailed historical case studies of insurgent organizations and conflicts. Prerequisite: None.

DA4860 - Regional Seminar in Low-Intensity Conflict: Far East (4 - 0)

As part of the regional seminar series, this course examines low-intensity conflict issues in the Far East. The seminar reviews the theoretical literature on political violence and analyzes the recent history of Asian-based terrorism and insurgency. It offers a series of detailed case studies of local organizations and conflict, and focuses on functional issues in the Far East. Prerequisites: None.

DA4883 - Networks and Nation-States (4 - 0)

This course focuses in detail on the relationship between transnational networks and the contemporary nation-state system. It emphasizes that transnational networks manifests themselves in many forms: social; political; philanthropic; criminal. Whatever the future holds for the nation-state system it is clear that transnational networks have taken on an important new (or reconfigured) role with the rise and uneven consolidation of globalization since the 1970s. The course begins with some basic definitional and conceptual issues. This is followed by sections on the history and contemporary significance of regional and global networks of various types. The overall objective of this course is to gain a better understanding of the structure and dynamics of transnational networks; those of a malevolent political character or organized criminal syndicates, as well as benevolent networks of differing types. This is done in a fashion that tries to retain a relatively discrete definition of the term "network", but also makes clear that they have been, and continue to be a more widespread element of world politics and international relations than is sometimes assumed. In this

spirit, the geographical range of the course is global and both discussion and research projects can and will focus on Latin America, Africa, the Middle East, and beyond.

Prerequisite: Students completed at least two quarters of course work, or instructor's permission..

DA4900 - Advanced Directed Studies in Special Operations Low Intensity Conflict (V - 0)

Supervised study in selected areas of special operations and low intensity conflict to meet the needs of individual students. Format and content may vary. Normally involves individual research under the direction of the instructor and submission of a substantial paper of graduate seminar quality and scope. May be repeated for credit if course content changes. Variable 1.0 - 4.0.

Prerequisite: Permission of Instructor.

EC

EC0810 - Thesis Research (0 - 8)

Every student conducting thesis research will enroll in this course.

EC0820 - Integrated Project (0 - 12)

Integrated Project

EC0950 - Seminar (0 - 1)

(No credit) Lectures on subjects of current interest will be presented by invited guests from other universities, government laboratories, and from industry, as well as by faculty members of the Naval Postgraduate School.

EC0951 - Electrical & Computer Engineering Seminar (0 - 0)

Department Seminar

EC1010 - Introduction to MATLAB (1 - 1)

An introductory course for students with little or no programming background using MATLAB. Basic concepts of the MATLAB environment are considered, such as matrix operations, vector and matrix manipulations, equation solving, simulation, programming, and graphing. This course prepares students for using MATLAB in future course work in the ECE department. Graded on a Pass/Fail basis only.

EC2010 - Probabilistic Analysis of Signals and Systems (3 - 1)

The foundations of signals and systems are developed from probabilistic and statistical approaches. Emphasis is on signal processing, communication systems, and computer networks relevant to military applications.

Topics include probability, random variables and random sequences; density and distribution functions; deterministic versus nondeterministic signals; expectation, the d.c. and the r.m.s. values of nondeterministic signals, correlation and covariance; radar and sonar signal detection; LTI systems, transformation of random variables and the central limit theorem; basic queuing theory and computer communication networks.

Prerequisite: EC2410 (may be concurrent).

EC2100 - Circuit Analysis (3 - 2)

The fundamental circuit analysis course for Electrical Engineering majors. The course considers circuit principles, circuit topology, direct current circuits, basics of operational amplifiers, natural response, forced response, total response, impedance concepts, and the application of the Laplace transform to solve circuit problems and transfer functions.

Prerequisite: PH1322 and MA2121 (may be concurrent).

EC2110 - Circuit Analysis II (3 - 2)

A continuation of EC2100. The course considers circuit principles, impedance concepts and steady-state ac circuits, ac power, frequency response and selectivity, and an introduction to machines and power converters.

Prerequisite: EC2100 (may be taken concurrently). .

EC2200 - Introduction to Electronics Engineering (3 - 3)

An introduction to electronic devices and circuits. Solid state physics and semiconductor fundamentals. Properties of p-n junctions in diodes, Bipolar Junction Transistors (BJT) and Field Effect Transistors (FET); static and dynamic models for these devices; and their linear and nonlinear applications. Applications of transistors in the design of amplifiers and digital systems. Ideal operational amplifiers characteristics and applications. Fabrication and the design of integrated circuits.

Prerequisite: EC2100.

EC2220 - Electrical Engineering Design (3 - 4)

A team-based capstone engineering design course emphasizing the application of electrical engineering principles, devices, and circuits to the design, analysis, implementation, and testing of electronic systems. The intensive laboratory component initially reviews various electronic circuits useful in the design of the final project. Final projects require the design, analysis, implementation, testing and demonstration of an electronic system that also incorporates realistic parameters impacting the design process, such as economics, ergonomics, ethics, environmental impact, safety, etc.

Prerequisite: EC2200.

EC2300 - Introduction to Control Systems (3 - 2)

This course presents classical analysis of feedback control

systems using basic principles in the frequency domain (Bode plots) and in the s-domain (root locus). Performance criteria in the time domain such as steady-state accuracy, transient response specifications, and in the frequency domain such as bandwidth and disturbance rejection are introduced. Simple design applications using root locus and Bode plot techniques will be addressed in the course. Laboratory experiments are designed to expose the students to testing and evaluating mathematical models of physical systems, using computer simulations and hardware implementations. ME2801 and EC2300 are equivalent courses. This course can be offered as an online course. Familiarity with the MATLAB development environment is assumed.

Prerequisite: AE2440/EC2440 and MA2121.

EC2320 - Linear Systems (3 - 1)

Formulation of system models including state equations, transfer functions, and system diagrams for continuous and sampled-data systems. Computer and analytical solution of system equations. Stability, controllability, and observability are defined. Introduction to design by pole placement using measured and estimated state feedback. Application to military systems is introduced via example.

Prerequisite: EC2100 and ability to program in MATLAB.

EC2400 - Discrete Systems (3 - 1)

Principles of discrete systems, including modeling, analysis and design. Topics include difference equations, convolution, stability, bilateral z-transforms and application to right-sided and left-sided sequences, system diagrams and realizations, and frequency response. Simple digital filters are designed and analyzed.

Prerequisite: MA1113 and ability to program in MATLAB.

EC2410 - Analysis of Signals and Systems (4 - 1)

Analysis of digital and analog signals in the frequency domain; properties and applications of the discrete Fourier transform, the Fourier series, and the continuous Fourier transform; analysis of continuous systems using convolution and frequency domain methods; applications to sampling, windowing, and amplitude modulation and demodulation systems.

Prerequisite: MA1113 & ability to program in MATLAB or consent of instructor..

EC2440 - Introduction to Scientific Programming (3 - 2)

This course offers an introduction to computer system operations and program development using NPS computer facilities. The main goal of the course is to provide an overview of different structured programming techniques, along with introduction to MATLAB/Simulink/GUIDE and to use modeling as a tool for scientific and engineering applications. The course discusses the accuracy of digital computations, ways to incorporate symbolic computations, and presents numerical methods in MATLAB functions. AE2440, EC2440, and SE2440 are the same course.

Prerequisite: Knowledge of single variable calculus and matrix algebra..

EC2450 - Accelerated Review of Signals and Systems (4 - 0)

An advanced review of continuous and discrete system theory intended for students who have previous education in these areas. Topics covered by each student will depend upon background and competence in the subject matter of EC2400, EC2410, and EC2320. Graded on Pass/Fail basis only.

Prerequisite: Sufficient background in linear systems theory..

EC2500 - Communications Systems (3 - 2)

In this first course on the electrical transmission of signals, the theory, design, and operation of analog and digital communication systems are investigated. Included are A/D conversion, modulation, demodulation, frequency-division multiplexing, and time-division multiplexing.

Prerequisite: EC2200, EC2410.

EC2650 - Fundamentals of Electromagnetic Fields (4 - 1)

This course covers electromagnetic field theory and engineering applications. Both static and dynamic electric and magnetic field theory is covered. The complete theory is presented in terms of Maxwell's equations and boundary conditions. Applications include induction, plane wave propagation in lossless and lossy media, analysis of finite transmission lines, and plane wave reflection. Labs provide practical experience with microwave instruments, components, and measurement techniques.

Prerequisite: MA1116 or equivalent.

EC2700 - Introduction to Cyber Systems (3 - 3)

This course supports the Cyber Systems curriculum, which is engaged in providing education and research in one of DoD/DON key technology areas. The course will provide the fundamentals of the underlying principles of cyber infrastructure and systems, inherent vulnerabilities and threats, and defensive security procedures. Topics covered in this course include number systems, computer systems, concepts in computer programming including C and assembly language, arrays, strings, pointers, stack and heap, memory corruption (buffer overflow), computer networks, Ethernet, Internet protocol, Address Resolution and routing protocols. Additional topics include wired and wireless communication systems, analog-to-digital conversion, and digital modulation.

Prerequisite: Previous exposure to a high-level computer programming language..

EC2820 - Digital Logic Circuits (3 - 3)

An introductory course in the analysis and design of digital logic circuits that are the basis for military and civilian computers and digital systems. No previous background in digital concepts or electrical engineering is assumed.

Topics include data representation, Boolean algebra, logic function minimization, the design and application of combinatorial and sequential SSI, MSI, and LSI logic functions including PLAs and ROMs, and the fundamentals of finite state machine design and applications. Laboratories are devoted to the analysis, design, implementation, construction, and debugging of combinatorial and sequential logic circuits using SSI, MSI, LSI, and programmable logic devices. PREREQUISITES: None

EC2840 - Introduction to Microprocessors (3 - 2)

An introduction to the organization and operation of microprocessing and microcomputers, both key embedded elements of military systems. Topics include: the instruction set, addressing methods, data types and number systems, stack and register organization, exception processing, assembly language programming techniques including macros, assembly language implementation of typical control structures, data structures, and subroutine linkage methods. Laboratory sessions teach a systematic method for program design and implementation. The laboratory assignments consist of a series of programs which collectively implement a major software project.

Prerequisite: Knowledge of a high level programming language..

EC2990 - Design Projects in Electrical Engineering (1 - 8)

Design projects under the supervision of faculty members. Individual or team projects involving the design of devices or systems. Projects will typically be in support of faculty members.

With advanced approval from the Academic Associate, and if taken for a letter grade, this course may be used to satisfy the major design experience at the advanced undergraduate level specified on the ECE department Undergraduate Education Evaluation Form.

Prerequisite: Consent of Instructor.

EC3000 - Introduction to Graduate Research (1 - 0)

This course is designed to prepare students to undertake graduate research and to write a thesis or dissertation. The first part of the course provides an overview of (1) the NPS Department of Electrical and Computer Engineering, the department's research program and its faculty, (2) the NPS Naval Research Program and the organization and functions of the NPS Office of Research & Innovation, (3) NPS library electronic resources, (4) an overview of S&T planning in the DoD, and (5) guidance on the thesis process. In the second part of the course, research opportunities are presented by the faculty. A broader view of the field of electrical and computer engineering is gained through student attendance at ECE Department seminars delivered by outside speakers. In the third part of the course, students are exposed to thesis research

currently being carried out in the ECE Department by attending thesis presentations delivered by graduating students. Graded on Pass/Fail basis only.

Prerequisite: Consent of Instructor.

EC3110 - Electrical Energy: Present and Emerging Technologies (3 - 2)

This course presents electrical energy topics for on shore facilities, expeditionary and ship applications divided into three categories; generation, distribution and consumption. For these three categories the current state of the art is presented first and then expounded with emerging technologies including renewable energy sources, energy harvesting, smart grid, micro-grids, smart metering, energy management systems, flexible AC transmission systems (FACTS), battery management systems, all electric and hybrid transportation systems, more efficient loads such as lighting, motors and power converters.

Prerequisite: PREREQUISITE: EC2100 or EO2102 (may be taken concurrently) or consent of instructor..

EC3130 - Electrical Machinery Theory (3 - 3)

An introduction to the analysis of magnetically-coupled circuits, dc machines, induction machines, and synchronous machines. The course will include explicit derivations of torque, voltage, and flux linkage equations, formulation of steady-state circuits, development of reference frame theory, and the basics of machine simulation as required in shipboard electric drive analysis.

Prerequisite: EC2100.

EC3150 - Power Electronics (3 - 2)

A detailed analytical approach is presented for the operation, performance, and control of the important types of power electronic converters found in naval shipboard power systems. The course reviews the characteristics of power semiconductor switching devices and introduces DC-DC converters, single-phase and three-phase line-frequency diode and thyristor rectifiers, PWM inverters and switch-mode power supplies.

Prerequisite: EC2110 or consent of instructor. Corequisite: EC2200 or consent of instructor.

EC3200 - Advanced Electronics Engineering (3 - 2)

Characteristics of differential and multistage amplifiers. Transistors frequency response, including Bipolar Junction Transistors (BJT), Junction Field Effect Transistors (JFET), and Metal Oxide Semiconductor Field Effect Transistors (MOSFET); characteristics and design consideration. Integrated circuit OPAMP applications; analysis and design of non-ideal OPAMPs. Applications of BJTs and Complementary Metal Oxide Semiconductors (CMOS) in integrated circuits, and different biasing techniques. Analysis and design of digital circuits, including Transistor–Transistor Logic (TTL), Emitter Coupled Logic (ECL), and CMOS logic families. Application and design feedback amplifiers and operational amplifiers applications in

analog filters and oscillators.

Prerequisite: EC2200.

EC3210 - Introduction to Electro-Optical Engineering (3 - 2)

An overview of the elements that comprise current military electro-optical and infrared (EO/IR) systems. Topics include properties of light, optical elements, quantum theory of light emission, operating principles of laser sources, propagation of Gaussian beams, laser sources, laser modulators, thermal sources of radiation, laser and IR detectors (photomultipliers, photoconductors, photodiodes, avalanche photodiodes), signal-to-noise analysis of direct- and heterodyne-receiver systems. Includes military applications of electro-optic and infrared technology such as missile seekers, laser designators, laser weapons, and Bragg-cell signal processors.

Prerequisite: EC2200, EC2650.

EC3220 - Semiconductor Device Technologies (3 - 2)

This course is intended to familiarize the student with solid state device operation and fabrication of present day semiconductors and transistor technologies. Topics include: fundamental theory of charge transport, semiconductor materials (Si, GaAs, SiGe, InP), bandgap engineering, epitaxy crystal growth, and semiconductor device manufacturing technology. A virtual wafer lab allows students to visualize parameters as impurity implants to electron flow. Measurement labs utilize hands-on wafer probe measurements of digital and analog devices.

Prerequisite: EC2200.

EC3230 - Space Power and Radiation Effects (3 - 1)

Fundamentals of different power systems utilized in spacecraft; photovoltaic power technology; solid-state physics, silicon solar cells, solar cell measurement and modeling, gallium arsenide cells and II-V compounds in general, array designs and solar dynamics. Radiation effects on solid state devices and materials. Survivability of solar cells and integrated circuits in space environment and annealing method. Other space power systems including chemical and nuclear (radioisotope thermoelectric generators and nuclear reactors). Energy storage devices and power conversion. Spacecraft power supply design. Note: EC3230 is taught with compressed scheduling (first six weeks of quarter).

Prerequisite: EC2200.

EC3240 - Renewable Energy at Military Bases and for the Warfighter (3 - 2)

The course will introduce participants to current energy use at military bases as well as mobile platforms power sources. Participants will be introduced to state-of-the-art renewable energy systems that would be utilized at military installations. This will include; detailed study of Photovoltaic & Solar Energy use, overview of wind energy & other renewable energy sources, as well as energy storage systems. Cost saving comparisons and environmental impact will be conducted. The course will also investigate the use of some of the above renewable systems in mobile platforms for the warfighters and expeditionary forces personal use.

Prerequisite: EC2100 or EO2102.

EC3280 - Introduction to MEMS Design (3 - 3)

This is a 4.5 credit hour class introducing the students to Micro Electro Mechanical Systems (MEMS). Topics include material considerations for MEMS and microfabrication fundamentals; surface and bulk micromachining; forces and transduction; forces in micro- nano- domains and actuation techniques. The laboratory work includes exercises to become proficient in computer aided engineering (CAE) software for the design of MEMS devices.

Prerequisite: EC2200 or MS2201 or PH1322 or consent of instructor.. Cross-Listed as: PH3280 and ME3780.

EC3310 - Optimal Estimation: Sensor and Data Association (3 - 2)

The subject of this course is optimal estimation and Kalman filtering with extensions to sensor fusion and data association. Main topics include the theory of optimal and recursive estimation in linear (Kalman filter) and nonlinear (extended Kalman filter) systems, with applications to target tracking. Topics directly related to applications, such as basic properties of sensors, target tracking models, multihypothesis data association algorithms, reduced order probabilistic models and heuristic techniques, will also be discussed. Examples and projects will be drawn from radar, EW, and ASW systems.

Prerequisite: EC2320, EC2010, MA2043 or consent of instructor.. Security Clearance Required: Secret.

EC3320 - Optimal Control Systems (3 - 2)

This course addresses the problem of designing control systems which meet given optimization criteria. The student is exposed to the development of the theory, from dynamic programming to the calculus of variation, and learns how to apply it in control engineering.

Prerequisite: EC2300, EC2320.

EC3400 - Digital Signal Processing (3 - 2)

The foundations of one-dimensional digital signal processing techniques are developed. Topics include Fast Fourier Transform (FFT) algorithms, block convolution, the use of DFT and FFT to compute convolution, and design methods for nonrecursive and recursive digital filters. Multirate signal processing techniques are also introduced for sampling rate conversion, efficient analog to digital, digital to analog conversion, time frequency decomposition using filter banks and quadrature mirror filters. Computer-aided design techniques are emphasized. The algorithms introduced have direct applications in sonar and radar signal processing, IR sensor

arrays, modern navy weapon systems, and also in voice and data communications.

Prerequisite: EC2410 or EC2400.

EC3410 - Discrete-Time Random Signals (3 - 2)

Fundamentals of random processes are developed with an emphasis on discrete time for digital signal processing, control, and communications. Parameter estimation concepts are introduced, and impact of uncertainty in parameter evaluation (estimated moments and confidence intervals) are presented. Random processes are introduced. DKLT and applications to image processing and classification problems are considered. Impact of linear transformations to linear systems is discussed. FIR Wiener, and matched filters are introduced. IIR Wiener filter introduced, time permitting. Applications to signal and system characterization in areas such as system identification, forecasting, and equalizations are considered to illustrate concepts discussed during the course.

Prerequisite: EC2410 (may be concurrent) and EC2010.

EC3450 - Fundamentals of Ocean Acoustics (4 - 0)

Introduction to various mathematical techniques (both exact and approximate), special functions (e.g., Bessel functions, Hankel functions, and Legendre polynomials), orthogonality relationships, etc., that are used to model and solve real world problems concerning the propagation of sound in the ocean. Topics include, for example, reflection and transmission coefficients, ocean waveguide pulse-propagation models based on normal mode and full-wave theory, the WKB approximation, three-dimensional ray acoustics, and the parabolic equation approximation.

Prerequisite: Standard undergraduate sequence of calculus and physics courses for engineering and science students..

EC3460 - Introduction to Machine Learning for Signal Analytics (3 - 2)

This course introduces basic concepts and tools needed to detect, analyze, model, and extract useful information from digital signals by finding patterns in data. It covers some of the fundamentals of machine learning as they apply in signal and information processing. The emphasis in the course is on practical engineering applications rather than theoretical derivations to give participants a broad understanding of the issues involved in the learning process. Supervised learning tools such as the Bayes estimator, neural networks and radial basis functions, support vector machines and kernel methods are presented. Unsupervised learning tools such as k-means and hierarchical clustering are discussed. Data transformation and dimensionality reduction are introduced. Performance measures designed to evaluate learning algorithms are introduced. Concepts presented are illustrated throughout the course via several application projects of specific interest to defense related

communities. Application topics may include target/signal identification, channel equalization, speech/speaker recognition, image classification, blind source separation, power load forecasting, and others of current interest.

Prerequisite: Knowledge of probability and random variables (EC2010, or OS2080, or OA3101, or equivalent), linear systems (EC2410 or equivalent), linear algebra (MA2043 or equivalent), ability to program in MATLAB, or consent of instructor..

EC3500 - Analysis of Random Signals (4 - 0)

Fundamental concepts and useful tools for analyzing non-deterministic signals and noise in military communication, control, and signal processing systems are developed. Topics include properties of random processes, correlation functions, energy and spectral densities, linear systems and mean square estimation, noise models and special processes.

Prerequisite: EC2500(may be concurrent) and EC2010, or consent of instructor..

EC3510 - Communications Engineering (3 - 2)

The influence of noise and interference on the design and selection of digital and analog communications systems is analyzed. Topics include link budget analysis and signal-to-noise ratio calculations, receiver performance for various analog and digital modulation techniques, and bandwidth and signal power trade-offs. Examples of military communications systems are included.

Prerequisite: EC3500 or EC3410.

EC3600 - Antennas and Propagation (3 - 2)

A fundamental understanding of antennas, scattering, and propagation is developed. Characteristics and design principles of common antenna types such as dipoles, arrays, horns, reflectors and micro strip patches, are considered. Concepts of antenna gain and effective area are used to develop power link equations. Scattering theory is introduced and propagation phenomena are considered for real-world scenarios. Design applications include phased, Yagi and log-periodic arrays, as well as shaped-beam reflector antennas, side lobe suppression, radar target scattering, stealth principles, surface waves, HF and satellite communications.

Prerequisite: EC2650 or equivalent.

EC3610 - Microwave Engineering (3 - 2)

This course provides an overview of the circuits and devices used in microwave radar communication and electronic warfare systems. The course covers network analysis using scattering parameters, transmission media, selected circuits, electron tubes, solid state devices, and monolithic integrated circuits. Circuits and devices are studied in the laboratory using both hardware and computer simulation.

Prerequisite: EC2650.

EC3615 - Radar Fundamentals (3 - 2)

This course will include the following topics: radar types such as CW and pulsed Doppler radar, radar range equation, basics of radar cross section, transmit power, EIRP, antenna gains, EM frequency spectrum, sources of losses such as propagation and implementation, receiver noise, noise figure, receiver sensitivity, range resolution, velocity resolution, detector schemes, detection and false alarm probabilities, RF/microwave device considerations, waveform design and ambiguity function. The course includes laboratory activities that are either software/Matlab and/or hardware-based.

Prerequisite: EC2650, and EC2400 or EC2410.

EC3630 - Radiowave Propagation (3 - 2)

This course treats the effects of the earth and its atmosphere on the propagation of electromagnetic waves at radio frequencies. Topics covered include ground waves, sky waves, ducting, reflection, refraction, diffraction, scattering, attenuation, and fading. Basic theory is covered and computer models are introduced where appropriate. Emphasis is placed on determination of the transmission loss between transmitting and receiving antennas. Computer laboratory exercises are used to illustrate the propagation characteristics of various indoor and outdoor environments, and their effects on system performance.

Prerequisite: EC2650 or Consent of Instructor.

EC3700 - Joint Network-Enabled Electronic Warfare I (3 - 2)

The concept of information operations (IO) and the critical role for electronic warfare (EW) are examined. The net-enabled force transformation is presented emphasizing how network-enabled EW technology provides a force multiplier for this transformation. Important EW technology components of SeaPower-21 are emphasized. The network space – battlespace duality and the Global Information Grid are also analyzed (FORCEnet). Metrics are presented to quantify the information value from wireless networks of distributed sensors and weapons. A direct assessment of the value of the network (information superiority) to the combat outcome (battlespace superiority) is presented. Integrated air defense suppression examples are studied using game theory to demonstrate the concepts. The role of intelligence also is emphasized. Sensor technologies and their use in the battlespace are presented. Mathematical models for electronic attack (EA) techniques are developed including those against GPS, RF and IR sensors. Off-board EA techniques including chaff, towed and rocket decoys, and digital image synthesizers are emphasized for counter-surveillance, counter-targeting and counter-terminal. High-power microwave and laser-based directed energy weapons are examined. Sensor protection techniques are discussed including an introduction to the new area of counter-electronic support. Students do a

research project on a topic of interest from the Force Transformation Roadmap. Laboratory exercises are also conducted in the Radar and Electronic Warfare Laboratory.

Prerequisite: EC2500 and EC3615 or consent of instructor.

EC3710 - Computer Communications Methods (3 - 2)

The course objective is to develop an understanding of computer communications networks with emphasis on the requirements of military environments and the U.S. Navy's combat platforms. Coverage includes the essential topics of network topology, connectivity, queuing delay, message throughput, and performance analysis. The layered network architectures, such as the seven-layer OSI model and DoD's TCP/IP protocol suite, are covered. The techniques and protocols used in these layers are discussed. Local area networking technologies such as Ethernet, FDDI and wireless Ethernet, and wide area technologies such as X.25 and frame relay are covered. Principles of networking devices (hubs, switches, and routers) are presented. Some distributed applications are presented briefly.

EC3730 - Cyber Network and Physical Infrastructures (3 - 2)

Cyber infrastructure systems and technologies of interest to the military. Copper and fiber media networks, telecommunication networks and signaling, the Internet, enterprise networks, network-centric sensing, collection, monitoring, dissemination, and distribution of critical data. Terrestrial wireless networks: cellular networks, local area and long haul data networks (GSM, WiFi, WiMAX, LTE, Link 16 and Link 22). Space based networks: satellite communication networks, wide area large sensor networks. Heterogeneous networks: end-la-end communication, sensing, collection, and distribution across fiber, terrestrial wireless, and satellite networks, protocols, design and performance analysis. Control and overlay networks such as Supervisory Control and Data Acquisition (SCADA) systems and the National power grid.

Prerequisite: EC2700 or permission of instructor.

EC3740 - Reverse Engineering in Electronic Systems (3 - 2)

This course presents fundamental, systems level concepts for developing an understanding of system functionality without a prior access to the system's design specifications. It considers generalized approaches to developing a set of specifications for a complex system through orderly examination of components of that system. The course illustrates procedures for identifying the system's components and their interrelationships. The course is divided into two parts. The first part focuses on software reverse engineering where students perform elementary reverse engineering on basic programs using assembly language and software disassembly. Topics related to software reverse engineering including

obfuscation techniques and malware analysis will be discussed. The second part of the course will focus on hardware reverse engineering by studying integrated circuit (IC) and circuit board analysis using SPICE and black box techniques. Other tools that aid in hardware reverse engineering such as JTAG will be studied in depth. Analysis of reverse engineering using mathematics, including power analysis will also be studied.

Prerequisite: EC2700.

EC3750 - Introduction to SIGINT Engineering (3 - 2)

An introduction to the technology of signals intelligence systems, with particular emphasis on the means for accessing signals of intelligence value. Covers the three major branches of SIGNIT: communications intelligence, electronic intelligence, and foreign instrumentation signals intelligence. Collection platform, receivers, and antennas are examined. Emitter location techniques are considered. Requires U.S. citizenship and Top Secret clearance with eligibility for SCI access.

Prerequisite: EC3410 or EC3500 or EO3512. Security Clearance Required: Top Secret SCI.

EC3760 - Information Operations Systems (3 - 2)

This course examines the Network-centric Environment that is the focus of the Information Operations (IO) infrastructure with emphasis on current and future implementation models. A Signals Intelligence (SIGINT) approach is taken in which the adversary's computer network system architecture is examined and evaluated for the purpose of exploitation, protection, and/or attack. A thorough review of the fundamentals of communications, computer networks, and advanced digital technologies is discussed. This course works closely with the Department of Defense to reinforce realistic approaches for solving critical IO issues within the community. Requires U.S. citizenship and TOP SECRET clearance with eligibility for SCI access.

Prerequisite: EC2700 or Consent of Instructor. Security Clearance Required: Top Secret SCI.

EC3761 - Fundamentals of Cyber Operations (Short Course) (1 - 1)

This course examines technical issues underpinning the collection of foreign intelligence by the US Intelligence Community (IC) through the use of cyber operations. Initial studies focus on the role of signals intelligence in supporting cyber operations and focus on methods for identifying and enumerating targets. Methods and techniques for vulnerability identification specific to the IC are discussed. Techniques for initial access are reviewed and discussed as are methods for privilege escalation. Techniques for installing target implants and mission modules are presented. The course concludes with a review of target objectives pursued through cyber operations. This course works closely with the Department of Defense to reinforce realistic approaches for solving critical cyber operations issues within the

IC. This is an 8-day short course.

Prerequisite: US Citizen; TOP SECRET SCI clearance; Basic Computer Networking Knowledge or permission of the Instructor. Security Clearance Required: .

EC3771 - Basic Network Traffic Analysis (Short Course) (1 - 0.5)

The Basic Network Traffic Analysis short course equips students with an in-depth understanding of the tools and techniques necessary for gaining deep insight into the operations and behavior of enterprise networks. In completing this course, the student will be able to systemically plan for data collection, capture traffic of interest, analyze the traffic, and take appropriate action as a result of the analysis. For a given data collection, the student is able to determine who is talking, what applications are being used, filter on conversations of interest, create statistical graphs related to issues of interest, employ expert systems to recognize anomalies and diagnose problem areas. Students are able to apply these skills for the purposes of general analysis, network troubleshooting, security analysis, and application performance evaluation. This is a 5-day short course.

Prerequisite: Demonstrated Computer Networking Knowledge or Permission of the Instructor.

EC3772 - Intermediate Network Traffic Analysis (Short Course) (1 - 0.5)

The Intermediate Network Traffic Analysis short course equips students with an in-depth understanding of the tools and techniques necessary for gaining deep insight into common operational requirements of DoD networks. Students will be well versed in the use of Wireshark, tshark, libpcap, and npcap. An extensive understanding of Wireshark is developed to include dissector evaluation, capture filters, display filters, and plot analysis. Through a series of case studies, students will be able to recognize the precursors of a cyber attack to allow them to take preventative measures. In the case of forensic analysis, students will be able to identify suspect traffic and make associations to identify root causes. This is a 5-day short course.

Prerequisite: EC3771 or permission of the Instructor.

EC3773 - Advanced Network Traffic Analysis (Short Course) (1 - 0.5)

The Advanced Network Traffic Analysis short course equips students with an in-depth understanding of the tools and techniques necessary for gaining deep insight through macro and statistical analysis of network flows. Statistical analysis methods will be introduced and applied to metadata associated with network flows. Flow record and Intrusion Detection/Prevention systems will be discussed and compared. Students will be well versed in the use of the ELK stack netflow module, tcpflow, NetworkMiner, snort, Argus tools and nfdump. This is a 5-day short course.

Prerequisite: EC3772 or permission of the Instructor..

EC3795 - Mobile Telecommunications Fundamentals (3 - 2)

This course establishes a foundation for advanced study specifically in mobile telecommunications pertinent to DoD and DoN missions. An extensive introduction of principles associated with wireless communications is provided beginning with mathematical foundations for radio frequency signals, propagation effects, radio transmitter and receiver components and antenna design. An introductory discussion of signals associated with unregulated commercial wireless (Bluetooth, WiFi) is provided. The majority of the course focuses on communications associated with commercial mobile telecommunications of interest to the DoD and DoN, to include protocols, signaling procedures, security, and management. The course will address all standardized generations of mobile telecommunications (GSM, CDMA, CDMA2000, UMTS, LTE, NR).

Prerequisite: EC2700 and PH1322 or Consent of Instructor..

EC3800 - Microprocessor Based System Design (3 - 2)

Advanced microprocessor system concepts are studied. Microprocessor systems are widely used for embedded control in military systems as well as for stand-alone computers. Topics covered are CPU operation and timing, address decoding, typical LSI support chips, exception processing, design of static and dynamic memory systems, worst-case timing analysis, bus arbitration, and direct memory access controllers. The laboratory consists of a design project integrating hardware and software using a state-of-the-art development system.

Prerequisite: EC2820.

EC3820 - Computer Systems (3 - 2)

The course presents a unified approach for the design of computer systems stressing the interacting processes implemented in hardware, software, and firmware. General features of operating systems are studied as well as specific features of an existing system. The elements of a multiprogramming system are introduced.

Prerequisite: EC2820.

EC3830 - Digital Computer Design Methodology (3 - 2)

A design and project-oriented course covering basic principles, theories, and techniques for practical design of digital systems. Emphasizes an integrated viewpoint combining essential elements of classical switching theory with a thorough understanding of modern design aids. Current military and commercial systems are used as design examples.

Prerequisite: EC2820.

EC3840 - Introduction to Computer Architecture (3 - 2)

The fundamental principles of computer architecture and processor design, including the influences of implementation technology, cost, performance, and the historical development of computer architecture. Levels of abstraction and instruction set/architecture design. Processor design and implementation, including the data path and the control unit. Computer design, including buses, the memory hierarchy, and the input/output subsystem. Factors affecting performance and performance measurement, evaluation, and comparison. The effects of embedded military applications on computer architecture.

Prerequisite: EC2820.

EC3910 - Special Topics in Electrical Engineering (V - V)

Courses on special topics in Electrical Engineering are offered under these numbers. In most cases, new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings. Prerequisite: None.

EC3920 - Special Topics in Electrical & Computer Engineering (V - V)

Courses on special topics in Electrical Engineering are offered under these numbers. In most cases new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC3930 - Special Topics in Electrical & Computer Engineering (V - V)

Courses on special topics in Electrical Engineering are offered under these numbers. In most cases, new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC3940 - Special Topics in Electrical & Computer Engineering (V - V)

Courses on special topics in Electrical Engineering are offered under these numbers. In most cases, new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC3950 - Special Topics in Electrical & Computer Engineering (V - V)

Courses on special topics in Electrical Engineering are offered under these numbers. In most cases, new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line

catalog for current offerings.

EC3960 - Special Topics in Electrical Engineering (V - V)

Courses on special topics in Electrical Engineering are offered under these numbers. In most cases, new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC3970 - Special Topics in Electrical & Computer Engineering (V - V)

Courses on special topics in Electrical Engineering are offered under these numbers. In most cases, new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC3980 - Special Topics in Electrical & Computer Engineering (V - V)

Courses on special topics in Electrical Engineering are offered under these numbers. In most cases, new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC3990 - Special Topics in Electrical & Computer Engineering (V - V)

Courses on special topics in Electrical Engineering are offered under these numbers. In most cases new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC4000 - Introduction to Doctoral Research (2 - 0)

The main objectives of the course are to foster interaction among the doctoral students and the department faculty and to promote excellence in research. Additional objectives of the course are to prepare the doctoral students to initiate the screening and qualifying steps of the program, to undertake dissertation research, and to publish and present research results. Along with an overview of the ECE Ph.D. program, the course provides guidance on the program preliminaries, such as the screening and qualification exams and minor requirements, and the dissertation research process. A broad overview of the current research problems in the field of electrical and computer engineering relating to the needs of national defense and in the ECE department in particular is presented. Students in the early stages of

their program will be exposed to ongoing dissertation research and advances in the field through research presentations delivered by doctoral students in the research phase of their program, NPS faculty and outside researchers. The course provides the opportunity for doctoral students at all levels of progress to meet once a week to discuss their research, share ideas, rehearse conference presentations and dissertation defenses, and to gain exposure to a diversity of research topics and ideas. Graded on Pass/Fail basis only.

Prerequisite: Approved ECE Ph.D. student or Consent of the ECE Ph.D. Program Committee..

EC4010 - Principles of Systems Engineering (3 - 2)

An introduction to systems engineering concepts and methods for the design and integration of complex defense systems, with emphasis on electrical engineering applications. Familiarity with the systems engineering process is developed through case studies of representative defense systems and a group design project which includes determination of system requirements from mission needs and operational requirements. Digital simulation models, including those in current use by DoD, are used to determine engineering and performance trade-offs.

Prerequisite: Four quarters in an NPS engineering curriculum or equivalent.

EC4130 - Advanced Electrical Machinery Systems (3 - 3)

The course delves into the analysis and design of motor drives for shipboard electrical power systems. It offers a detailed examination of the modeling for power converters, both as rectifiers and inverters, as well as various types of electric motors. Coupled with contemporary control theories and controller design, the course further explores practical design challenges and their solutions specific to shipboard electrical power systems.

EC4150 - Applied Power Electronics (3 - 2)

The course presents steady state and dynamic analysis of modern power electronic converters for advanced shipboard electric power distribution with emphasis on comparison to military standards. Physics-based modeling are used to simulate power converters and their control systems in microgrids for Navy shipboard and shore applications. The course includes some more advanced topics like resonant converters, renewable energy power conditioning converters and grid-interface inverters.

Prerequisite: EC3150 and electrical machine theory, or consent of instructor..

EC4210 - Electro-Optic Systems Engineering (3 - 0)

Advanced topics and application of electro-optics. Military applications of electro-optic and infrared technology such as laser communications, laser radar, and Bragg cell signal processors. Signal-to-noise analysis of

laser detector performance. Student reports on EO/IR topics of current military interest.

Prerequisite: EC3210.

EC4220 - Introduction to Analog VLSI (3 - 2)

Modern active circuit design topologies; analog and sampled data networks. Analysis of transfer function properties, stability and causality. Higher order filter design and synthesis. Use of computer simulation tools, SPICE, and different device models for network analysis. Transformation methods and switched-capacitor filtering and non-filtering applications. Introduction to analog VLSI techniques using stray-insensitive switched-capacitor networks. Examples of such analog VLSI designs in military applications.

Prerequisite: EC2400 and EC3200 or EC2200 with consent of instructor.

EC4230 - Reliability Issues for Military Electronics (3 - 2)

This course investigates where and why semiconductor devices fail in military environments. Topics include limitations of commercial-off-the-shelf (COTS) integrated circuits, thermal failure, electrostatic breakdown, noise in solid state devices, packaging reliability issues, radiation effects due to space and nuclear environments, and the limited availability of military integrated circuit suppliers.

Prerequisite: EC3220.

EC4280 - Micro Electro Mechanical Systems (MEMS) Design II (2 - 4)

Same as ME4780 and PH4280. This is the second course in Micro Electro Mechanical Systems (MEMS) Design. This course will expose students to advanced topics on material considerations for MEMS, microfabrication techniques, forces in the micro- and nano-domains, and circuits and systems issues. Case studies of MEMS-based microsensors, microactuators, and microfluidic devices will be discussed. The laboratory work includes computer aided design (CAD) and characterization of existing MEMS devices. The grades will be based on exams, lab projects, and a group design project.

Prerequisite: EC3280.

EC4300 - Advanced Topics in Modern Control Systems (3 - 0)

Advanced topics and current developments in control systems are presented in this course. The list of special topics includes (but it is not limited to) robotics systems, autonomous vehicles, and design by robust techniques.

Prerequisite: Consent of Instructor.

EC4310 - Fundamentals of Robotics (3 - 2)

This course presents the fundamentals of land-based robotic systems covering the areas of locomotion, manipulation, grasping, sensory perception, and teleoperation. Main topics include kinematics, dynamics, manipulability, motion/force control, real-time programming, controller architecture, motion planning, navigation, and sensor integration. Several Nomad mobile robots will be used for class projects. Military applications of robotic systems will be discussed.

Prerequisite: (MA2043 or MA3042) and either (EC2300 or EC2320) or consent of instructor..

EC4320 - Design of Robust Control Systems (3 - 2)

This course presents advanced topics on control system design. Major emphasis is on robust techniques in order to account for uncertainties on the systems to be controlled. Several applications show the trade-offs in several applications, such as missile and/or underwater vehicles control design. Advanced concepts on H2 and H-infinity will be introduced as part of the course.

Prerequisite: EC3310, EC3320.

EC4330 - Navigation, Missile, and Avionics Systems (3 - 2)

Principles of missile guidance, including guidance control laws, basic aerodynamics and six degree-of-freedom motion simulation. Additional topics are selected from the following areas to address the general interests of the class: advanced guidance laws, passive sensors, INS guidance, fire control and tracking systems, and ballistic missile targeting.

Prerequisite: EC3310. Security Clearance Required: Secret.

EC4350 - Nonlinear Control Systems (3 - 2)

This course presents techniques for automatic control of nonlinear systems with application to current military and robotic systems. Main topics include the analysis and design of nonlinear systems with phase plane and describing function methods, Lyapunov and sliding mode control techniques. Accuracy limit cycles, jump resonances, relay servos, and discontinuous systems will also be considered.

Prerequisite: EC2300, EC2320.

EC4400 - Advanced Topics in Signal Processing (3 - 0)

Special advanced topics in signal processing not currently covered in a regularly scheduled course and relevant to advanced naval and other military applications. Topics may include digital filter structures and implementations, advanced computational topics and architectures for signal processing, imaging, recent work in signal modeling, array processing, or other topics of interest.

Prerequisite: Consent of Instructor.

EC4430 - Multimedia Information and Communications (3 - 2)

The course objective is to present the essentials of real-time communication of digital multimedia (audio, video and text) information by bringing together topics from digital signal processing (information processing), digital communications (information transmission and reception), and computer networking (information distribution). Algorithms for compression of multimedia information are presented. Related international

standards such as G.728, JPEG, MPEG, MP3, LZW, and IS95 are discussed. Major topics include digital representation and compression of multimedia information, transmission (storage) and distribution of compressed information, and end-to-end delivery issues such as loss, reliability, security, and encryption of multimedia information.

Prerequisite: EC3400 or instructor's consent.. Security Clearance Required: Secret.

EC4440 - Statistical Digital Signal Processing (3 - 2)

Modern methods of digital signal processing are developed in this course from a statistical point of view. Methods are developed for processing random signals through statistical data analysis and modeling. Topics include adaptive filtering, linear prediction, MA, and AR signal modeling, spectrum estimation and basic machine learning concepts. Techniques presented are applied to various engineering problems such as system identification, forecasting, and equalization. The algorithms introduced have direct applications in communication, sonar, radar systems signal processing, and modern Navy weapon systems.

Prerequisite: EC3410 or EC3500 and MA3042 or consent of instructor.

EC4450 - Array Signal Processing (3 - 2)

This course provides mathematical development and fundamental principles of sensor array signal processing techniques as applicable to the design and operation of active and passive sonar systems critical to naval operations. Topics from aperture theory, array theory, classical and adaptive array signal processing, and signal detection are covered. The array signal processing principles developed in this course can be extended to applications in cellular communication systems, radar systems, and other fields. Along with the electronic systems engineering curriculum, this course supports the undersea warfare and engineering acoustics curricula, and others. PREREQUISITES: EC3400 and EC3410/EC3500 or EO3402 or instructor's consent.

Prerequisite: EC3400 and EC3410/EC3500 or EO3402 or equivalent or instructor's consent..

EC4480 - Image Processing and Recognition (3 - 2)

This course provides image processing background for understanding modern military applications, such as long range target selection, medium range identification, and short range guidance of new weapons systems. Subjects include image sampling and quantization, image representation, enhancement, transformation, encoding, and data compression. Predictive coding, transform coding, and inter frame coding techniques are also introduced. 3D to 2D imaging projections are also introduced to extract 3D information either from motion or stereo imaging. Some effort is directed toward image compression techniques particularly suited for multimedia video conferencing.

Prerequisite: EC3400.

EC4500 - Advanced Topics in Communications (3 - 0)

Topics and current developments in communications relevant to advanced naval and other military applications. Offered on an occasional basis with the topics determined by the instructor.

Prerequisite: Consent of Instructor.

EC4510 - Cellular Communication (3 - 0)

This course presents the fundamentals of cellular communications. Cellular architectures, propagation models, modulation formats, diversity techniques, equalization, error control, multiple access techniques, networking, and standards such as AMPS, N-AMPS, IS-54, GSM, and IS-95 are covered.

Prerequisite: May be taken concurrently with EC3510..

EC4530 - Soft Radio (3 - 2)

An introduction to soft radios, devices that generate (transmitter) and/or process (receiver) digital communications signals in software and in reconfigurable hardware. The course covers basic radio frequency (RF) design principles, soft radio architectures, analysis of receiver operation, and existing soft radio efforts.

Prerequisite: EC3510 or consent of instructor.

EC4550 - Digital Communications (4 - 0)

This course presents the advantages and limitations of modern military M-ary digital communications systems. M-ary modulation formats, matched filter receivers, probability of symbol error calculations, coherent and non-coherent receivers, carrier and symbol synchronization, modems, bandwidth and signal energy, diversity combining, and fading channels are covered. Examples of current operational and proposed military and commercial space and earth links are treated.

Prerequisite: EC3510.

EC4560 - Spread Spectrum Communications (3 - 2)

Methods of reducing the effects of hostile jamming on military radio communications systems are considered. Direct sequence spread spectrum systems and frequency-hopped spread spectrum systems are examined with regard to their LPI, LPD, AJ, and multiple access capabilities. Time-hopped and hybrid systems are also considered. Coarse and fine synchronization problems and techniques are presented.

Prerequisite: EC3510.

EC4570 - Signal Detection and Estimation (4 - 0)

Principles of optimal signal processing techniques for detecting signals in noise are considered. Topics include maximum likelihood, Bayes risk, Neyman-Pearson and min-max criteria and calculations of their associated error probabilities (ROC curves). Principles of maximum likelihood, Bayes cost, minimum mean-square error (MMSE), and maximum a posteriori estimators are

introduced. Integral equations and the Karhunen-Loeve expansion are introduced. The estimator-correlator structure is derived. Emphasis is on dual development of continuous time and discrete time approaches, the latter being most suitable for digital signal processing implementations. This course provides students the necessary foundation to undertake research in military radar and sonar systems.

Prerequisite: EC3410 or EC3500.

EC4580 - Error Correction Coding (4 - 0)

Digital military communication systems often employ error control coding to improve effectiveness against noise, fading, and jamming. This course, together with EC4560 provides students the necessary foundations for understanding the principles of such systems. Topics include Shannon's channel capacity theorem and coding methods for error control in digital communications systems, including convolutional, block, concatenated, and turbo codes as well as trellis-coded modulation. Applications of error control coding to modern digital communications systems are discussed.

Prerequisite: EC3510.

EC4590 - Communications Satellite Systems Engineering (3 - 0)

Communication satellite systems including the satellite and user terminals. Subjects include orbital mechanics, satellite description, earth terminals, detailed link analysis, frequency division multiple access, time division multiple access, demand assignment, random multiple access, and spread spectrum multiple access. Various military satellite communications systems are introduced.

Prerequisite: EC3510, EO4516.

EC4600 - Advanced Topics in Electromagnetics (V - V)

Selected advanced topics in electromagnetics that are not currently covered in regular courses offerings, and relevant to naval and other military applications. Topics may include, but are not limited to, computational electromagnetics, scattering and radiation, propagation, and new device and antenna concepts.

A minimum of 4 credits is required if a specific course offering is to be eligible as part of any certificate program.

Prerequisite: EC3600.

EC4610 - Radar Systems (3 - 2)

The radar range equation is developed in a form including signal integration, the effects of target cross-section, fluctuations, and propagation losses. Modern techniques discussed include pulse compression frequency modulated radar, moving target indicator (MTI) and pulse Doppler systems, monopulse tracking systems, multiple unit steerable array radars, and synthetic aperture systems. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed, with pulse compression, and with the

measurement of radar cross section of targets.

Prerequisite: EC2650, and EC3410 or EC3500 (may be concurrent)..

EC4615 - Advanced Radar (3 - 2)

This course covers a comprehensive treatment of important state-of-the-art radar techniques. The objective of this course is to cover the fundamental concepts and methods of radar detection theory, radar estimation theory, target tracking, range-Doppler processing, space-time adaptive processing (STAP), synthetic aperture radar (SAR), inverse SAR (ISAR), and machine learning (ML) for radar. This course primarily covers the concepts of advanced radar signal processing methods that are used in military and surveillance systems for the detection, classification, and identification of targets.

Prerequisite: EC3615 or instructor's consent.

EC4630 - Radar Cross Section Prediction and Reduction (3 - 2)

This course covers the design and engineering aspects of stealth and its impact on platform and sensor design. Signature prediction methods in the radar, infrared (IR), and laser frequency bands are discussed. Radar cross section (RCS) analysis methods include geometrical optics and diffraction theory, physical optics and the physical theory of diffraction, and numerical solutions to integral and differential equations. Prediction methods for IR and laser cross sections (LCS) are also introduced. Signature reduction by shaping, materials selection, and active and passive cancellation are applied to each frequency regime. The measurement of these cross sections is also covered.

Prerequisite: EC3600 or consent of instructor.

EC4640 - Airborne Radar Systems (3 - 2)

The main objective of this course is to discuss concepts and digital signal processing techniques involved in modern airborne radars, which detect targets in presence of large ground clutter and other interferences. Radar waveform (or modes) are treated as continuous wave (CW), high pulse repetition frequency (HPRF), medium pulse repetition frequency (MPRF), and low pulse repetition frequency (LPRF). Practical implementation and the signal processing associated with each mode will be elaborated. Advantages and limitations of each mode shall be discussed. Military applications of these modes will be discussed in the existing airborne and surface based radar systems. Concepts and algorithms are covered for digital pulse compression, MTI clutter cancellation, Doppler processing, constant false alarm rate (CFAR) detection, ambiguity resolution, synthetic array radar (SAR) processing and other associated techniques and algorithms.

Prerequisite: EC4610 or equivalent.

EC4680 - Joint Network-Enabled Electronic Warfare II (3 - 2)

The course is intended for U.S. students with Secret

clearance. The course continues the discussion of counter electronic support and begins with an introduction to low-probability-of-intercept (LPI) emitter signaling techniques and technologies. The origin and importance of the LPI emitter are emphasized. Case studies are shown to demonstrate the capability of the LPI emitter as an anti-ship capable missile seeker. Network enabled receiver techniques are presented highlighting the benefits of the sensor-shooter-information grid and swarm intelligence. The new challenges facing the intercept receiver design and the trends in receiver technology are addressed. To increase the processing gain of the receiver, time-frequency signal processing methods are presented and include the pseudo Wigner-Ville distribution, quadrature mirror filter bank trees for wavelet decomposition and the Choi-Williams distribution. Bi-frequency techniques are also emphasized and include cyclostationary processing for estimating the spectral correlation density of the intercepted signal. Calculations using each signal processing method are shown to demonstrate the output information and its correlation with the input signal parameters. New detection results are then derived by the student for various LPI signaling schemes to illustrate the parameter extraction methods developed. Autonomous emitter classification architectures are also presented. Laboratory simulation exercises are conducted to demonstrate the concepts. Requires U.S. citizenship and a Secret clearance.

Prerequisite: EC3700. Security Clearance Required: Secret.

EC4685 - Principles of Electronic Warfare (3 - 2)

This course covers a comprehensive treatment of the signaling principles of electronic warfare (EW). The objective of this course is to cover the fundamental concepts and effects of electronic attack (EA), electronic support (ES), and electronic protection (EP). This course mainly deals with electronic signaling techniques in the electromagnetic (EM) spectrum specially in the radio frequency and microwave domains especially in terms of radar and communications signaling. Basic radar and communications concepts will be reviewed. EA covers various techniques such as traditional noise jamming and advance techniques such as coherent types of jammers. EP signal processing techniques such as anti-jam, low probability of intercept, and direction finding are discussed in detail. ES techniques such as spectrum awareness, electronic intelligence (ELINT), and signal intelligence (SIGINT) are also presented. Unlike most EW discourses, which simply discuss system qualitative effects of EW, concrete quantitative performance measures are presented. The class only briefly touches on passive techniques, e.g. chaff and radar corner reflector deployment, and destructive attacks and/or asset protection with missiles. There will be hardware and software laboratory activities. A project may be assigned.

Prerequisite: EC3615 and EC2500, or instructor's consent.

EC4690 - Joint Network-Enabled Electronic Warfare II (3 - 2)

The course is intended for international students and contains the same material as EC4680. The course continues the discussion of counter electronic support and begins with an introduction to low-probability-of-intercept (LPI) emitter signaling techniques and technologies. The origin and importance of the LPI emitter are emphasized. Case studies are shown to demonstrate the capability of the LPI emitter as an anti-ship capable missile seeker. Network enabled receiver techniques are presented highlighting the benefits of the sensor-shooter-information grid and swarm intelligence. The new challenges facing the intercept receiver design and the trends in receiver technology are addressed. To increase the processing gain of the receiver, time-frequency signal processing methods are presented and include the pseudo Wigner-Ville distribution, quadrature mirror filter bank trees for wavelet decomposition and the Choi-Williams distribution. Bi-frequency techniques are also emphasized and include cyclostationary processing for estimating the spectral correlation density of the intercepted signal. Calculations using each signal processing method are shown to demonstrate the output information and its correlation with the input signal parameters. New detection results are then derived by the student for various LPI signaling schemes to illustrate the parameter extraction methods developed. Autonomous emitter classification architectures are also presented. Laboratory simulation exercises are conducted to demonstrate the concepts.

Prerequisite: EC3700.

EC4710 - High Speed Networking (3 - 2)

The course systematically develops the traffic characteristics of DoD and commercial broadband services (video, voice, text, and other multimedia information) and determines the need for high-speed networks with emphasis on quality of service. Queuing theory is used in the design and analysis of the various modules of a high-speed network: traffic modeling, switches, admission control, scheduling, traffic monitoring, and congestion control. Emerging trends and technologies that enable deployment of high-speed global networks for tactical, commercial, and residential use are discussed. Topics include queuing theory, traffic models, traffic management, and broadband technologies, such as ATM, Gigabit Ethernet, DSL, and cable access. Laboratory is concerned with the use of OPNET for simulation studies of various network topologies.

Prerequisite: EC3710 or CS3502 or Consent of instructor.

EC4715 - Cyber System Vulnerabilities and Risk Assessment (3 - 2)

The course utilizes reverse engineering principles to identify and assess vulnerabilities in electronic, communication, and control systems and analyze risk to

provide tradeoffs. Vulnerabilities in cyber systems based on genetic, developmental, and those caused by system overload are presented. Widely accepted industry and military standards, underlying technologies, specification mismatches and interoperability, and resource constraints are examined to identify vulnerabilities of interest. Vulnerability assessment at component and system level along with prioritization and elimination procedures are discussed. Risk analysis for secure operation of the system and relevant tradeoffs are presented. Laboratory exercises provide hands-on experience.

Prerequisite: EC3730, EC3740.

EC4725 - Advanced Telecommunication Systems Engineering (3 - 2)

Studies the engineering of communication transport networks, presenting basic concepts in conventional telephony and traffic engineering such as blockage, availability, dimensioning and survivability. The public switched network (PSTN), mobile switched networks (MSN) and public land mobile networks (PLMN) are discussed. The Signaling System No.7 (SS7) architecture for the PSTN is presented along with a variety of transport technologies including the Synchronous Optical Network (SONET)/ Synchronous Digital Hierarchy (SDH). Dense Wavelength Division Multiplexing (DWDM) is also examined. Voice over IP (VoIP) and its associated signaling protocol, the Session Initiation Protocol (SIP), is examined. Skype is used as a case study. VoIP vulnerabilities are also discussed. Cellular telecommunications standards, including GSM/2G, GPRS, UMTS/3G, LTE/4G and 5G are studied. Security measures for different telecommunications standards are also discussed. Concludes with a discussion of Network Management Systems.

Prerequisite: EC3795 or EC3710 or CS3502 or Consent of instructor..

EC4730 - Covert Communications (3 - 2)

Electronic signal and data communication mechanisms in which the presence of a message being transmitted is concealed in plain sight of other signals or data are presented. Information hiding in user data, protocol data, and radio, electronic, acoustic and other sensory signals is examined. The techniques of steganography, covert channels, low probability exploitation, and information concealment in analog signals are studied. Techniques and mechanisms for establishing robust, secure covert communication schemes are introduced. The detection, analysis, and abortion of adverse covert communication schemes are discussed. Design of systems suitable for attack and defense of covert communications using programmable logic devices is introduced. Low probability of detect, low probability of intercept, and anti-jamming techniques are reviewed. Embedding and extraction algorithms of steganography are presented. Related topics of watermarking and embedded malware are reviewed.

Prerequisite: EC3730, EC3710.

EC4735 - Telecommunications Systems Security (3 - 2)

Examines underlying technical security issues, policies, standards, implementations, and technologies associated with large-scale commercial telecommunications systems. Reviews the infrastructure and components of carrier class networks to include transport multiplexers and multi-protocol switches. Discusses the public switched telephone network (PSTN) and public land mobile network (PLMN). Begins with a review of the need for Signaling System No. 7 (SS7) and how security is implemented in SS7 networks. Presents fundamental trust assignments in second generation (2G) cellular mobile networks and specifically analyzes trust relationships between core components of the PLMN subsystems. Specifically discusses air interface (Um, Gm) protection measures and presents case studies of systemic flaws. Presents evolutionary changes in security practices in third (3G) and fourth generation (4G) protocols and standards. Examines underlying principles of lawful intercept (LI) implementation and discusses the evolution of LI capability from the PSTN through 3G and 4G networks. Studies the protection of data services in the PLMN and IP Multimedia Subsystem(IMS). Specifically focuses on the General Packet Radio Service (GPRS) Tunneling Protocol (GTP) and Roaming Exchanges (GRX). Discusses future research and proposed security standards in next generation systems.

Prerequisite: EC3710 or EC3730.

EC4745 - Mobile Ad-hoc Wireless Networks (3 - 2)

The course presents the fundamental principles, design issues, performance analysis, and military applications of infrastructure and ad hoc wireless packet switched networks. Radio wave propagation, wireless channel characteristic, orthogonal frequency division multiplexing, transceiver design, channel coding, and other physical layer technologies are reviewed. Principles of wireless local area and wide area (cellular) networks are presented. Design and performance analysis of medium access control mechanisms - contention, reservation and scheduling - are covered. Mobile IP protocol is presented, and reactive and proactive protocols for routing in ad hoc networks are introduced. The performance of TCP over wireless networks is analyzed. Security in infrastructure and ad hoc networks is addressed. Sensor networks are introduced. Energy management is discussed. The widely used and emerging wireless networking standards are reviewed. Hardware laboratory assignments provide hands-on experience and OPNET projects allow simulation of large scale networks to complement the theory presented in the course.

Prerequisite: EC3710 or CS3502 or Consent of instructor.

EC4747 - Data Mining in Cyber Applications (3 - 2)

Data mining concepts, theories and methods are examined and applied to the cyber domain. Specific

applications considered include network and computer intrusion detection, malware detection, fraud detection and identity theft. Classification approaches, including heuristic, Bayesian, neural network and support vector machine approaches are examined. Association analysis using both attribute- and graphical based approaches are studied. Cluster analyses, both hierarchical and partitional approaches, are examined. The application of these concepts, theories and methods culminate in an in-depth study of anomaly detection techniques, methodologies and associated system designs and implementations relevant to the cyber mission.

Prerequisite: EC2010, EC3730 or their equivalents, working knowledge of Python and panda library extensions or consent of the instructor..

EC4750 - SIGINT Systems II (3 - 4)

Detailed problems and principles of Signals Intelligence (SIGINT) are presented. Several SIGINT scenarios are studied in class, and students select one for a team project. The scenarios taught are based on SIGINT needs from the National Security Agency (the scenarios are highly classified). The selected SIGINT scenario will require a conceptual design or realignment of national SIGINT systems to satisfy the operational commander's SIGINT needs. Requires U.S. citizenship and TOP SECRET clearance with eligibility for SCI access.

Prerequisite: EC3750. Security Clearance Required: Top Secret SCI.

EC4755 - Network Traffic, Activity Detection, and Tracking (3 - 2)

Network traffic characterization, traffic engineering/management and detection and tracking of traffic anomalies are covered with a focus on statistical and information theoretic concepts, signal processing, and control theory. Network (cyber) traffic is characterized based on statistical and information theoretic approaches such as self similarity and information entropy. Traffic flows and traffic flow analysis are presented; multimedia nature of network traffic discussed. Traffic engineering techniques of congestion control, traffic redirection, and admission control are examined utilizing network flows and queue management and analysis. Detection theory is introduced. Detection of threat activity based on traffic anomalies is examined. Neyman-Peason criterion and the receiver operating characteristic are presented. Traffic flow analysis for activity tracking is discussed. Case studies of local area networks, the Internet, sensor networks, and wireless networks including the 4G systems are conducted. Laboratories will provide hands-on experience and introduce tools of traffic characterization, detection, monitoring, and tracing.

Prerequisite: EC3730, EC3500.

EC4765 - Cyber Warfare (3 - 2)

Cyber warfare explored from an electrical engineering perspective. Historical examples of military cyber warfare operations are reviewed. Rudimentary denial-of-service techniques are initially discussed and progress to intelligent waveform-specific forms of computer network attack (CNA). The effect of communications signaling manipulation is analyzed in examples involving mobile wireless networks such as Global Systems Mobile (GSM), and the IEEE 802.11 and 802.16 standards. Extension of cyber warfare concepts to large scale systems is presented to include concepts in distributed denial of service attacks, distributed storage, distributed sensor coordination, and information exfiltration.

Prerequisite: EC3760.

EC4770 - Wireless Communications Network Security (3 - 2)

Examines the security mechanisms and protocols for thwarting attacks on emerging wireless networks including wireless LANs, sensor networks, mobile ad hoc networks and wireless cellular standards. Specifically, examines security primitives including confidentiality assurance, integrity and authentication in the context of different wireless networks. Block and stream ciphers, such as the Data Encryption Standard, Advanced Encryption Standard and RC4 are studied. Evaluates Public key cryptography (PKC) and its associated algorithms (RSA). Discusses approaches to integrity assurance in the form of cryptographic hash functions. Examines all of the above factors in the context of a variety of network topologies to include personal area networks (PAN-Security in Bluetooth), wireless local area networks (WLAN), and wireless metropolitan area networks (LTE and WiMax). Analyzes and compares protocol implementations such as Wired Equivalent Privacy (WEP) and Wi-Fi Protected Access (WPA/WPA2). Also analyzes security in wireless cellular standards, including 2G (GSM), 3G, and 4G(LTE). The course studies communication vulnerabilities in wireless systems with example attacks such as Denial of Service (DoS), replay, and man-in-the-middle (MITM). Security in mobile ad hoc networks, including wireless sensor networks and Internet of Things (IoT) is also studied.

Prerequisite: EC3710 or EC3730.

EC4785 - Internet Engineering (3 - 2)

This course examines the optimal design and analysis of interconnected, heterogeneous computer networks, specifically those employed by the US Navy (e.g., IT-21). A common theme throughout will be the confluence of connection-oriented and connectionless data communications and their overarching networking methodologies. The course will focus primarily on the TCT/IP suite. Techniques for segmentation and reassembly, routing, transfer agent placement, error control, throughput analysis, broadcasting, and multicasting will be examined in detail. Performance of common distributed applications will be analyzed.

Prerequisite: EC3710 or CS3502 or Consent of instructor..

EC4790 - Cyber Architectures and Engineering (3 - 2)

The course addresses the holistic design, analysis and integration of the three-tiered cyber architecture of the medium, network, and services. Interoperability and interconnection of heterogeneous networks are discussed. Service oriented architectures and service orchestration mechanisms to include such techniques as artificial intelligence, control theory, min-max algorithm and feedback analysis are introduced. Network centric services and system design for both wired and wireless platforms are emphasized. Tools such as WSDL and SoaML will be introduced. System availability calculations and quality of service issues at different levels of the system are discussed in-depth. Comprehensive approaches to security across all levels of the system-medium, network, and services-are analyzed. Development of network centric, distributed engineering applications will be considered for static as well as mobile services. Sensor networks, information fusion, and end-to-end services are studied.

Prerequisite: EC3730 or EC3710.

EC4795 - Wireless Device Security (3 - 2)

This advanced course extends earlier study in communications devices and software defined radio to include security vulnerabilities and countermeasures from the perspective of the radio signal and the wireless device. Mobile device architectures to include mobile operating systems (OS), dynamic resources and service components. Mobile OS security models and application implementations. Radio signal vulnerabilities include signal interception, rouge access points, wireless intrusion, client misassociation, unauthorized association, emitter geographical location, direction finding, and device fingerprinting. Wireless device vulnerabilities include malware, resource attacks, backdoor access, reverse engineering, side channel attacks, covert channels, and aspects of software defined and cognitive radios.

Prerequisite: EC4765; or EC3500 and EC4530.

EC4800 - Advanced Topics in Computer Engineering (3 - 0)

Advanced topics and current developments in computer architecture including such subjects as: graphics and multimedia processors relevant to military applications and workstations; computer structures for artificial intelligence and large data bases; supercomputers and massively parallel architectures; advanced logic design, hardware/software co-design, and multiple-valued logic.

Prerequisite: Consent of Instructor.

EC4810 - Fault-Tolerant Computing (3 - 2)

Introduction to fault-tolerant computing. The causes and effects of computer, digital system, and software failure. The fundamental concepts and techniques for the design and implementation of fault-tolerant computers, testing digital systems, and software. Modeling, simulation, and evaluation of fault-tolerant systems. Military and space applications of fault-tolerant computing.

Prerequisite: EC3840 or EC3800.

EC4820 - Advanced Computer Architecture (3 - 2)

Techniques to achieve high-performance computing, including advanced architectural features and highly parallel processors. Techniques for improving processor, memory subsystem, and I/O subsystem performance, including pipelining, memory interleaving, multi-level caching, and parallel I/O. Parallel computer models, scalability, and clustering. Parallel programming, the role of the compiler, and compiler parallelization techniques. Performance metrics, evaluation, and comparisons between parallel processors. Enabling technologies for highly parallel computers, including the use of microprocessors and field-programmable gate arrays. Distributed memory. Processor/cluster interconnection networks. Advanced implementation technologies and techniques, including reconfigurable computing. Military applications of high-performance computers and parallel processors.

Prerequisite: EC3800 or EC3820 or EC3830 or EC3840.

EC4830 - Digital Computer Design (3 - 2)

This course presents digital system design techniques that can be used in tactical embedded systems. It involves a study of the architecture of and the design process for digital computer systems. Topics covered include instruction set architectures, advanced computer arithmetic, hierarchical design techniques, and design of systems using standard and custom VLSI devices. Modern computer-aided design tools are emphasized. Laboratory project is the design of a digital computer.

Prerequisite: EC3800 or EC3830.

EC4870 - VLSI Systems Design (3 - 2)

Introduction to the design and implementation of Complementary Metal Oxide Semiconductor (CMOS) and Bipolar CMOS (BiCMOS) Very Large Scale Integration (VLSI) digital Integrated Circuits (ICs). Topics covered include the specification of the high-level functional design, the design, implementation, and simulation of low-level cells, floor planning and the assembly of low-level cells into the high-level design using hierarchical place-and-route techniques, circuit extraction and simulation for functional verification, timing analysis, and power estimation, and the principles of bulk CMOS, BiCMOS, and SOS/SOI IC fabrication. Applications of VLSI ICs in military systems are also covered. The course is centered around laboratory projects where student groups design, implement, simulate, and submit for fabrication, a full-custom CMOS or BiCMOS, VLSI IC. IC functionality is selected by each student group. A field trip to a commercial foundry and clean room tour is also included.

Prerequisite: EC2200 and either EC3800 or EC3830 or EC3840.

EC4900 - Topics for Individual Study in Electrical Engineering (V - V)

Supervised study in selected areas of Electrical Engineering to meet the needs of the individual student. A written report is required at the end of the quarter. Graded on Pass/Fail basis only.

Prerequisite: Consent of the department chairman.

EC4910 - Advanced Special Topics in Electrical Engineering (V - V)

Courses on advanced special topics in Electrical Engineering are offered under these numbers. In most cases new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC4920 - Advanced Special Topics in Electrical Engineering (V - V)

Courses on advanced special topics in Electrical Engineering are offered under these numbers. In most cases new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC4930 - Advanced Special Topics in Electrical Engineering (V - V)

Courses on advanced special topics in Electrical Engineering are offered under these numbers. In most cases new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings

EC4940 - Advanced Special Topics in Electrical Engineering (V - V)

Courses on advanced special topics in Electrical Engineering are offered under these numbers. In most cases new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings

EC4950 - Advanced Special Topics in Electrical Engineering (V - V)

Courses on advanced special topics in Electrical Engineering are offered under these numbers. In most cases new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering

Department's on-line catalog for current offerings.

EC4960 - Advanced Special Topics in Electrical Engineering (V - V)

Courses on advanced special topics in Electrical Engineering are offered under these numbers. In most cases new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC4970 - Advanced Special Topics in Electrical Engineering (V - V)

Courses on advanced special topics in Electrical Engineering are offered under these numbers. In most cases new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC4980 - Advanced Special Topics in Electrical Engineering (V - V)

Courses on advanced special topics in Electrical Engineering are offered under these numbers. In most cases new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC4990 - Advanced Special Topics in Electrical Engineering (V - V)

Courses on advanced special topics in Electrical Engineering are offered under these numbers. In most cases new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EC5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

EC5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council. Prerequisite: Advancement to Candidacy.

EN

EN3000 - Defense Energy Seminar (2 - 0)

To ensure that students receive the most current and credible information, the Naval Postgraduate School has invited talks from nationally and internationally known speakers. These speakers' seminars will be an important contribution to the student's overall education in energy, and will help the student further develop the breadth required to understand and address the Nation's growing challenges in energy security.

EN3010 - Introduction to Energy Systems for Robotics (4 - 0)

This course will provide students with information and guidance in the basic technologies and concepts in operational energy related to robotic and autonomous systems applications. The objective of the course is to provide the civilian and active-duty workforce with a distributed learning experience that includes the essential concepts and skills necessary to understand the energy considerations for DOD robotic and autonomous systems. The course focuses on the effective use of robotics in the modern battlespace, the inherent operational energy challenges in ensuring mission success, and energy considerations when assessing or defining the system requirements or performance parameters for new system acquisition.

Prerequisite: None.

EN4010 - Energy Intelligence, Surveillance, Reconnaissance and Targeting (ISRT) (4 - 0)

This course will provide students with information and guidance in the basic technologies and concepts in energy intelligence, surveillance, reconnaissance, and targeting. The objective is to discuss the concept of Energy ISR which is the intelligence discipline to sense, measure and estimate all aspects of the adversary's energy supply chain to determine the adversary's ability to plan, conduct and sustain competition and combat. Students will review areas of collection and estimation including sources of energy (e.g., petroleum fuels. LNG and electricity generated from a variety of sources, including nuclear) at fixed installations, and characteristics of production (rates, capacity, operating states, efficiency, vulnerabilities); energy delivery systems (power grids, rail, road transportation, vessel delivery to vessels at-sea (JP-5) air refueling (JP-8), etc.); battery manufacture, supply-replacement, recharge logistics and supply chains; and consumers of energy and demand rates to sustain combat functions (energy use, peak and steady-state demand, demand cycles, etc.).

Prerequisite: None.

EN4020 - Case Studies in Operational Energy (4 - 0)

This Case Study course will provide students with relevant, real-world scenarios in which they can express their understanding and solutions to problems found in these modern situations. It is expected that the case analyses will build upon the energy concepts that the student has already reviewed during their entire Operational Energy course work. Case study development will help students analyze and find solutions to complex problems with foresight and confidence, exercising the totality of the knowledge gained during their studies.

Topics will be derived from three different major topic areas: unmanned autonomous system, refuel (contested) logistics, and directed energy. Subtopics include the following: physics and energy fundamentals, joint logistics analysis, analysis of military operations, energy systems for robotics, unmanned weapons, weapons systems technology, energy systems for robotics, directed energy weapons, and ethical considerations in energy.

Prerequisite: Enrollment in the three energy certificates and/or with AA approval..

EO

EO2102 - Basic Electronics and Electrical Machines (4 - 2)

An introduction to the fundamental tools of circuit analysis including Kirchhoff's current and voltage laws, series-parallel resistance combinations, voltage and current dividers, superposition, The Venin and Norton equivalent circuits, source transformations, and nodal and mesh analysis. The students are then exposed to frequency domain phasor techniques for analyzing AC circuits. An introduction to power calculations and three-phase systems is next presented. The remainder of the course focuses on the basic operational characteristics of power system components such as transformers, synchronous machines, induction machines, DC machines and power converters.

Prerequisite: MA2121 (may be concurrent).

EO2402 - Introduction to Linear Systems (4 - 1)

A course in the rudiments of linear systems for naval officers in non-electrical engineering curricula. Principles of discrete and continuous-time systems. Topics include difference equations, discrete and continuous convolution, correlation, transfer functions, and system diagrams. Transform applications in communication and control systems.

Prerequisite: Ability to program in a higher level language.

EO2512 - Introduction to Communications & Countermeasures (4 - 2)

A first course in communications and countermeasures for the Information Warfare curriculum. The course considers basic electricity and electronics, noise analysis, amplitude modulation, frequency modulation, digital coding and transmission.

Prerequisite: MA3139 or EC2410 or (MA1113 and EO2402).

EO2525 - Probabilistic Analysis of Signals and Communication Systems (4 - 1)

Basic analog and digital communications techniques are discussed. The foundations of signals and systems are developed from probabilistic and statistical approaches. Emphasis is on communication systems relevant to military applications. Topics include AM, FM, probability, random variables, probability density and distribution functions; deterministic versus nondeterministic signals; expectation, the dc and rms values of nondeterministic signals, correlation and covariance; LTI systems, transformation of random variables, and the central limit theorem.

Prerequisite: MA2121, PH1322.

EO2652 - Fields, Waves, and Electromagnetic Engineering (4 - 1)

This course covers electromagnetic field theory and engineering applications. Static electric and magnetic field theory is developed and Maxwell's equations are presented. Applications include plane wave propagation, analysis and design of transmission lines, wave guides, resonators, and high frequency components. Labs provide practical experience with microwave instruments, components, and measurement techniques. The objective of the course is to provide a foundation for subsequent study of microwave engineering, antennas, scattering, and radio wave propagation for application in the areas of communications, radar, and electronic warfare.

Prerequisite: MA1116 and PH1322; or consent of instructor.

EO2701 - Introduction to Cyber Systems (4 - 2)

EDO-specific Intro to Cyber Systems. The course will provide the fundamentals of the underlying principles of cyber infrastructure and systems, inherent vulnerabilities and threats, and defensive security procedures. Topics covered in this course include number systems, computer systems, concepts in computer programming including C and assembly language, arrays, strings, pointers, stack and heap, memory corruption (buffer overflow), computer networks, Ethernet, Internet protocol, Address Resolution and routing protocols. Additional topics include wired and wireless communication systems, analog-to-digital conversion, digital modulation, cyber security and defense, and Industrial Control Systems.

Prerequisite: Previous exposure to a high-level computer programming language.

EO3402 - Signals and Noise (3 - 1)

A course in the rudiments of modern signal processing for naval officers in non-electrical engineering curricula. Topics include signal processing in the frequency domain using the DFT and FFT, random signals, their description and processing. Applications to signal detection, demodulation, filtering, beamforming, target tracking, and other relevant naval and military operations.

Prerequisite: EO2402 and OS2103 or equivalent.

EO3404 - Applied Digital Signal Processing (3 - 2)

This course introduces the fundamentals of digital signal processing as applied to one dimensional acoustic signals. The course covers the fundamental theory of signals and systems, the application of the DFT (Discrete Fourier Transform) to problems in spectral estimation, digital filter design, detection of pulses by correlation and fundamentals of array processing. The laboratories are entirely based on processing of acoustic signals using Matlab.

EO3502 - Telecommunications Systems Technology (4 - 0)

A broad-based course in telecommunications systems technology for a multidisciplinary audience. The course considers analog and digital communications systems. Specific topics include amplitude and angle modulation transmission and reception; baseband and passband digital modulation; system noise; transmission lines, waveguides and antennas; fiber optics; satellite communications.

Prerequisite: MO1901.

EO3510 - Space Communications Systems: Fundamentals and Analysis (4 - 2)

Same as SS3610. With a focus on satellite communications/SIGINT, this course provides an understanding of the basic elements of a communications system and their relationship to system performance. Fundamental concepts such as current/voltage relationships, time and frequency domains, power spectral density, random signals, and communications system components and functions are covered. Following development of the signal to noise equation, system performance will be analyzed with respect to various design characteristics such as modulation, bandwidth and power trade offs, and the use of spread spectrum techniques.

Prerequisite: PH1322 or permission of the instructor.

EO3512 - Telecommunications Engineering (4 - 1)

The second course in communications and countermeasures for the Information Warfare curriculum. The course considers signals and protocols for networks, time and frequency domain multiplexing, transmission lines, antennas, and fiber optics, and cellular communication concepts.

Prerequisite: EO2512.

EO3525 - Communications Engineering (4 - 1)

The influence of noise and interference on the design and selection of digital communications systems is analyzed. Topics include link budget analysis and signal-to-noise

ratio calculations, receiver performance for various digital modulation techniques, bandwidth and signal power trade-offs, an introduction to spread spectrum communications, and multiple access techniques. Examples of military communications systems are included.

Prerequisite: EO2525.

EO3602 - Electromagnetic Waves, Transmission Lines, and Antennas (4 - 2)

This course covers elements of electromagnetic field theory as applied to transmission lines, propagating waves, and antenna radiation. The objective of the course is to provide a foundation for the subsequent study of antennas, devices, and propagation environment on the design and performance of communications, radar and electronic warfare systems. Labs provide practical experience with commercial simulation software, microwave instruments, components, and measurement techniques. This course is intended for students not in the 590 curriculum.

Prerequisite: MA1116 and PH1322.

EO3730 - Cyber Communications Architectures (4 - 0)

The purpose of this course is to develop literacy and familiarity with Navy, DoD, and allied enterprise information systems and emerging technology trends. It presents basic concepts in conventional and military telephony and telecommunication networks; examines DoN implementations from intra-ship, ship-to-ship and long haul; and discusses architectures and components of the GIG including both classified and unclassified networks. It discusses interoperability of diverse network architectures and the impact of mobile platforms on operations.

Prerequisite: CY3100, CY3110. Security Clearance Required: Secret.

EO3911 - Interdisciplinary Studies in Electrical and Computer Engineering (V - V)

Courses on special topics of joint interest to electrical and computer engineering and other areas are offered under these numbers. In most cases, new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

EO4409 - Engineering Acoustics Capstone Project (2 - 4)

See PH4409 for course description and prerequisites.

EO4516 - Communication Systems Analysis (4 - 2)

The final course in communication systems engineering for the Space Systems Operations curriculum. The course considers propagation effects on signal transmission; end-to-end path calculations for wire/coax, and RF systems including terrestrial ground links and satellite communications; spread spectrum; wireless/cellular communications.

Prerequisite: EO3516.

EO4612 - Microwave Devices, Propagation, and Radar Systems (4 - 2)

The radar range equation is developed in a form including signal integration, the effects of target cross section, fluctuations, and propagation losses. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed. Microwave transmitters, receivers, and components are discussed. Modeling of the propagation environment and the target scattering characteristics are covered. Propagation channels covered include the troposphere, ionosphere and ground waves.

Prerequisite: EO3602 (may be concurrent) or consent of instructor.

EO4911 - Advanced Interdisciplinary Studies in Electrical and Computer Engineering (2 - 0)

Courses on advanced special topics of joint interest to electrical and computer engineering and other areas are offered under these numbers. In most cases, new courses are offered as special topics of current interest with the possibility of being developed as regular courses. See the Electrical and Computer Engineering Department's on-line catalog for current offerings.

FL

FL0001 - Language (0 - 0)

This course is a generic identifier for a foreign language course taken at the Defense Language Institute (DLI).

FL0002 - Language (0 - 0)

This course is a generic identifier for a foreign language course taken at the Defense Language Institute (DLI).

FL0003 - Language (0 - 0)

This course is a generic identifier for a foreign language course taken at the Defense Language Institute (DLI).

FL0004 - Language (0 - 0)

This course is a generic identifier for a foreign language course taken at the Defense Language Institute (DLI).

FL0005 - Language (0 - 0)

This course is a generic identifier for a foreign language course taken at the Defense Language Institute (DLI).

FL0006 - Language (0 - 0)

This course is a generic identifier for a foreign language course taken at the Defense Language Institute (DLI).

FL0007 - Language (0 - 0)

This course is a generic identifier for a foreign language course taken at the Defense Language Institute (DLI).

FL0008 - Language (0 - 0)

This course is a generic identifier for a foreign language course taken at the Defense Language Institute (DLI).

FL0009 - Language (0 - 0)

This course is a generic identifier for a foreign language course taken at the Defense Language Institute (DLI).

GB

GB1000 - Quantitative Skills for Graduate Management Studies (0 - 3)

This course is intended to help prepare students in the Department of Defense Management. The objective of the course is to reduce student's difficulties with quantitative tools in core courses, and allow them to focus on subsequent course materials. This is achieved through problem solving sessions that ensures the student has proficiency in basic pre-algebra, algebra, and graph-reading/drawing skills as demonstrated by weekly exams. Prerequisites: None.

GB3010 - Managing for Organizational Effectiveness (4 - 0)

Organizations, including defense organizations, are complex, purposive, open systems. As open systems, they face challenges of external adaptation and effectiveness and of internal coherence and efficiency. Our purpose is to understand the structures and processes that make up organizations in order to appreciate how they succeed and why they falter or fail. Our focus is on "organizational diagnosis", which requires us to apply relevant theories to evaluate organizational performance. To do this, we will examine topics that include: organizational structure, motivation and reward systems, organizational culture, power and conflict, effective teams, and the leadership characteristics involved in effectively managing today's organizations. Although these topics are relevant to all organizations, we will pay special attention to their application in the context of the Department of Defense and military organizations.

Prerequisite: Enrollment in DDM Degree Program.

GB3012 - Communication for Managers (3 - 0)

OPEN TO MBA STUDENTS, OR BY PERMISSION OF INSTRUCTOR. This course provides DoD and international military officers and civilians with the communication strategies and skills to manage and lead in the dynamic DoD environment. Instruction focuses on assessing various communication models, making strategic media choices, writing effective informative documents, developing associates' communication competencies through various feedback roles, and giving lucid briefings.

Prerequisite: GB3010 or consent of instructor.

GB3070 - Economics of the Global Defense Environment (4 - 0)

This course introduces you to economics as a social science and teaches you the tools of micro-economic analysis that are necessary to understand and conduct economic policy analyses. One of the key tools of economic analysis is Cost-Benefit Analysis (CBA). You will learn the utility as well as the challenges of using CBA to study the role of the public sector in our market economy. After a brief introduction to CBA, which includes motivating the need for conducting CBA in the public sector, we study the fundamental tools of microeconomics, including supply and demand, elasticity, market equilibrium, social welfare, the effects of government interventions in the economy, and how firms make decisions in competitive and non-competitive markets. We then turn to the study of how to conduct CBA and how to be critical consumers of such analyses.

Prerequisite: MA2XXX College Algebra or equivalent.

GB4014 - Strategic Management (4 - 0)

Strategic Management entails the establishment of an organization's direction and the implementation and evaluation of that direction in view of the organization's external environment and its internal capabilities. The principal aim of this course is the transfer and adaptation of the principles of business strategic management to the Department of Defense and other government agencies. In previous courses, students concentrated on the functional elements of management (e.g., accounting, finance, acquisition, logistics, contracting, etc.). This course addresses the challenges of setting direction and implementing strategies for the total system or whole organization. Cases and approaches from the public and private sectors enable students to develop the knowledge, skills, and abilities to strategically think, plan, and manage.

Prerequisite: GB3010, GB3012.

GB4043 - Decision Modeling Methods (3 - 0)

This course familiarizes the students with applications, assumptions, and limitations of the quantitative methods in modeling. It focuses on the development of mathematical and spreadsheet models, the verification of those models, sensitivity analysis of the solutions generated from a model, and the implementation of those

solutions. Some of the topics covered include linear programming, non-linear and integer programming, simulation, and forecasting. The process of modeling and particular modeling tools are applied to business problems in finance, acquisition, logistics and manpower planning.

Prerequisite: MN3041.

GB4044 - Defense-Focused Managerial Inquiry (3 - 0)

Fundamentally, this is a course in thinking critically and analytically. It is also a unique, practical opportunity for students to develop a research question, methodology, and proposal for their MBA project or master's thesis. Indeed, many students can expect to complete the initial stages of their MBA project or thesis by fulfilling the course requirement for a team-based research report. As Cooper and Schindler write: "Research is any organized inquiry carried out to provide information for solving problems. Business research is a systematic inquiry that provides information to guide business decisions. This includes reporting, descriptive, explanatory, and predictive studies. The managers of tomorrow will need to know more than any managers in history. Research will be a major contributor to that knowledge. Managers will find knowledge of research methods to be of value in many situations. They may need to conduct research either for themselves or for others. As buyers of research services, they will need to be able to judge research quality. Finally, they may become research specialists themselves." Punch prefers to describe research as "organized common sense," since it "supports the idea that good research is within the grasp of many people." In this way, we can "simplify the more technical aspects of research methods, and enhance understanding, by showing the logic behind them." This course similarly seeks to examine the logic of research methods-- recognizing that these methods may differ across disciplines and subspecialties--rather than focus on detailed models or procedures that may hold little meaning for the military's managers. It is not a course in rules or required steps; rather, it is a course in understanding the principles, concepts, and range of techniques that define the craft of research. Prerequisite: None.

GB4053 - Defense Budget Policy and Financial Management Systems (4 - 0)

This course analyzes the resource requirements process within the Department of Defense (DoD) and in the executive and legislative branches of the federal government. It begins with a summary of the current threat situation and potential changes to it. Once the threat is defined, the study of the resource allocation process to meet the threat begins. The course covers the resource planning and budgeting processes of the Department of the Navy, DoD and the federal government. It includes the politics of executive and congressional budgeting, and DoD budget and financial management processes and procedures including budget formulation and execution. It also includes analysis of the Planning, Programming, Budgeting and Execution system (PPBES) used by DoD to plan, budget and implement national defense resource management policy and programs. Other areas included are budget process and fiscal policy reform and the dynamics of internal DoD competition for resources. Executive and congressional budget processes are assessed to indicate how national security policy is resourced and implemented through the budget process. Spending for national security policy is tracked from budget submission through resolution, authorization and appropriation. Budget formulation, negotiation, and execution strategies are evaluated to indicate the dynamics of executive-legislative competition over resource allocation priorities. Supplemental appropriation patterns and current year budget execution patterns and problems are also considered.

Prerequisite: MN3056, or MN3050 and MN3051, or approved by AA or instructor.

GB4090 - Capstone Project (0 - 6)

CAPSTONE PROJECT. OPEN TO DDM STUDENTS, OR BY PERMISSION OF INSTRUCTOR.

GB4430 - Defense Transportation System (4 - 0)

This course examines how the Defense Transportation System supports the DOD mission, including the responsibilities of USTRANSCOM and its Transportation Component Commands, CONUS transportation and strategic lift, as well as institutional constraints and other managerial issues. Prerequisites: None.

GB4999 - Elective (4 - 0)

ELECTIVE COURSE TO BE SELECTED BY STUDENT WITH APPROVAL BY ACADEMIC ASSOCIATE

X00

GBXXXX - Core Elective (V - 0)

STUDENT MUST SELECT AN ELECTIVE COURSE, EITHER 2 OR 3 CREDIT HOURS.

GC

GC3015 - Leading Teams (3 - 0)

This course focuses on leading teams, including team development, process analysis, and leadership skill-building. Students learn to design teams wisely, sustain positive team development, foster excellent problem-solving processes, catalyze innovation, and support a learning-focused and productive team environment.

Students analyze DoD teams as systems of interrelated components working towards a common purpose, learn how design factors affect team processes and performance, and identify challenges and pitfalls of group decision making. They learn to plan interventions that will help teams think more critically and make better decisions. The course concludes with exercises in leading collaboration within culturally diverse teams. Knowledge and skills from the course will have immediate application in many organizational settings.

Prerequisite: none. Cross-Listed as: Cross-listed with MN3015.

GC4011 - Ethical Leadership in Public Organizations (3 - 2)

Given the regular calls from the Navy for better prepared leaders with a strong moral compass, this course focuses on advanced concepts of leadership development in public organizations:

1. That are directly and immediately applicable for NPS students;
2. That will serve them for the rest of their careers, spanning both military and other public service roles;
3. That will enable them to build character and competence within the units they lead while establishing positive, empowering relationships with their followers.

Our students will become more effective leaders and make more ethically sound decisions as they: (a) assess their own abilities, values, strengths, and weaknesses; (b) take responsibility for their own ethical and leadership development; and (c) work consciously on developing character alongside leadership competence. This course is designed to *consolidate* the leadership skills that students have already developed, and *propel* students to the next level of advanced leadership capabilities.

Prerequisite: Prerequisite: GB3010, GE3010, MN4474, or another course that introduces organizational behavior, processes, and leadership.. Cross-Listed as: GC4011: Online version of MN4011. Given the regular calls from the Navy for better prepared leaders with a strong moral compass, this course focuses on advanced concepts of leadership development in public organizations: That are directly and immediately applicable for NPS students;   That will serve them for the rest of their careers, spanning both military and other public service roles;   That will enable them to build character and competence within the units they lead while establishing positive, empowering relationships with their followers Our students will become more effective leaders and make more ethically sound decisions as they: (a) assess their own abilities, values, strengths, and weaknesses; (b) take responsibility for their own ethical and leadership development; and (c) work consciously on developing character alongside leadership competence. This course is designed to consolidate the leadership skills that students

have already developed, and propel students to the next level of advanced leadership capabilities..

GC4017 - High-performance Decision Practices (3 -)

This advanced course helps the student to master social, psychological, and organizational aspects of successful decision making. The focus is on principles and processes that facilitate effective decision making and support collaborative relations among stakeholders. Students learn and apply these principles at the individual, group, and inter-group levels, experimenting with distinct approaches to decision making and analyzing the usefulness of each approach. The course addresses creativity and brainstorming, cognitive biases and mitigation strategies, ethics in ambiguous situations, group decision dynamics, approaches to improve group decision making, stakeholder analysis, judgment under uncertainty, and development of cooperative solutions.

Prerequisite: none. Cross-Listed as: Cross-listed with MN4017.

GE

GE3010 - Organizations as Systems and Structures (3 - 0)

GE3010 Organizations as Systems and Structures (3-0) Winter/Summer. Defense organizations are purposive systems comprising tasks and technologies, vertical and lateral coordination structures and processes, reward systems, and individual motivation. This course prepares leaders to understand the organizational system components and their relationships: inputs (e.g., environment, history), design factors (i.e., people, task, structure, culture) and outputs/outcomes (e.g., productivity, satisfaction, growth). A primary focus is on the organizational level of analysis and includes such topics as environment, hierarchy and structural configuration, with special emphasis on the context and organization of DoD. Applications and cases address command and control, joint task forces and network centric operations with attention to organizational theory and design tradeoffs. Prerequisite: None.

GE3011 - Management of Teams (2 - 0)

Teams are a building block of today's organizations. Teams are evident throughout DoD in such forms as operational squads, integrated product teams (IPTs), R&D innovation teams, and Joint Task Forces. The course examines the differences between groups and teams, between leader-managed and self-managed teams, between virtual and face-to-face teams, and between effective and ineffective teams. Analysis of effective teams include such issues as team dynamics, decision making, rewards, commitment, and the management of conflict (inter-personal, intra-team, and inter-team) in which power, influence and negotiation play central parts.

GE3040 - Statistics for Executive Management (3 - 0)

GE3040 is an introduction to the science and art of converting data into information for managerial and policy analysis. This course focuses on the descriptive and inferential statistical concepts useful for conducting managerial and policy analysis. Topics include measurement scales, descriptive statistics for quantitative and qualitative data, basic probability concepts and the Normal Distribution, sampling theory, sampling distributions, point and interval estimation, hypothesis testing, correlation analysis, and trend analysis. The course will draw examples from the application of statistics to problems across the subfields of Management, including Managerial Strategy, Economics, Finance, Budgeting, Logistics Management, Human Resource Management, Managerial Accounting, and Acquisitions. Excel statistical tools will be utilized for data analysis and presentation.

Prerequisite: Open to EMBA students, or by consent of instructor..

GE3042 - Process Analytics (4 - 0)

This course provides strong grounding in the analytical techniques necessary for analyzing, improving and managing operational processes that create and deliver an organization's primary products and services. Accordingly, this course provides DoD managers with the foundation to effectively design, manage and control operational processes. The course design consists of two inter-linked modules -- (1) process analysis, and (2) process improvement and control. Prerequisite: None. Quarter Offered: As Required.

GE3050 - Financial Reporting and Analysis (3 - 0)

This course covers theory, concepts, and practices underlying Financial Accounting and Financial Reporting. The conceptual structure underlying the reporting of economic events in the form of the balance sheet, the income statement, and the statement of cash flows is first presented. Accounting recognition and measurement issues surrounding revenues, expenses, assets, liabilities and equity are introduced and analyzed. Finally, different forms of financial analysis based on financial report information are addressed. Throughout the course, emphasis is placed on the manager or user perspective. Attention is given to the federal government financial reporting model and standards. Prerequisite: None.

GE3051 - Cost Management (3 - 0)

This course introduces students to cost management concepts and theories which are used by managers to make decisions on the allocation of financial, physical, and human resources to achieve strategic as well as short-term organizational goals and objectives and evaluate performance using financial and non-financial measures. The course is designed for those having a prior course in financial reporting and analysis or financial accounting. Cost management includes traditional tools and techniques such as cost behavior for decision making, activity costing, cost allocation, and standard costing.

Prerequisite: GE3050.

GE3070 - Economics for Defense Managers (3 - 0)

 Develops the fundamental tools of microeconomics and macroeconomics, and applies them to defense management and resource allocation. Course centers on defense applications of economic theory. Topics covered include: defense and the macro economy; markets and their interactions with defense acquisition and contracting; national security implications of globalization; and efficiency in defense decision making.

Prerequisite: MA2XXX, College algebra..

GE3109 - Ethics and Moral Development (3 - 0)

Offered to EMBA students in their first quarter: The objective of this course is to provide newly-enrolled Executive MBA students with an introduction to the ethical challenges of the global Defense business environment facing Navy corporate business leaders and resource managers. Through the use of case analyses and discussion, the course will explore the application of ethical thinking to contemporary issues in the private and public sectors. The course goals include: 1) introduce ethical concepts which are relevant to the moral and ethical dilemmas inherent in business decisions; 2) help students develop the critical thinking and analytical skills required to address complex issues; 3) identify the range of ethical problems facing senior leaders in business and government; and 4) encourage the students to develop a personal approach to achieve ethical outcomes in the corporate-level decision-making process. The students will use the managerial perspective and critical thinking skills developed in this course throughout the remainder of their studies to identify the ethical dimension in the process of formulating and implementing Navy policy and business strategies required to build and maintain the Fleet of the 21st Century. Prerequisite: None.

GE3221 - Principles of Acquisition and Program Management I (3 - 0)

 This is the first of two courses which provides the student with an understanding of the underlying concepts, fundamentals and philosophies of the Department of Defense systems acquisition process and the practical application of program management methods within this process. The course examines management characteristics and competencies, control policies and techniques, systems analysis methods and functional area concerns. Techniques for interpersonal relationships will

be examined in team exercise settings. Topics, from a program management perspective, include the evolution and current state of systems acquisition management, the system acquisition life cycle, requirements analysis, systems engineering, contract management, resource management, test and evaluation, user-producer acquisition management disciplines and activities; and program planning, organizing, staffing, directing and controlling. Case studies are used to analyze various acquisition issues. Defense Acquisition University (DAU) has granted MN 3221-MN3222, GE3221-GE3222 equivalency for ACQ 101, ACQ 201, PMT 251, PMT 257, BCF 102 and BCF 103. PREREQUISITE: None.

GE3222 - Principles of Acquisition and Program Management II (3 - 0)

This is the second of two courses which provides the student with an understanding of the underlying concepts, fundamentals and philosophies of the Department of Defense systems acquisition process and the practical application of program management methods within this process. The course examines management characteristics and competencies, control policies and techniques, systems analysis methods and functional area concerns. Techniques for interpersonal relationships will be examined in team exercise settings. Topics, from a program management perspective, include the evolution and current state of systems acquisition management, the system acquisition life cycle, requirements analysis, systems engineering, contract management, resource management, test and evaluation, user-producer acquisition management disciplines and activities; and program planning, organizing, staffing, directing and controlling. Case studies are used to analyze various acquisition issues. Defense Acquisition University (DAU) has granted MN 3221-MN3222, GE3221-GE3222 equivalency for ACQ 101, ACQ 201, PMT 251, PMT 257, BCF 102 and BCF 103.

Prerequisite: GE3221 or permission of instructor.

GE3510 - Defense Financial Management Practice (3 - 0)

This course is designed for MBA students and presumes the student has a foundation including the PPBE system and Congressional Authorization and Appropriation processes. This course concentrates on financial management practices within DoD as distinct from policy and budgeting theory. The course covers the actors and activities and mechanics of building and defending budgets. It covers funding mechanisms for programs and activities, addressing the proper use and management of appropriated, reimbursable, and revolving funds. Basic principles of fiscal law are explored. It then addresses financial management and stewardship topics including budgetary accounting, management of cost drivers, the relationship between comptrollership and contracting, and internal controls. Contemporary financial management issues are discussed. Exercises and case

studies are used to develop the students' ability to apply financial management concepts to real life situations.

GE4016 - Strategic Management (4 - 0)

Strategic Management entails the establishment of an organization's direction and the implementation and evaluation of that direction in view of the organization's external environment and its internal capabilities. The principal aim of this course is the transfer and adaptation of the principles of business strategic management to the Department of Defense and other government agencies. In previous courses, students concentrated on the functional elements of management (e.g., accounting, finance, acquisition, logistics, contracting, etc.). This course addresses the challenges of setting direction and implementing strategies for the total system or whole organization. Cases and approaches from the public and private sectors enable students to develop the knowledge, skills, and abilities to strategically think, plan, and manage. PREREQUISITES: NONE.

GE4043 - Business Modeling and Analysis (3 - 0)

This course introduces mathematical modeling for a sound conceptual understanding of the decision-making process. This course familiarizes the students with applications, assumptions, and limitations of the quantitative methods in modeling. It focuses on the development of mathematical and spreadsheet models, the verification of those models, sensitivity analysis of the solutions generated from a model, and the implementation of those solutions. Some of the topics covered include linear programming, non-linear and integer programming, simulation, and forecasting. The process of modeling and particular modeling tools are applied to business problems in finance, acquisition, logistics and manpower planning. Prerequisites: None.

GE4052 - Managerial Finance (3 - 0)

Study of capital budgeting techniques. This course provides an overview of the basic concepts and principles of financial management in the private sector and its implication on government contracting. It is designed to provide insights into the financial decision-making process encountered by commercial enterprises. The major emphasis is on financial environment, risk and return analysis, valuation models, cost of capital determination, optimal capital structure, and short-term and long-term financing.

Prerequisite: GE3050, GE3051.

GE4053 - DoD Mission and Resource Determination (4 - 0)

This course analyzes the resource requirements process within the Department of Defense (DoD) and in the executive and legislative branches of the U.S. federal

government. It begins with a summary of the current threat situation and potential changes to it. Once the threat is defined, the study of the resource allocation process to meet the threat begins. The course covers the resource planning and budgeting processes of the Department of the Navy, DoD and the federal government. It includes the politics of executive and congressional budgeting, and DoD budget and financial management processes and procedures including budget formulation and execution. It also includes analysis of the Planning, Programming, Budgeting and Execution system (PPBES) used by DoD to plan, budget and implement national defense resource management policy and programs. Other areas included are budget process and fiscal policy reform and the dynamics of internal DoD competition for resources. Executive and congressional budget processes are assessed to indicate how national security policy is resourced and implemented through the budget process. Spending for national security policy is tracked from budget submission through resolution, authorization and appropriation. Budget formulation, negotiation, and execution strategies are evaluated to indicate the dynamics of executive-legislative competition over resource allocation priorities. Supplemental appropriation patterns and current year budget execution patterns and problems are also considered.

Prerequisite: MN3156, or GE3050 and GE3051, or approved by AA or instructor.

GE4101 - Collaborative Problem Solving I (3 - 3)

GE4101 is the first part of the capstone project which uses a collaborative approach to integrate the knowledge and skills gained in the MS(SL&M) program. Participants are introduced to an applied research framework designed to enable them to work from theory to identify a business problem to be solved for a command; create a research design for data collection and analysis; and form conclusions and recommendations.

Prerequisite: Completion of the previous seven quarters of the EMBA program.

GE4102 - Collaborative Problem Solving II (3 - 3)

GE4102 is the second part of the capstone project which uses a collaborative approach to integrate the knowledge and skills gained in the EMBA program. Participants work in small teams to prepare a project proposal, a final report, and a presentation containing recommendations to solve one of the command's business problems.

Prerequisite: Completion of the previous seven quarters of the EMBA program.

GE4480 - Defense Supply Chain Management (3 - 0)

This course is designed to provide an introduction to supply chain management (SCM). A supply chain is a network of organizations that supply and transform materials, and distribute final products to customers. Supply chain management is a broadly defined term for the analysis and improvement of flows of material, information, and money through this network of suppliers, manufacturers, distributors, and customers. SCM also plays a vital role in the military operations. The objective of SCM is to deliver the right product to the right customer at the right time. SCM emphasizes inventory-service level tradeoffs across the chain of players that, together, provide the product to a customer. Logistics has traditionally focused on materials issues within and downstream from the factory while SCM looks at the entire network of players, both up and down stream, and perhaps has more of an emphasis on information flows through the network. Logistics has traditionally been considered a more tactical topic while SCM has risen to prominence in recent years for addressing strategic aspects of product distribution. Ultimately, logistics and SCM activities are concerned with coordinating demand and supply. Common elements in that coordination are the management of materials (inventories), the location of materials (warehouses), and the movement of materials (transportation). As part of the coordination, an analyst must consider product and process designs as well as information flows between various players in the networks. These elements form the basis of this course. The two main objectives of this course are to help students understand: (1) the fundamental concepts and techniques necessary for attaining a world class performance in supply chain management and (2) how these concepts and techniques can be applied to design, plan and operate supply chains supporting military operations.

Prerequisite: GE3042.

IO

IO0001 - Seminar Series in IO Topics (0 - 2)

Seminar lectures in Information Operations. Prerequisite: None.

IO0810 - Information Operations Thesis Research (0 - 8)

Information Operations thesis research

IO3100 - Information Operations (4 - 0)

This course, available in the classroom or through asynchronous Internet-based education, provides a survey of Information Operations (IO) along the time line of peace, to conflict, and back to the cessation of hostilities. Students study the specific methods and elements of IO and how they integrate with other elements of national power to meet national security objectives. Prerequisites: None.

IO4300 - Planning and Execution of Military Operations in the Information Environment (3 - 2)

This course refines the students' ability to develop and

analyze Information Operations plans. Students learn to integrate seemingly disparate disciplines (national security affairs, information warfare/operations, computer science, physics (kinetic warfare), and operations analysis) into a cogent operations plan as an integral part of a theater campaign plan. US only with SECRET clearance.

Prerequisite: NW3230, IW3101, OS3000. Security Clearance Required: Secret.

IS

IS0001 - Seminar Sessions (0 - 2)

Seminar Sessions in Information Systems for IST Students. Prerequisite: None.

IS0123 - Computer Skills Development I (0 - 2)

(No credit) (Accelerated first 6 weeks of quarter.) An introduction to the use and operation of microcomputers with emphasis on hardware basics, the operating system, and word processing. Emphasis on applications in systems management. Graded on Pass/Fail only.

IS0810 - Thesis Research (0 - 8)

Thesis research time for IST Students. Prerequisite: None.

IS3001 - Information Sciences for Defense (3 - 0)

The purpose of this course is to introduce first quarter students from the Information Systems and Technology and the Joint C4I curricula to an overview of the information environment in the Department of Defense. During this quarter students will be exposed to the tactical and business systems, technologies, organization, culture, policies and issues regarding the acquisition, operations and management of technology. Specific topics include the DoD information environment, enterprise architecture and systems, systems development polices and processes as well as critical issues of security, privacy and issues of identity. Prerequisites: None.

IS3181 - Integrating and Leveraging Information Technologies (3 - 0)

The attributes of information technology are studied in conjunction with the management aspects of developing and maintaining systems in support for DoN and the Joint Services. This course is heavily project and case study oriented. Mini-cases force the student to apply theory from reading to realistic DoN settings. These case studies will force tradeoff, resource allocation decisions, development of strategy for specific problems, etc. PREREQUISITE: Lead Program Students Only.

IS3200 - Enterprise Systems Analysis and Design (3 - 2)

This course covers the concepts, models, and processes used by enterprise systems analysts to determine: 1) The current situation of an organization that desires to improve itself; 2) The problems and opportunities in this situation; and 3) The plans and specifications that can be formed to feasibly address these problems or opportunities. The course covers how enterprise -level system analysis is performed to successfully define and develop systems requirements how to apply these to system design. Additionally, the fundamentals of information system design are discussed and applied. The overall goal for the course is for the students to understand the system development life cycle, system analysis and design methodologies, and have applied them in a team project within the class. Prerequisites: None.

IS3201 - Enterprise Database Management Systems (4 - 2)

Enterprise database management systems are the core of all information systems capabilities. The course provides the foundational knowledge, language, and capabilities to create, operate and manage enterprise-level data management systems. Students will learn the essential activities of how to store, retrieve, manage, and control data using a relational database management system. They not only will learn how to build a database application using modern database tools, and but also how to deploy database technology in a larger, organizational context to support problem solving. Further, by the time students have completed the course, they will understand the major steps required to manage complex database projects. Prerequisites: None.

IS3202 - Thin-Client Database Systems Development (4 - 2)

At the core of modem information systems is the ability for remote users to gain access to centralized data management services. This course is designed to familiarize students with the various approaches for developing database-driven, interactive, dynamic capabilities for accessing data through thin-client systems. These approaches include client-side scripting using Java scripts; server-side scripting using Active Server Pages; and Extensible Markup Language (XML) technologies. An integrated development environment is used throughout the course to demonstrate the application of these approaches. Students are expected to develop a fully functional, dynamic capability using the approaches/technologies learned in class.

Prerequisite: IS3200, IS3201, or permission from the instructor.

IS3210 - Information and Knowledge Management Issues in Defense (4 - 0)

This elective course on defense knowledge & information management integrates theory with practice to help prepare current and future leaders to leverage knowledge and knowing for competitive advantage in learning organizations. Knowing refers to knowledge in action and is concerned with activities (e.g., decisions, behaviors, work) in the organization. Using emerging knowledge-flow theory as its intellectual base, the theoretical part of the course helps professionals understand: how knowledge is both critical and unique; how it builds and depends upon information; and how to design effective work processes, organizations and technologies around dynamic knowledge and information. Using application cases for group critique, the problem-based learning part of the course examines a diverse set of knowledge-based processes and organizations in operation today, and it offers both principles for and experience in identifying strengths and weaknesses. Students also select new or operational knowledge-based processes for evaluation, and work individually as consultants to assess and redesign them around knowledge flows. This course may be offered as an online course. This course may be offered as an online course. You can view more details at the NPS online Web site. Prerequisite: None.

IS3301 - Computer-Based Tools for Decision Support (3 - 2)

This course introduces the principles for designing, implementing and using computer-based tools to support a variety of decision-making situations. A key objective of the course is to introduce managerial decision-making technology in a format that is not too abstract or too mathematical. We cover a variety of analytical techniques for decision making in complex environments, involving single or multiple criteria made under certainty and uncertainty. Students learn the difference between building "private" models and "public" models and are introduced to software engineering practices for engineering quality models. Exemplary computer-based applications that support or involve the use of formal decision making methods and tools are discussed. Group projects will supplement and reinforce the course's learning objectives.

Prerequisite: IS3200, IS3201.

IS3302 - Database Management for Decision Support (3 - 2)

Database management systems that support decision making constitute essential components of information-driven organizations. These systems are employed in a wide array of activities, ranging from combat support to logistics and administration. This course covers the essential aspects of database management systems and their role in supporting decision making. The course is a hands-on, technically oriented course that provides students with an understanding of conceptual database management techniques as well as the application using decision support tools. This course is intended for students in the ISO (356) and IC4I (365) curricula. Prerequisite: None.

IS3330 - Research Methods for Information Sciences (3 - 0)

The purpose of this course is to provide an overview of research design for research in the Information Sciences (IS) field. This overview consists of understanding the preliminary considerations that go into selecting a qualitative, quantitative, or mixed methods research design. These include knowing the definition for these different approaches, considering philosophical worldviews, reviewing the literature, understanding the use of theory, anticipating ethical issues, and developing writing strategies. We will discuss the process of research as it relates to each approach in IS research. This process includes writing an introduction, specifying a purpose statement, and developing research questions and/or hypotheses. This course will focus on the methods and procedures for quantitative, qualitative, and mixed methods studies. In this course, the following objectives will be emphasized: I. Develop an understanding of the basic characteristics of qualitative and quantitative methods research and the differences among these approaches. 2. Be able to discuss the major philosophical worldviews related to research. 3. Define the major strategies of inquiry used in qualitative and quantitative methods research. 4. Learn how to search the research literature on a topic of interest. 5. Understand the role of literature and theory in qualitative, quantitative, and mixed methods research. 6. Develop writing strategies for qualitative and quantitative methods research proposals and reports. 7. Anticipate ethical issues related to research. 8. Understand the elements that comprise a good introduction to an IS research study. 9. Be able to write a purpose statement for qualitative, quantitative, or mixed methods research. 10. Develop research questions and or hypotheses for qualitative and quantitative methods research. 11. Understand the procedures involved in developing quantitative and qualitative methods research plans. Prerequisites: None

IS3333 - Thesis Research for Information Sciences (2 - 0)

Introduction to the thesis research process and requirements for IS Department Students.

IS3450 - RF and EW Concepts in Networked Systems (4 - 0)

This course is a non-engineering overview of Radio Frequency (RF) Communications concepts used in networked communications systems. It covers RF signaling

terminology and basic RF theories by examining in-depth subject areas like: 1. RF Waveforms, 2. Fourier transforms, 3. data rates and bandwidth, 4. antennas, and 5. RF atmospheric limitations. Additionally, the course discusses how RF is used in several modern communications systems, such as 1. Link 16, 2. Wireless LANS, 3. Cell phone systems (GSM and LTE), 4. Satellite communications (SATCOM). Prerequisites: None.

IS3460 - Networked Autonomous and Unmanned Systems (4 - 0)

This unclassified course examines autonomous and unmanned systems and platforms from a systems and operational perspective. Historical and modern systems are discussed to include Industrial Control Systems, botnets, UxVs, etc. The nature of autonomy versus unmanned systems is examined. Opportunities and security issues presented by the growing dependence upon these systems and platforms are studied. The ethics of using unmanned and autonomous platforms and systems for warfare is examined, along with the ethics of attacking such systems when integrated into society. Operational applications within the private and public sectors, as well as the military, are discussed. Current and future research into autonomy is examined. Prerequisites: None.

IS3502 - Network Operations I (4 - 2)

This course introduces the basics of network operations. Topics covered include but are not limited to configuring and managing networks, routers, and servers (file, e-mail, web, DNS, printer, etc.); network monitoring and traffic analysis; storage and bandwidth allocation; quality of service, performance monitoring and analysis; deploying and managing firewalls and malware/intrusion detection/prevention systems; configuring access controls; managing and retaining logs; setting up VPNs and secure connections; business continuity and disaster recovery planning; managing software patches; and network policy and compliance. Prerequisites: None.

IS3504 - Modern Network Operating Systems: Windows 2003 Server (3 - 2)

This course focuses on the planning, design, installation, configuration and management of network operating systems used throughout DoD and private industry. Network operating systems are compared with single user operating systems to understand differences and similarities. Popular client/server and peer-to-peer systems are examined to provide a thorough understanding of the correct applications of each. Network labs provide in-depth analysis of such topics as file server configuration and administration, multi-level network security procedures and global file server synchronization processes.

Prerequisite: IS3502.

IS3710 - Identity Management Operations (3 - 0)

This course will integrate theory with practice to help prepare students with ways of thinking about how to leverage Identity for competitive advantage in operational environments. The focus of this course is on the design architecture for integrated systems which will allow for the collection, analysis, storage, and dissemination of information related to the identity of a person. This course is one of several that will collectively comprise the requirements for Identity Management specialization tracks in both the Information Science and Computer Science degree programs. Completion of four courses: CS3686, CS3699, IS3710, and IS3720, will meet the requirements for earning the Federal/DoD Identity Management Certificate offered by NPS. Prerequisites: None.

IS3720 - Identity Management Policy (3 - 0)

The goals for the Identity Management Policy Course are to provide the student with the necessary ways to think about the creation or implementation of Identity Management policies. The focus is to provide students with a background on the approaches to the verification of personal identity and the implications in a digital environment. As individuals become more conscious of the collection of data regarding their actions, the student must understand the implications of privacy in this changing environment. There will be a strong, case-based focus on the laws, ethics, and moral implications of the collection, analysis, storage, and dissemination of personal data so that the student can prudently apply the appropriate policy. Additionally, the policies and procedures for the provisioning, propagating, maintaining, and removal of personally identifiable information will be discussed. The student will be required to develop a case study for a scenario that will address the policy implications and create a solution to meet the operational requirements. Prerequisite: None.

IS4010 - Technology in Homeland Security (4 - 0)

Offered through the Center for Homeland Defense and Security. In today's Information Age, Homeland Security professionals and the agencies they lead are more dependent than ever on technology to strengthen national preparedness. The need to detect particular threats, communicate, create and transfer information and knowledge through the use of interoperable technologies in real-time has become even more critical to our national security. This course provides Homeland Security professionals with the requisite knowledge and critical thinking skills to better understand, analyze, select, implement, and use technology within and among Homeland Security organizations. This course is open to Homeland Security Students Only.

IS4031 - Economic Evaluation for Enterprise Technology Investments (4 - 0)

The objectives of this course are to provide the student with the tools and methodologies that will allow for the objective economic evaluation of enterprise information systems from a business perspective. The course will focus on the alignment of IT investment to strategic goals and productivity, the methods of obtaining IT services through outsourcing, and the importance of managing to the needs of the enterprise. Included in this course are the components for creating a Defense Business Case, options theory/real options and market comparables. The goal is for the students to be able to include critical economic factors into IT investment decision-making. Prerequisite: None.

IS4053 - Spectral and Polarimetric Tools and Analysis Techniques (3 - 2)

Analysis of multi-dimensional data sets, from multispectral and optical polarimetric imaging systems. Nature of spectral data, analysis methods with application to military and civil problems. Primary focus is on the use of statistical techniques (spectral imaging). Basic theory of optical polarimetric imaging and analysis.

Prerequisite: PH3052.

IS4056 - Geographic Information Systems (3 - 2)

Theory and application of geographic information systems. Topics include spatial data models, map projections, data fusion, satellite surveying, spatial query and analysis, and cartographic principles. Application of GIS to decision making processes and the solution of current real-world problems. Prerequisites: None.

IS4182 - Enterprise Information Systems Strategy and Policy (4 - 0)

Enterprise Information Systems Strategy and Policy: How to Be an Effective CIO or IT Strategist. This course aims to make students fluent in architecture-based decision making for enterprise systems strategy and policy. Students should become capable of significantly enhancing the prospects of an enterprise through effective, strategic use of IT architecture. The student should be capable of suggesting significant improvements in existing or proposed architectures, demonstrating both analysis and synthesis skills. Topics include: the enterprise and extended enterprise; information processing for competitive superiority; technology evolution and adaptive stresses; the role of the era; information systems architecture and enterprise architecture; architecting; U.S. Government architecture efforts; 000 imperatives; information superiority; network-centric warfare; and architecture synthesis and evaluation. Prerequisite: None.

IS4188 - Collaborative Technologies (4 - 1)

Collaborative technologies and multiple agent decision support architectures become the central application elements of emerging Global Information Grid, FORCEnet, DARPA NICCI and other sensor-decision maker networking initiatives. The first part of the course is based on the analysis of collaboration in different human organizations and the requirements to agent-based decision support architecture. The second part of the course is focused on studies of intelligent agents and multiple agent architecture From the beginning of the course students are involved in the hands-on practice with wireless collaborative environments including GPS units, pocket PCs, laptops, and other devices . We start with using peer-to-peer Groove collaborative tool and NPS agents-facilitators. We later move on to several demonstrations including client-server GENOA system implementation for Homeland Security and PACOM POST virtual meetings via the Lotus Same Place System. Prerequisites: None.

IS4201 - Enterprise Database Development (4 - 2)

An elective course that will focus on the technological infrastructure as well as the management processes related to the operations and maintenance of enterprise data management systems.

Prerequisite: IS3201.

IS4205 - Big Data Management, Architecture, and Applications (3 - 2)

This course is designed to provide students with a comprehensive knowledge and understanding of Big Data management, architecture, and applications. It begins by describing what is Big Data, its importance to DoD/DoN, and the need for a Big Data platform for facilitating scalable management and processing of vast quantities of data. The course then describes the architecture of a Big Data platform at both the hardware and system software level. This is followed by describing an end-to-end application architecture required to realize a big data solution. The remainder of the course focuses on learning how to perform critical analyses and visualizations with emphasis on Big Data problems faced by DoD/DoN. The course concludes with an overview of Big Data non-functional requirements and deployment issues as well as a presentation of Big Data case studies. Labs are used throughout the course to reinforce the concepts presented.

Prerequisite: IS3200, IS3201.

IS4210 - Knowledge Superiority (3 - 0)

This elective course on knowledge superiority integrates theory with practice to help prepare current and future leaders to leverage knowledge and knowing for competitive advantage in learning organizations. Knowing refers to knowledge in action, and is concerned with activities (e.g., decision, behaviors, work) in the

organization. Using emerging knowledge-flow theory as its intellectual base, the theoretical part of the course helps professionals understand how knowledge is both critical and unique, and equips them to design effective work processes, organizations and technologies around knowledge flows. Using real-time cases for group critique, the problem-based learning part of the course examines a diverse set of knowledge-based processes and organizations in operation today, and offers both principles for and experience in identifying strengths and weaknesses. Students also select new or operational knowledge-based processes for evaluation, and work individually as consultants to assess and redesign them around on knowledge flows. This course may be offered as an online course. You can view more details at the NPS web site.

Prerequisite: IS3210 or equivalent (with instructor permission).

IS4220 - Technology Enabled Process Improvement (3 - 2)

The focus of this class is on practical application of Business Process Reengineering (BPR), lean six sigma (L6S) and TQL principles to enable innovative redesigns of core defense processes. These tools are principles that define a set of heuristics or "rules-of-thumb" that help the analyst accomplish the transformational goals required in dramatically changing core processes to create greater value. The course makes use of process analysis and measurement methodologies to ensure productivity increases as a result of the process redesigns. The students will define an existing process, model it in simulation software and analyze the current state. Then through the application of learned principles, demonstrate the application of IT to the process and compare the before and after to determine impact.

Prerequisite: IS3200 and IS4031, or consent of the instructor.

IS4300 - Project Management for Enterprise Systems (3 - 2)

The objective of this course is to educate the student in areas of great concern to the DoD in the field of IT project management to include software engineering and risk management. The course examines both the technological tools of software production as well as the software engineering techniques for software project management. Software testing, metrics, and reliability are also covered. DoD software standards and metrics programs are included.

Prerequisite: CS3030 and IS3200 and OS3004.

IS4301 - Data Warehousing, Data Mining and Visualization (4 - 2)

This elective course is designed to provide graduate students with the concepts of data warehousing, data mining and visualization. This course emphasizes both technical and managerial issues and the implications of

these emerging technologies on those issues. This course has a distinctly "real-world" and DoD orientation that emphasizes application and implementation over design and development. A state of the art system/tool will be used to help students understand and apply the concepts in the class.

Prerequisite: IS3201, IS3301, and IS3200, or permission of instructor..

IS4505 - Wireless Networking (3 - 2)

This course is designed to introduce students to a broad range of wireless networking topics essential to understanding the IEEE STD 802.11, and related technologies and tasks necessary to install, manage and support wireless local area networks (WLAN). Upon successful completion of the course, students will be prepared to take the CWNA certificate examination if so desired. Students will gain knowledge of evolving RF/WiFi technologies, link budget planning, and OSI layer 1 and 2 networking architectures which are highly relevant and extensible to other networking domains. The course's coverage of networking principles (i.e. PHY/MAC layer frames, packets and POE) and electrical engineering (i.e., RF math, signal, antenna concepts, and link budget analyses) nicely complement the CS/EO prerequisites. The course also introduces students to a variety of emerging tactical wireless technologies and RF planning tools currently fielded by the joint force. Prerequisites: IS/CS3502. EO3502 and IW3450 are excellent precursor courses, but they are not required.

Prerequisite: IS3502 or CS3502 and EO3502 or IW3450 or consent of instructor..

IS4520 - Systems Thinking and Modeling for a complex World (4 - 0)

This course introduces system dynamics modeling for the analysis of organizational policy and strategy. Students will learn to visualize an organization in terms of the structures and policies that create dynamics and regulate performance. The goal is to use the analysis and modeling techniques of system dynamics to improve their understanding of how complex organizational structures drive organizational performance, and then to use that understanding to design high-leverage interventions to achieve organizational goals. We use computer-based simulations to model long-term side effects of decisions, systematically explore new strategies, and develop our understanding of complex systems (analogous to the "flight simulators" that pilots use to learn about the dynamics of flying an aircraft). Prerequisites: None.

IS4550 - Internet Appliances and ME Centric Computing (3 - 2)

In the next decade, computing as we know it will be radically transformed around highly personalized devices that know their users, know how to get work done, and can interact with billions of devices and services over the

Internet. Computing empires built up on traditional OSI 7-level stacks will lose their preeminence. In the emerging new world of Internet appliances, the center of the universe will become the individual, and products will be built around knowledge of how to serve that user. Billions more people will gain access to computing power this way, and our daily experience will shift from endless efforts to tame incomprehensible software products to being masters of a universe of appliances and services that aim to please. This transition is inevitable, because hyper-complex technology isn't welcomed or assimilated fast enough, and pressures exist to find better paths to market. The clear path for powerful technology is to reach many more customers through a radical simplification of what customers must do to employ it. This revolution is underway now, and it will fundamentally alter the landscape for IT, IT management, and strategic uses of technology. The course will look into various technologies including personalization, web services, wireless communications, Internet (including IP v. 6), and identity services that are driving the changes. Student projects will create Me-Centric innovations pertinent to their domains of interest. Prerequisites: None.

IS4700 - Introduction to the Philosophy of Science (3 - 2)

This course is designed to help prepare the prospective Ph.D. in Information Sciences (IS) candidate to engage in original research. The focus will be on understanding the underpinnings of doing science by studying the work of modern philosophers of science. The course will review the epistemologies (economic, behavioral, physics-based, and general systems based) serving as a scaffolding for the development of original theory development in the field of IS. The characteristic features of the received view, hypothetical-deductive formalism will be reviewed along with the modern challenges to this framework. The distinction between the instrumental-realist positions will be examined in light of its implications for theory development in IS. Students should understand the requirements for theory generation in terms of the underlying assumptions of given epistemic perspectives as a result of taking this course. Prerequisites: None.

IS4710 - Qualitative Methods for Research (3 - 2)

This course explores qualitative research methods. Quantitative research methods are powerful, but not all research questions and settings are amenable to these methods. Research problems that may be better suited to investigation through qualitative research methods include; early stage exploratory research, how and why questions, studies in which the phenomena of interest are intertwined with their contexts (e.g., where people, technology and organizations interact), investigations of individual and small-group behaviors (e.g., leaders, project teams, user groups), understanding rare and idiosyncratic events (e.g., catastrophes, new technology introductions,

organizational changes), and research in which potential sample sizes are small, or measures cannot be operationalized practically. In this course, you will learn to recognize when qualitative research methods are appropriate. You will learn how to design and assess qualitative research. You will be exposed to a variety of qualitative research approaches including, ethnography, grounded theory, and case analysis. You will gain theoretical and experiential knowledge of how to use qualitative research methods.

Prerequisite: IS4700.

IS4720 - Quantitative Methods for Research (3 - 2)

This course equips Information Science doctoral students with the quantitative methods necessary to support dissertation research, using real-world project data and case studies. Topics include: defining research objectives, formulating and testing hypotheses, designing experiments, developing analytic and simulation models, collecting data, analyzing data, validating models, using quantitative software tools, and presenting results in written and oral reports. Prerequisites: None.

IS4730 - Design of Experiments for Research (3 - 2)

Design of Experiments for PhD Students.

Prerequisite: IS4700, IS4710, IS4720.

IS4790 - Research Seminar for Ph.D. Students (0 - 3)

Research seminar class for IS Ph.D. program.

IS4800 - Directed Study in Information Sciences (V - V)

Directed study of selected areas of information science to meet the needs of the individual student. Intended primarily to permit students to pursue in-depth subjects not fully covered in formal class work or thesis research. Grading on Pass/Fail basis or standard grading criteria are both available.

Prerequisite: Consent of instructor and department chairman.

IS4925 - Special Topics in Information Systems (V - V)

Special topics courses are first-run courses that are intended to gauge student response and interest. Once a course has run once, if successful, it will be submitted to the academic council for final approval.

IS4926 - Network Operating Centers (3 - 2)

The course provides analytical background for implementing telecommunications management systems and integrating management infrastructure into the information grid design. It targets operations support for GIG, terrestrial, satellite, and mobile wireless network operation centers. The course combines classroom activities with research and design experience in telecommunication networks configuration, fault, and

performance management. In the center of analytical work is the project-based study of management functions and information models for SNMP MIBs, TMN, and architectures. The advanced study issues include an introduction to knowledge-based management and intelligent agent technology. The applications target the needs of GIG operations, C4ISR networks management, Joint Experimentation, Fusion Centers, and Network Operation Centers environment. They employ features of LAN/WAN networks, ATM networks, PCS networks, satellite/wireless networks, UAV, HALO, and other platforms. During the course work, students will gain basic knowledge of several commercial telecommunications management systems used by the NOCs: Spectrum, HP Open View, Tivoli, Unicenter TNG, Micro Muse, etc. The classroom, studies, and projects teamwork are facilitated by the on-line distributed learning and shared electronic workspace environment.

Prerequisite: IS3502, or consent of instructor..

IS4927 - Special Topics in Information Systems (V - V)

Special topics courses are first run courses that are intended to gauge student response and interest. After a course has run once, if successful, it will be submitted to the academic council for final approval. Prerequisite: None.

IS5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

IS5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council. Prerequisite: Advancement to Candidacy.

C000

ISCS01 - Elective Course Required (V - 0)

REQUIRED ELECTIVE COURSE, TO BE SELECTED PRIOR TO START OF QUARTER. MAY BE IS OR CS COURSE, APPROVED BY THE ACADEMIC ASSOCIATE.

IT

IT1500 - Informational Program Seminar for International Officers (4 - 0)

Provides International students with an awareness and functional understanding of internationally recognized human rights and the American democratic way of life. Areas of emphasis introduced during the seminar include civil-military relations, human rights, relationships in a democratic society, and a comparative look at the U.S. free enterprise system.

IT1600 - Communication Skills for International Officers (3 - 0)

A first-quarter course that provides the opportunity to enhance English speaking and listening skills for professional and academic environments through exercises, group discussions, and instructional briefings on a variety of subjects. The course addresses pronunciation, fluency, idiomatic usage, cultural conventions, and language functions by incorporating texts, videos, and realia to improve collaborative interaction. Building reading and writing skills is part of the course but not the main focus. Enrollment for students who are required to take the TOEFL for admission to NPS is determined by individual interviews conducted during Orientation Week. Graded pass/fail.

IT1700 - Academic Writing for International Officers (3 - 0)

Prepares international students for the task of writing research papers and/or a thesis for an American institution of higher-education. A vigorous dedication to the writing process (pre-writing, writing, revision, and proofing) is required. The course covers the rhetorical considerations and styles of academic writing by examining appropriate organization, content, audience consideration, voice, and source citation in anticipation of degree coursework. Analysis and discussion of sample articles and essays from a variety of sources are important elements supporting skills development. Students should expect to devote up to six (6) non-instruction hours each week for completing assignments. This course is required for students with TOEFL writing scores lower than 23 (others can be considered on a case-by-case basis) and must be completed before thesis writing commences. Graded pass/fail.

IW

IW0810 - Thesis Research for IW Students (0 - 8)

Thesis research work for IW students. Prerequisite: None.

IW3101 - Military Operations in the Information Environment (4 - 0)

This course provides a survey of military operations in the information environment along the time line of peace, to conflict, and back to cessation of hostilities. This is

accomplished by studying the theoretical underpinnings and implementation of military actions in the information environment to influence decisions in both the biological domain (human) and non-biological/cyber domain (hardware, software and spectra). Topics include but are not limited to military-civilian relationships, human cognition and decision-making, social influence, cyberspace operations, C2 structures, legal issues and considerations in IO, the joint planning process, and intelligence support to IO. Prerequisite: None. Classification: None.

IW3921 - Non-Kinetic Warfare (3 - 0)

This course explores the complex nature of engaging targets in the information environment. Emphasis is on the myriad disciplines involved in using information systems as weapons systems and information as projectiles. Using the framework of joint fires and targeting processes students will develop an understanding of how to engage an opponent through the use of information related capabilities (IRCs) and networked computer and social systems to achieve effects in the physical domain. This course is conducted at the unclassified level utilizing open source information.

Prerequisite: IW3101 or IO3100..

IW4301 - Advanced Topics in Influence Modeling (4 - 0)

This course provides students the opportunity to develop an Influence Model and to use this model to conduct analysis in support of actual military requirements. Students will design, construct and analyze influence models in collaboration with fellow students. Work completed as part of this course may be included in one or more Naval Postgraduate School Technical Reports. Each project may be briefed to appropriate senior DoD leadership as well if deemed suitable for such briefings by the Instructor. Students must have access to a United States Government computer network and have access to "For Official Use Only" (FOUO) data. SECRET level work may be conducted as well by special arrangement with the Instructor.

IW4500 - Information Warfare Systems Engineering (3 - 2)

This course applies Systems Engineering Principles to design an Information Warfare System. Project teams will develop an Information Warfare System from requirements determination through and including preliminary design. The five pillars of Information Warfare will be used in the design process, including information security considerations. Lectures will discuss both Systems Engineering principles and Information Warfare concepts.

Prerequisite: IW3101.

IW4800 - Directed Study for IW Students (V - V)

Directed Study for IW/EW students. Credit hours are variable and must be chosen on a case by case basis.

IW4900 - Special Topics in Information Operations (V - V)

Special Topics in Information Operations. Credit hours are variable and will be assigned on a case by case basis.

IW4925 - Special topics in Information Warfare (V - V)

Special topics courses are first-run courses that are intended to gauge student response and interest. Once a course has run once, if successful, it will be submitted to the academic council for final approval.

IW4950 - Advanced Information Warfare Systems (3 - 2)

This course examines the use of modern Electronic Warfare (EW) systems in support of information warfare operations. Modern EW systems studied include IDECM, Towed FO decoys, AIEWS, MAWS, ASPJ, Advanced Standoff Jammers, Stand-in Jamming, DECM and Situational Awareness. Advanced topics including stealth, directed energy weapons, modern threats, GPS jamming, hard kill/soft kill interactions, MASINT and DRFM systems are discussed. The laboratory includes visits to EW manufacturers and invited lecturers on advanced topics. Prerequisites: None.

IW4960 - Advanced Information Warfare Systems (3 - 2)

The characteristics and performance of modern Electronic Warfare Systems are discussed. Course topics include: the Advanced Radar Threat, Architecture and Technology of EA systems, EA against modern radar systems, Noise and DECM EA systems, DDS and DRFMs, characteristics of modern ES systems, Expendables and Towed Decoys, Directed Energy systems and Stealth principles.

Prerequisite: EO4612 or consent of the instructor.

MA

MA0118 - Multivariable Calculus for Operations Research (4 - 0)

First-order linear differential equations, curves and surfaces, polar coordinates, vector algebra and calculus, functions of several independent variables, partial derivatives, Taylor series, chain rule, maxima and minima, directional derivatives and gradient, Lagrange multipliers, double integrals.

Prerequisite: MA1114.

MA0134 - Problem Solving Session for MA1113/4 (0 - 3)

Offered for no credit, pass/fail. Students must be concurrently enrolled in either MA1113 or MA1114, but

the course is not mandatory for either course.

MA0156 - Problem solving session for MA1115/6 (0 - 3)

Offered for no credit, pass/fail. Students must be concurrently enrolled in either MA1115 or MA1116, but the course is not mandatory for either course.

MA0810 - Thesis Research (0 - 8)

Every student conducting thesis research will enroll in this course.

MA1010 - Algebra and Trigonometry (V - 0)

Real number system, complex numbers, exponents and radicals, algebraic expressions and operations, linear and quadratic equations, inequalities, functions and graphs, polynomials and their zeros, rational functions, exponential and logarithmic functions, systems of equations, matrices, trigonometry and unit circles, trigonometric identities and functions. PREREQUISITE: None.

MA1025 - Introduction to Mathematical Reasoning (4 - 0)

An introductory course in logic and elementary discrete mathematics to be taken by students in Operations Research, Mathematics, and Computer Science. Considerable emphasis is placed on propositional and predicate logic, and on techniques of proof in mathematics. Mathematical topics include sets, functions, and relations. Coverage of combinatorics includes an introduction to permutations, combinations, the pigeon-hole principle, and the principle of inclusion/exclusion. No previous experience with this material is assumed. Prerequisite: None.

MA1112 - Single Variable Calculus I (4 - 0)

Review of analytic geometry and trigonometry, functions of one variable, limits, derivatives, continuity and differentiability; differentiation of algebraic, trigonometric, logarithmic and exponential functions with applications to maxima and minima, rates, differentials; product rule, quotient rule, chain rule; anti-derivatives, integrals and the fundamental theorem of calculus; definite integrals, areas. This course is the same as MA1113 except that it is taught at a slower pace at the rate of four hours per week for a full quarter.

Prerequisite: None.

MA1113 - Single Variable Calculus I (4 - 0)

Review of analytic geometry and trigonometry, functions of one variable, limits, derivatives, continuity and differentiability; differentiation of algebraic, trigonometric, logarithmic and exponential functions with applications to maxima and minima, rates, differentials; product rule, quotient rule, chain rule; anti-derivatives, integrals and the fundamental theorem of calculus; definite integrals, areas. Taught at the rate of nine hours per week for five weeks. Prerequisites: None.

MA1114 - Single Variable Calculus II with Matrix Algebra (4 - 0)

Topics in calculus include applications of integration, special techniques of integration, infinite series, convergence tests, and Taylor series. Matrix algebra topics covered are: the fundamental algebra of matrices including addition, multiplication of matrices, multiplication of a matrix by a constant and a column (vector) by a matrix; elementary matrices and inverses, together with the properties of these operations; solutions to mxn systems of linear algebraic equations using Gaussian elimination and the LU decomposition (without pivoting); determinants, properties of determinants; and a brief introduction to the arithmetic of complex numbers and DeMoivre's theorem. Taught at the rate of nine hours per week for five weeks.

Prerequisite: MA1113.

MA1115 - Multi Variable Calculus (4 - 0)

Vector algebra and calculus, directional derivative, gradient, polar coordinates and parametric equations, functions of several independent variables, limits, continuity, partial derivatives, chain rule, maxima and minima, double and triple integrals, cylindrical and spherical coordinate systems. Taught at the rate of nine hours per week for five weeks.

Prerequisite: MA1114.

MA1116 - Vector Calculus (3 - 0)

The calculus of vector fields; directional derivative, gradient, divergence, curl; potential fields; Green's, Stokes', and the divergence integral theorems. Applications in engineering and physics. Taught at the rate of seven hours per week for five weeks.

Prerequisite: MA1115.

MA1118 - Multivariable Calculus for Operations Research (4 - 0)

First-order linear differential equations, curves and surfaces, polar coordinates, vector algebra and calculus, functions of several independent variables, partial derivatives, Taylor series, chain rule, maxima and minima, directional derivatives and gradient, Lagrange multipliers, double integrals.

Prerequisite: MA1114.

MA1995 - Mathematics for Scientific Engineering I (5 - 1)

This course is taken concurrently with MA1996 (8 - 1). Descriptions of all topics in both courses are provided in this course description but half of these topics are taught in MA1996 (8 - 1). Precalculus review, complex numbers

and algebra, complex plane, DeMovire's Theorem, matrix algebra, LU decomposition, Cramer's rule, eigenvalues and eigenvectors. Limits and rates of change, derivatives, rules of differentiation, extreme values, indefinite integrals, vectors in the plane, definite integrals, applications and modeling physical problems, special functions, vectors in space, partial derivatives multiple integrals, integration in vector fields, extreme values, power series, first and second-order ordinary differential equations with applications. This course was designed for Engineering students. PREREQUISITE: None.

Prerequisite: None. Corequisite: MA1996 - Mathematics for Scientific Engineering II.

MA1996 - Mathematics for Scientific Engineering II (5 - 1)

This course is taken concurrently with MA1995 (8 - 1). Descriptions of all topics in both courses are provided in this course description but half of these topics are taught in MA1995 (8 - 1). Precalculus review, complex numbers and algebra, complex plane, DeMovire's Theorem, matrix algebra, LU decomposition, Cramer's rule, eigenvalues and eigenvectors. Limits and rates of change, derivatives, rules of differentiation, extreme values, indefinite integrals, vectors in the plane, definite integrals, applications and modeling physical problems, special functions, vectors in space, partial derivatives multiple integrals, integration in vector fields, extreme values, power series, first and second-order ordinary differential equations with applications. This course was designed for Engineering students. PREREQUISITE: None.

Prerequisite: None. Corequisite: MA1995 - Mathematics for Scientific Engineering I.

MA2025 - Bridge to Advanced Mathematics (4 - 1)

MA2025 is a first course in discrete mathematics for students of mathematics and computer science. Topics include propositional and predicate logic up to the deduction theorem, methods of mathematical proof, naive set theory, properties of functions and relations, mathematical induction, an introduction to divisibility and congruences, an introduction to
enumerative combinatorics, and an introduction to graphs and trees. Prerequisites: None.

MA2043 - Introduction to Matrix and Linear Algebra (4 - 0)

The fundamental algebra of vectors and matrices including addition, scaling, and multiplication. Block operations with vectors and matrices. Algorithms for computing the LU (Gauss) factorization of an MxN matrix, with pivoting. Matrix representation of systems of linear equations and their solution via the LU factorization. Basic properties of determinants. Matrix inverses. Linear transformations and change of basis. The four fundamental subspaces and the fundamental theorem of linear algebra. Introduction to eigenvalues and

eigenvectors.

Prerequisite: Students should have mathematical background at the level generally expected of someone with a B.S. in Engineering, i.e., familiarity with calculus and solid algebra skills. EC1010 (May be taken concurrently.).

MA2097 - Engineering Mathematics III (4 - 0)

The course content includes: Ordinary differential equations, i.e., linear and nonlinear (first order) equations, homogeneous and non-homogeneous equations, linear independence of solutions, power series solutions, systems of differential equations, Laplace and Fourier transforms, as well as the fundamental algebra of vectors and matrices including addition, scaling, and multiplication. Block operations with vectors and matrices. Algorithms for computing the LU (Gauss) factorization of an MxN matrix, with pivoting. Matrix representation of systems of linear equations and their solution via the LU factorization. Basic properties of determinants. Matrix inverses. Linear transformations and change of basis. The four fundamental subspaces and the fundamental theorem of linear algebra. Introduction to eigenvalues and eigenvectors. And Singular Value Decomposition. Prerequisites: MA1996 or equivalent.

Prerequisite: MA1996.

MA2121 - Differential Equations (4 - 0)

Ordinary differential equations: linear and nonlinear (first order) equations, homogeneous and non-homogeneous equations, linear independence of solutions, power series solutions, systems of differential equations, Laplace transforms. Applications include radioactive decay, elementary mechanics, mechanical and electrical oscillators, forced oscillations and resonance.

Prerequisite: MA1114.

MA2300 - Mathematics for Management (5 - 0)

Mathematical basis for modern managerial tools and techniques. Elements of functions and algebra; differential calculus of single- and multi-variable functions; integration (anti-differentiation) of single-variable functions. Applications of the derivative to rates of change, curve sketching, and optimization, including the method of Lagrange multipliers.

Prerequisite: College algebra.

MA3025 - Logic and Discrete Mathematics II (4 - 1)

Provides a rigorous foundation in logic and elementary discrete mathematics to students of mathematics and computer science. Topics from logic include modeling English propositions, propositional calculus, quantification, and elementary predicate calculus. Additional mathematical topics include elements of set theory, mathematical induction, relations and functions, and elements of number theory.

Prerequisite: MA2025 (preferable) or MA1025.

MA3030 - Introduction to Combinatorics and Its Applications (4 - 1)

Provides a thorough grounding in elementary combinatorics and its applications to computer science and discrete probability theory to students of computer science who concurrently take MA3025, Logic and Discrete Mathematics. Topics from combinatories include fundamental counting rules, binomial and multinomial theorems, the pigeonhole and inclusion/exclusion principles, and homogeneous recurrence relations. Elementary discrete probability is covered, up to the expectation of a discrete random variable.

Corequisite: MA3025.

MA3042 - Linear Algebra (4 - 0)

Finite-dimensional vector spaces, linear dependence, basis and dimension, change of basis. Linear transformations and similarity. Scalar product, inner product spaces. Orthogonal subspaces and least squares. LU (with pivoting), Cholesky, and QR factorizations. Eigenvalues/eigenvectors, diagonalization. Hermitian matrices, quadratic forms, definite matrices. Vector and matrix norms, orthogonal transformations, condition numbers.

Prerequisite: MA1114.

MA3046 - Matrix Analysis (4 - 1)

This course provides students in the engineering and physical sciences curricula with an applications-oriented coverage of major topics of matrix and linear algebra. Matrix factorizations (LU, QR, Cholesky), the Singular Value Decomposition, eigenvalues and eigenvectors, the Schur form, subspace computations, structured matrices. Understanding of practical computational issues such as stability, conditioning, complexity, and the development of practical algorithms.

Prerequisite: MA2043 and EC1010.

MA3110 - Intermediate Analysis (4 - 0)

Multi-variable calculus integrated with linear algebra. Functions of several variables, continuous transformations, Jacobians, chain rule, implicit function theorem, inverse function theorem, extreme, optimization and Lagrange multiplier technique. Applications in Operations Research.

Prerequisite: MA1115 and MA3042.

MA3132 - Partial Differential Equations and Integral Transforms (4 - 0)

Solution of boundary value problems by separation of variables; Sturm-Liouville problems; Fourier and Bessel series solutions, Fourier transforms; classification of second-order equations; applications, method of characteristics. Applications to engineering and physical science. Satisfies the ESR in differential equations for the Applied Mathematics program.

Prerequisite: MA2121 and MA1116.

MA3139 - Fourier Analysis and Partial Differential Equations (4 - 0)

Fourier series; solution of the one and two-dimensional wave equations, D'Alembert's solution, frequency and time domain interpretations; Fourier integral transforms and applications to ordinary and partial differential equations and linear systems; Convolution theorems. Course covers basic material essential for signal processing, filtering, transmission, waveguides, and other related problems. Applications include spectral analysis of electronic signals, e.g., radar or sonar. Designed for UW and EW/IW students.

Prerequisite: MA1115 and MA2121.

MA3185 - Tensor Analysis (3 - 0)

Definition and algebra of tensors. Dyadic representation in Cartesian and general components. Calculus of tensor fields in curvilinear coordinates. Derivation and application of the basic equations of heat conduction, rigid body mechanics, elasticity, fluid mechanics, electromagnetism, Newtonian and Einsteinian orbital mechanics.

Prerequisite: MA1116.

MA3232 - Numerical Analysis (4 - 0)

Provides the basic numerical tools for understanding more advanced numerical methods. Topics for the course include: Sources and Analysis of Computational Error, Solution of Nonlinear Equations, Interpolation and Other Techniques for Approximating Functions, Numerical Integration and Differentiation, Numerical Solution of Initial and Boundary Value Problems in Ordinary Differential Equations, and Influences of Hardware and Software.

Prerequisite: MA1115, MA2121 and ability to program in MATLAB and MAPLE.

MA3243 - Numerical Methods for Partial Differential Equations (4 - 1)

Course designed to familiarize the student with analytical techniques as well as classical finite difference techniques in the numerical solution of partial differential equations. In addition to learning applicable algorithms, the student will be required to do programming. Topics covered include: Implicit, Explicit, and Semi-Implicit methods in the solution of Elliptic and Parabolic PDE's, iterative methods for solving Elliptic PDEs (SOR, Gauss-Seidel, Jacobi), the Lax-Wendroff and Explicit methods in the solution of 1st and 2nd order Hyperbolic PDEs.

Prerequisite: MA3132 and the ability to program in a high level language such as Fortran, C, or MATLAB.

MA3261 - Basic Parallel Computation (3 - 0)

The course has two goals: First, to introduce fundamental issues such as shared vs. distributed memory, connection topologies, communication algorithms, speedup, efficiency, storage requirements, granularity, pipelining,

problem scaling, and useful paradigms for algorithm development. Second, to develop working proficiency by designing, implementing, and evaluating the performance of several parallel algorithms. These include, but are not limited to, numerical quadrature, matrix computations, sorting, network analysis, and dynamic programming.

Prerequisite: MA1115 or MA3025 and ability to program in a high-level language.

MA3301 - Linear Programming (4 - 0)

See OA3201 for course description and prerequisites.

MA3393 - Topics in Applied Mathematics (V - 0)

(Variable hours 1-0 to 4-0.) A selection of topics in applied mathematics. The course content varies and the credit varies. This course is intended to reflect study for the beginning graduate student in an area for which no formal course is taught. Credit for this course may be granted more than one time to an individual student.

Prerequisite: Consent of instructor.

MA3560 - Applied Modern Algebra and Number Theory (4 - 0)

This course is devoted to aspects of modern algebra and number theory that directly support applications, principally in communication. The algebraic emphasis is on ring and field theory, with special emphasis on the theory of finite fields, as well as those aspects of group theory that are important in the development of coding theory. Elements of number theory include congruences and factorization. Applications are drawn from topics of interest to DoN/DoD. These include error correcting codes and cryptography.

Prerequisite: MA3025.

MA3607 - Introduction to Real Analysis (4 - 0)

The objective of this course is for students to achieve a solid understanding of the basic concepts, analysis, and proofs in advanced calculus, including: limits, sequences, series, continuous functions, uniform convergence and uniform continuity, differentiation, and Riemann integration. This is a mathematics course in the pure sense. Proofs will be emphasized, and the student will learn how to reproduce, understand, create and enjoy mathematical proofs.

Prerequisite: MA1114.

MA3610 - Topology, Fractals, and Chaotic Dynamics (3 - 0)

An introductory course on chaotic dynamics systems and fractals. Topics covered include: flows on the line, bifurcations, linear systems, phase plane, limit cycles, the Lorenz equations, fractals, and one-dimensional maps. Applications include population growth, laser threshold, the pendulum, relaxation oscillations, and synchronized chaos.

Prerequisite: MA1115 and MA2121.

MA3677 - Theory of Functions of a Complex Variable (4 - 0)

Selected topics from the theory of functions of a complex variable; analytic functions, power series, Laurent series. Singularities of analytic functions; contour integration and residues; applications of residues to real integrals and Laplace transforms, zeros of analytic functions, infinite product representation for analytic functions; maximum modulus theorems for analytic and harmonic functions; conformal mapping. Applications include interference effects in optics and problems from heat flow and fluid flow.

Prerequisite: MA1115.

MA3730 - Theory of Numerical Computation (3 - 0)

Analysis of computational methods used for the solution of problems from the areas of algebraic equations, polynomial approximation, numerical differentiation and integration, and numerical solutions of ordinary differential equations.

Prerequisite: MA2121.

MA4026 - Combinatorial Mathematics (4 - 0)

Advanced techniques in enumerative combinatorics and an introduction to combinatorial structures. Topics include generating functions, recurrence relations, elements of Ramsey theory, theorems of Burnside and Polya, and balanced incomplete block designs. Application areas with DoD/DoN relevance range from mathematics to computer science and operations research, including applications in probability, game theory, network design, coding theory, and experimental design.

Prerequisite: MA3025.

MA4027 - Graph Theory and Applications (4 - 0)

Advanced topics in the theory of graphs and digraphs. Topics include graph coloring, Eulerian and Hamiltonian graphs, perfect graphs, matching and covering, tournaments, and networks. Application areas with DoD/DoN relevance range from mathematics to computer science and operations research, including applications to coding theory, searching and sorting, resource allocation, and network design.

Prerequisite: MA3025.

MA4103 - Thesis Topics Seminar (3 - 0)

Explores in depth discrete dynamical systems and the thesis topics of students enrolled in the Applied Mathematics degree program. Fulfills the ESR to provide students with the experience of organizing and presenting applied mathematical ideas to students and faculty, including a classroom environment. Graded on a Pass/Fail basis only.

Prerequisite: Consent of Instructor.

MA4237 - Advanced Topics in Numerical Analysis (V - 0)

(Variable credit, usually 4-0.) The subject matter will vary according to the abilities and interest of those enrolled. Applications of the subject matter to DoD/DoN are discussed.

Prerequisite: Consent of Instructor.

MA4242 - Numerical Solution of Ordinary Differential Equations (4 - 0)

Adams formulas, Runge-Kutta formulas, extrapolation methods, implicit formulas for stiff equations; convergence and stability, error estimation and control, order and stepsize selection, applications.

Prerequisite: MA3232.

MA4243 - Numerical Solution of Partial Differential Equations (3 - 1)

Finite difference methods for parabolic, elliptic, and hyperbolic equations, multi-grid methods; convergence and stability, error estimation and control, numerical solution of finite difference equations, applications.

Prerequisite: MA3132, MA3232 suggested.

MA4245 - Mathematical Foundations of Galerkin Methods (4 - 0)

Variational formulation of boundary value problems, finite element and boundary element approximations, types of elements, stability, eigenvalue problems.

Prerequisite: MA3132, MA3232 or equivalent.

MA4248 - Computational Linear Algebra (4 - 1)

Development of algorithms for matrix computations. Rounding errors and introduction to stability analysis. Stable algorithms for solving systems of linear equations, linear least squares problems and eigen problems. Iterative methods for linear systems. Structured problems from applications in various disciplines.

Prerequisite: MA3046, or consent of instructor, advanced MATLAB programming.

MA4261 - Distributed Scientific Computing (4 - 0)

General principles of parallel computing, parallel techniques and algorithms, solution of systems of linear equations, eigenvalues and singular value decomposition, domain decomposition and application (e.g., satellite orbit determination and shallow water fluid flow).

Prerequisite: MA3042 or MA3046, MA3132, and MA3232..

MA4301 - Nonlinear Programming (4 - 0)

See OA4201 for course description and prerequisites.

MA4302 - Design of Experiments (3 - 1)

See OA4101 for course description and prerequisites.

MA4303 - Regression Analysis (4 - 0)

See OA4102 for course description and prerequisites.

MA4304 - Time Series Analysis (4 - 0)

See OA4308 for course description and prerequisites.

MA4305 - Stochastic Models II (4 - 0)

Course objectives are to discuss methods of stochastic modeling beyond those taught in OA3301 and give students an opportunity to apply the methods. Topics include conditioning; renewal processes; renewal reward processes; length biased sampling; semi-Markov models, and novel queuing, reliability and maintenance models. The Topics are illustrated by DoD applications. This course also is offered as OA4301. Prerequisites: None.

MA4311 - Calculus of Variations (4 - 0)

First and second order tests, Lagrange multipliers, Euler-Lagrange equation, non-smooth solutions, optimization with constraints, Weierstrass condition, optimal control of ODE systems, Pontryagin maximum principle. Applications may include: control and dynamical systems, estimation, weak formulations, Hamilton's variational principle, or others depending on the interests of the students.

Prerequisite: MA2121.

MA4321 - Stability, Bifurcation and Chaos (3 - 0)

Differential equations and dynamical systems, equilibrium of autonomous systems, stability, Liapunov's method, examples of chaos, local bifurcations of vector fields and maps, chaotic dynamical systems.

Prerequisite: MA3610.

MA4322 - Principles and Techniques of Applied Mathematics I (4 - 0)

Selected topics from applied mathematics to include: Dimensional Analysis, Scaling, Stability and Bifurcation, Perturbation Methods- regular and singular with boundary layer analysis, as well as, asymptotic expansions of integrals, integrals equations, Green's functions of boundary value problems, and distribution theory.

Prerequisite: MA3042 and MA3132; MA3232 strongly recommended.

MA4323 - Principles and Techniques of Applied Mathematics II (4 - 0)

Continuation of MA4322. Selected topics include: calculus of variations, Hamiltonian Mechanics, distribution theory and Green's Functions in two and three dimensions, and discrete models.

Prerequisite: MA4322.

MA4332 - Partial Differential Equations (4 - 0)

This course provides an introduction to the theory of

partial differential equations. It includes the following topics: classification of second order equations; initial value and boundary value problems for hyperbolic, parabolic, and elliptic partial differential equations; existence and uniqueness of linear elliptic and parabolic PDEs; nonlinear parabolic and elliptic PDEs; Hamilton-Jacobi equations; systems of conservation laws and nonlinear wave equations; transform methods and Green's functions.

Prerequisite: MA3132, and MA3232 strongly recommended.

MA4335 - Linear and Nonlinear Waves (3 - 0)

Analysis of the two main classes of wave motion, hyperbolic waves and linear dispersive waves. Topics covered include: kinematic waves, shock waves, shock structure and shock fitting, Burger's equation, the wave equation, linear dispersive waves, wave patterns and water waves.

Prerequisite: MA3132.

MA4362 - Astrodynamics (3 - 0)

Review of the two-body problem. The effects of a third point mass and a distributed mass. Expansion of the disturbing potential in series of Legendre functions. Variation of parameter equations for osculating orbital elements. Perturbation and numerical solution techniques. Statistical orbit determination. Codes used by the military to maintain the catalog of artificial satellites and space debris.

Prerequisite: SS3500 or equivalent.

MA4372 - Integral Transforms (3 - 0)

The Laplace, Fourier and Hankel transforms and their inversions; Asymptotic behavior. Applications to problems in engineering and physics.

Prerequisite: MA3132.

MA4377 - Asymptotic and Perturbation Methods I (4 - 0)

Advanced course in the application of approximate methods to the study of integrals and differential equations arising in physical problems. Topics covered include: asymptotic sequences and expansions, integrals of a real variable, contour integrals, limit process expansions applied to ordinary differential equations, multiple variable expansion procedures and applications to partial differential equations.

Prerequisite: MA3132.

MA4378 - Asymptotic and Perturbation Methods II (3 - 0)

Continuation of MA4377.

Prerequisite: MA4377.

MA4391 - Analytical Methods for Fluid Dynamics (4 - 0)

The basic fluid dynamic equations will be derived, and a variety of analytical methods will be applied to problems in viscous flow, potential flow, boundary layers, and turbulence. Applications in aeronautics will be discussed.

Prerequisite: MA3132 or MA3139.

MA4392 - Numerical Methods for Fluid Dynamics (4 - 0)

Numerical methods exclusively will be applied to fluid dynamics problems in viscous flow, potential flow, boundary layers, and turbulence. Applications in aeronautics will be discussed.

Prerequisite: MA3232 and MA4391.

MA4393 - Topics in Applied Mathematics (V - V)

A selection of topics in applied mathematics. The course content varies but applications of interest to the DoN/DoD will be discussed. Credit may be granted for taking this course more than once. Variable credits.

Prerequisite: Consent of Instructor.

MA4400 - Cooperation and Competition (4 - 0)

The course will develop game theoretic concepts in evaluations of the importance of players in bargaining situations and of elements in networks. Topics covered include cooperative and noncooperative games, bargaining, the Shapley Value, and coalitions. The course will study applications to military problems and applications to economics, political science, and biology. There will be extensive reading from the literature.

Prerequisite: MA3042, OA3201, and an introductory course in probability.

MA4404 - Structure and Analysis of Complex Networks (4 - 0)

The course focuses on the emerging science of complex networks and their applications, through an introduction to techniques and models for understanding and predicting their behavior. The topics discussed will be building mainly on graph theory concepts, and they will address the mathematics of networks, their applications to computer networks and social networks, and their use in research. The students will learn the fundamentals of dynamically evolving complex networks, study current research in the field, and apply their knowledge in the analysis of real network systems through a final project. DoD applications include security of critical communication infrastructure.

Prerequisite: MA4027.

MA4494 - Topics in Network Science (4 - 0)

The course content varies and applications of interest to the DoN/DoD will be discussed. Credit may be granted for taking this course more than once. This course is designed to be used towards the Network Science Certificate program.

Prerequisite: Consent of Instructor.

MA4550 - Combinatorial and Cryptographic Properties of Boolean Functions (4 - 0)

The course will discuss the Fourier analysis of Boolean functions and the relevant combinatorics with an eye

toward cryptography and coding theory. Particular topics will include avalanche features of Boolean functions, correlation immunity and resiliency, bentness, trade-offs among cryptographic criteria and real-life applications in the designs of stream and block ciphers.

Prerequisite: MA3025 or a similar combinatorial/discrete mathematics course (and recommended, but not required, an introductory course in probability).

MA4560 - Coding and Information Theory (4 - 0)

Mathematical analysis of the codes used over communication channels is made. Techniques developed for efficient, reliable and secure communication are stressed. Effects of noise on information transmission are analyzed and techniques to combat their effects are developed. Linear codes, finite fields, single and multiple error-correcting codes are discussed. Codes have numerous applications for communication in the military, and these will be addressed.

Prerequisite: MA3560.

MA4565 - Advanced Modern Algebra (3 - 0)

A continuation of MA3560. Rings, ring homomorphism, integral domains and euclidean domains. Unique factorization rings, polynomial rings. Modules and ideals. Noetherian rings, Field extension and Galois theory.

Prerequisite: MA3560.

MA4570 - Cryptography - Foundations and Practice (4 - 1)

The methods of secret communication are addressed. Some simple cryptosystems are described and classical techniques of substitution and transposition are considered. The public-key cryptosystems, RSA, Discrete Logarithm and other schemes are introduced. Applications of cryptography and cryptanalysis.

Prerequisite: MA3560.

MA4593 - Topics in Algebra (3 - 0)

A selection of topics in algebra. Content of the course varies. Credit for taking the course more than once is allowed. Students may select a topic of interest to the DoN/DoD, so the course can support the MERs in a variety of curricula.

Prerequisite: MA3560.

MA4620 - Theory of Dynamical Systems (4 - 0)

This course provides an introduction to the theory of dynamical systems providing a basis for the analysis and design of systems in engineering and applied science. It includes the following topics: Second order linear systems; contraction mapping, existence and uniqueness of solutions; continuous dependence on initial conditions; comparison principle; Lyapunov stability theorems; LaSalle's theorem; linearization methods; nonautonomous systems; converse theorems; center manifold theorems; and stationary bifurcations of nonlinear systems.

Prerequisite: MA2121.

MA4635 - Functions of Real Variables I (3 - 0)

Semi-continuous functions, absolutely continuous functions, functions of bounded variation; classical Lebesgue measure and integration theory, convergence theorems and Lp spaces. Abstract measure and integration theory, signed measures, Radon-Nikodym theorem; Lebesgue decomposition and product measure; Daniell integrals and integral representation of linear functionals. Prerequisites: None.

MA4636 - Functions of Real Variables II (3 - 0)

Continuation of MA4635.

Prerequisite: MA4635.

MA4675 - Complex Analysis (4 - 0)

A continuation of MA3675, MA3676. Differential equations in the complex plane, transform methods, the Wiener-Hopf method, integral equations, discrete Fourier analysis.

Prerequisite: MA3677.

MA4693 - Topics in Analysis (3 - 0)

A selection of topics in analysis. Content of the course varies. Students will be allowed credit for taking the course more than once.

Prerequisite: Consent of Instructor.

MA5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

MA5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council. Prerequisite: Advancement to Candidacy.

R000

MAR125 - Introduction to Finite Mathematics (3 - 0)

(NO CREDIT) (Meets last 6 weeks of quarter.) An introduction to the elements of set theory and mathematical reasoning. Topics covered include: symbolic logic (propositional calculus, truth tables, predicates, and quantifiers); methods of proof (direct and indirect proof, mathematical induction, case analysis and counter examples); sets and set operations; relations and functions.

ME

ME0000 - Reactors/Mechanical Engineering Seminar (0 - 0)

Seminar to be taken the quarter prior to start of 571 Curriculum.

ME0810 - Thesis Research (0 - 8)

Every student conducting thesis research will enroll in this course.

ME0820 - Integrated Project (0 - 8)

Integrated Project

ME0951 - MAE Seminar (No Credit) (0 - 1)

Lectures on subjects of current interest are presented by NPS faculty and invited experts from other universities and government or industrial activities. All students must register for the Seminar every quarter.

ME1000 - Preparation for Professional Engineers Registration (3 - 0)

The course will cover the topics from the 8-hour Professional Examination given by the State of California for Professional Engineer. Discussion will involve applicable engineering techniques, including design and analysis of mechanical systems and components. Graded on Pass/Fail basis only.

Prerequisite: Prior passage of Fundamentals of Engineering (FE) Exam or consent of instructor.

ME1810 - Thesis Proposal Preparation (1 - 0)

The course is designed to support Mechanical and Aerospace Engineering students in their fourth quarter in the selection of a topic for thesis research culminating in the development of their thesis proposal. The course is given in the Pass/Fail mode, evaluated by the submission of an approved thesis proposal by the end of the quarter.

Prerequisite: MAE students in their fourth quarter or consent of Academic Associate..

ME2101 - Engineering Thermodynamics (4 - 2)

A comprehensive coverage of the fundamental concepts of classical thermodynamics. Behavior of real substances, units and thermodynamic properties. The laws of thermodynamics. Equations of state. Entropy and enthalpy, ideal and real processes. Thermodynamic analysis of common power and refrigeration cycles. Stoichiometric combustion basics.

Prerequisite: MA1115.

ME2201 - Introduction to Fluid Mechanics (3 - 2)

Properties of fluids, hydrostatics and stability of floating and submerged bodies. Fluid flow concepts and basic equations in steady flows: mass, momentum, and energy considerations. Dimensional analysis and dynamic similitude. Viscous effects and fluid resistance. Basic pipe flows, Moody Diagrams and losses in components.

Prerequisite: ME2503.

ME2501 - Statics (4 - 0)

This course introduces the concepts of engineering based on forces in equilibrium of simple structures, trusses, frames, and machines. Topics include forces and moments, particles and rigid bodies in equilibrium.

Prerequisite: MA1113, MA1114 (may be taken concurrently).

ME2502 - Dynamics (4 - 1)

Kinematics and kinetics of particles and rigid bodies. Rectilinear, plane curvilinear, and space curvilinear motion. Newton's laws of motion. Work, energy, impulse and momentum, and impact. Plane motion of rigid bodies. Relative motion in translating and rotating frames of reference. Gyroscopic forces and motion.

Prerequisite: ME2501.

ME2503 - Engineering Statics and Dynamics (5 - 0)

Forces and moments, equilibrium equations, statically indeterminate objects, trusses, methods of joints and sections, centroids, composites, rectilinear and plane curvilinear motion, absolute and relative motion, work and energy, virtual work, impulse and momentum, impact, system of particles, rigid body motion, moving frame, plane motion, fixed-axis rotation.

Prerequisite: MA1115 (may be concurrent).

ME2601 - Mechanics of Solids I (4 - 1)

Concepts of stress, strain and deformation; axial force; normal stress and normal strain; shear force; shear stress and shear strain; torsion; angle of twist; bending moment; bending moment diagram and shear force diagram; flexural strain; transverse deflection; statically determinate and indeterminate structures; thin-walled pressure vessels; combined loading; stress and strain transformation; Mohr's circle; principal stress; maximum shear stress; and failure criteria.

Prerequisite: ME2501 and MA1114.

ME2801 - Introduction to Control Systems (3 - 2)

This course presents classical analysis of feedback control systems using basic principles in the frequency domain (Bode plots) and in the s-domain (root locus). Performance criteria in the time domain such as steady-state accuracy, transient response specifications, and in the frequency domain such as bandwidth and disturbance rejection are introduced. Simple design applications using root locus and Bode plot techniques will be addressed in the course. Laboratory experiments are designed to expose the students to testing and evaluating mathematical models of physical systems, using computer

simulations and hardware implementations. ME2801 and EC2300 are equivalent courses. This course can be offered as an online course.

Prerequisite: AE2440 or EC2440 or SE2440 or equivalent.. Corequisite: MA2121.

ME3150 - Heat Transfer (4 - 1)

Introduction to the various modes of heat transfer and their engineering applications. Steady and unsteady conduction using thermal circuit analogs and analytical techniques. External and internal forced convection, fundamentals and correlations. External natural convection. Boiling. Condensation. Heat exchanger, boiler and condenser analysis including design problems. Thermal radiation, spectra, view factors and material properties.

Prerequisite: ME2101, ME2201, and MA3132 (may be taken concurrently).

ME3201 - Applied Fluid Mechanics (4 - 1)

Steady one-dimensional compressible flow. Fundamentals of ideal-fluid flow, potential function, stream function. Analysis of viscous flows, velocity distribution in laminar and turbulent flows, introduction to the elements of the Navier-Stokes equations, solution of classical viscious laminar flow problems. Applications to Naval Engineering.

Prerequisite: ME2101, ME2201, and MA3132 (may be taken concurrently).

ME3205 - Missile Aerodynamics (4 - 1)

Potential flow, thin-airfoil and finite wing theories via vortex lattice methods. Linearized equations, Ackeret theory, Prandtl-Glauert transformations for subsonic and supersonic wings. Planform effects. Flow about slender bodies of revolution, viscous crossflow theory. Modern numerical flow analysis tools will be utilized to investigate realistic compressible flow problems over missile and air vehicle shapes.

Prerequisite: Undergraduate Fluids or by consent of instructor.

ME3240 - Marine Power and Propulsion (4 - 2)

This course provides an introduction to the basic principles of power and propulsion systems, with an emphasis on performance of platforms and weapons for naval applications. The laws of thermodynamics and fluid mechanics are applied to analyze and design of components and systems. The thermodynamics of simple gas and vapor cycles are presented, including the Otto, Diesel, Brayton and Rankine cycles, and complex and combined cycles with intercooling, reheat, regeneration and combined cycles. The aerothermodynamics of compressors, combustors, turbines, heat exchangers, inlets and nozzles are presented along with preliminary design methods, such as meanline design of turbomachinery. Component matching and engine operation of simple gas generators is treated. Mechanical and structural design aspects of engine development are

presented. Propeller characteristics and propulsion/vehicle integration are presented and cavitation is briefly covered. This course includes laboratories on gas turbines, diesels and turbomachinery.

ME3410 - Mechanical Engineering Instrumentation and Measurement Lab (2 - 4)

Introduction to measurement systems, statistical analysis of data, error analysis, uncertainty analysis, manipulation of data including electrical readout and processing, data acquisition fundamentals and Fourier decomposition and dynamic signals. Measurements of temperature, pressure , velocity, flow rates. Energy balances, surface temperature visualization, flow visualization. Measurement of motion using accelerometers and encoders. Measurement of strain and force. Operational amplifiers, analog computers, filters.

Prerequisite: ME2801, ME3150, ME3521 (ME3150 and ME3521 may be taken concurrently).

ME3420 - Computational Foundations for Robotics (3 - 2)

This course is a hands-on introduction to the foundational computational concepts and development practices employed in the engineering of robotics and autonomous systems. Topics include both general purpose programming and intermediate techniques specific to robotics, e.g., component-based development, event-based programming, cyber-physical interface, real-time execution, etc. Students successfully completing the class will have the computational understanding and skills to be successful in future engineering coursework at NPS. Because the basic programming review is accelerated, in order to succeed in the course, students should have previously learned a procedural programming language.

ME3440 - Engineering Analysis (4 - 0)

Rigorous formulation of engineering problems arising in a variety of disciplines. Approximate methods of solution. Finite difference methods. Introduction to finite element methods.

Prerequisite: ME2201 and ME2503.

ME3450 - Computational Methods in Mechanical Engineering (3 - 2)

The course introduces students to the basic methods of numerical modeling for typical physical problems encountered in solid mechanics and the thermal/fluid sciences. Problems that can be solved analytically will be chosen initially and solutions will be obtained by appropriate discrete methods. Basic concepts in numerical methods, such as convergence, stability and accuracy, will be introduced. Various computational tools will then be applied to more complex problems, with emphasis on finite element and finite difference methods, finite

volume techniques, boundary element methods and griddles Lagrangian methods. Methods of modeling convective non-linearities, such as upwind differencing and the Simpler method, will be introduced. Discussion and structural mechanics, internal and external fluid flows, and conduction and convection heat transfer. Steady state, transient and eigenvalue problems will be addressed.

Prerequisite: MA3132, ME2101, ME2601, ME3201. (ME3201 may be taken concurrently.).

ME3521 - Mechanical Vibration (3 - 2)

Elements of analytical dynamics, free and forced response of single degree and multi-degree of freedom systems. Dynamic response using modal superposition method. Properties of stiffness and inertia matrices, orthogonality of modal vectors, eigenvalue problem, modal truncation, vibration isolation and suppression. Vibration of bars, shafts, and beams. Supporting laboratory work.

Prerequisite: ME2502, ME2601, MA2121 or by consent of instructor.

ME3611 - Mechanics of Solids II (4 - 0)

Differential equation for beam deflection; non-symmetric bending; shear center; curved beams; torsion on thin-walled open or closed non-circular cross-sections; beams on elastic foundation; axially symmetric solids; introduction to theory of elasticity; thermal stresses; energy methods; and elastic instability.

Prerequisite: ME2601.

ME3711 - Design Of Machine Elements (4 - 1)

Design of representative machine elements with consideration given to materials selection, tolerances, stress concentrations, fatigue, factors of safety, reliability, and maintainability. Typical elements to be designed include fasteners, columns, shafts, journal bearings, spur and helical gears, and clutches and brakes. In addition to traditional design using factors of safety against failure, particular emphasis is placed on design for specified reliability using probabilistic design methods.

Prerequisite: ME2201, ME2601.

ME3712 - Capstone Design Project (1 - 6)

Design teams apply integrated and systematic design processes to real multifunctional and multidisciplinary problems in mechanical systems. Students develop process concepts, planning, design methodology, material selection, manufacturing and engineering analysis. Capstone design projects include projects provided by industry partners as well as DoD sponsors. The scope of design problems range across both engineering and non-engineering issues in the integrated design process.

Prerequisite: ME3150, ME3450, ME3521, ME3711. (ME3150, ME3450, ME3521, ME3711 may be taken concurrently as corequisites.).

ME3720 - Introduction to Unmanned Systems (3 - 2)

This course provides an overview of unmanned systems technology and operations, including navigation, vehicle dynamics, power and propulsion, communications, navigation, motion planning fundamentals. Operational and design considerations for single and multi-vehicle operations are presented. Volume and weight limitations on payload and range are covered as are energy and power constraints.

Prerequisite: Permission of Instructor.

ME3750 - Platform Survivability (4 - 0)

This course introduces the concepts and analytical tools used in designing and testing survivable combat platforms and weapon systems. The applications are to a broad range of platforms and weapons, including submarines, surface ships, fixed and rotary wing aircraft, cruise missiles, and satellites in a hostile (non-nuclear) environment. The technology for increasing survivability and the methodology for assessing the probability of surviving hostile environments are presented. Topics covered include: current and future threat descriptions; the mission/threat analysis; combat analysis of SEA, vulnerability reduction technology for the major systems and subsystems; susceptibility reduction concepts, including stealth; vulnerability, susceptibility, and survivability assessment; and trade-off methodology. PREREQUISITES: None.

ME3780 - Introduction to Micro Electro Mechanical Systems Design (3 - 3)

This is a class introducing students to Micro Electro Mechanical Systems (MEMS). Topics include material considerations for MEMS and microfabrication fundamentals; surface, bulk and non-silicon micromachining; forces and transduction; forces in micro-nano- domains and actuation techniques. Case studies of MEMS based microsensor, microactuator and microfluidic devices will be discussed. The laboratory work includes computer aided design (CAD) of MEMS devices and group design projects.

Prerequisite: EC2200 or MS2201 or PH1322 or consent of instructor.. Cross-Listed as: EC3280 and PH3280.

ME3801 - Dynamics and Control of Marine and Autonomous Vehicles I (3 - 2)

First part of the course develops 6DOF equations of motion of marine and autonomous vehicles. Initially we discuss kinematics, followed by vehicle dynamics and overview of forces and moments acting on the marine/autonomous vehicles. Second part of the course introduces basic concepts of linear systems analysis as well as linear systems design using state-space techniques. All the examples used in the second part of the course are based on the model of an Autonomous Underwater Vehicle derived in the first part. The course

includes a lab that further illustrates the concepts developed in class using hardware-in-the loop simulation of an autonomous vehicle.

Prerequisite: ME2801.

ME4101 - Advanced Thermodynamics (4 - 0)

This course reviews elementary definitions, concepts and laws of thermodynamics and then extends these to cover general thermodynamics and advanced topics. The concepts of availability, exergy, irreversibility, and general equilibrium conditions in single and multi-component systems. Gas- vapor mixtures in heating ventilation and cooling (HVAC). Modified, combined and solar thermal power cycles. Refrigeration and cryogenic cycles. Thermal storage. Chemical reactions and combustion.

Prerequisite: ME2101 or by consent of instructor.

ME4160 - Applications of Heat Transfer (4 - 0)

Applications of heat transfer principles to engineering systems. Design topics include heat exchangers (e.g., boilers, condensers, coolers), cooling electronic components, heat pipes, solar collectors, turbine blade cooling.

Prerequisite: ME3150.

ME4161 - Conduction Heat Transfer (4 - 0)

Steady-state heat conduction in multi-dimensions with and without heat sources. Transient conduction. Numerical methods for heat conduction. Mechanical Engineering applications.

Prerequisite: ME3150.

ME4162 - Convection Heat Transfer (4 - 0)

Fundamental principles of forced and free convection. Laminar and turbulent duct flows and external flows. Dimensionless correlations. Heat transfer during phase changes. Heat exchanger analysis with Mechanical Engineering applications.

Prerequisite: ME3150, ME3201.

ME4613 - Finite Element Methods (4 - 0)

Introduction to the fundamental concepts of the finite element method. Weighted residual methods and weak formulation. Element discretization concept and shape functions. Generation of element matrices and vectors, and their assembly into the matrix equation. Application of boundary and initial conditions. Isoparametric elements and numerical integration techniques. Computer programming and application to engineering problems such as boundary value, initial value and eigenvalue problems.

Prerequisite: MA3132 and MA3232 or by consent of instructor..

ME4202 - Compressible and Hypersonic Flow (4 - 0)

One-dimensional, compressible flow is reviewed. Two-dimensional and axis-symmetric supersonic of ideal gases. Oblique shocks and expansion waves. General compressible flow equations. Potential supersonic and conical flows. Compressible scaling and transonic area ruling. Effects of very high velocity and low density. Hypersonic flow. Mach number independence and equivalence principles. Newtonian method. Blunt and slender body solutions. Real gas behavior and effect on shock and boundary layers. Applications are presented to satellite parasitic drag and re-entry flows.

Prerequisite: ME3201 or consent of instructor.

ME4211 - Applied Hydrodynamics (4 - 0)

Fundamental principles of hydrodynamics. Brief review of the equations of motion and types of fluid motion. Standard potential flows: source, sink, doublet, and vortex motion. Flow about two-dimensional bodies. Flow about axisymmetric bodies. Added mass of various bodies and the added-mass moment of inertia. Complex variables approach to flow about two-dimensional bodies. Conformal transformations. Flow about hydro and aerofoils. Special topics such as dynamic response of submerged bodies, hydroelastic oscillations, etc. Course emphasizes the use of various numerical techniques and the relationship between the predictions of hydrodynamics and viscous flow methods.

Prerequisite: ME3201.

ME4220 - Viscous Flow (4 - 0)

Development of continuity and Navier-Stokes equations. Exact solutions of steady and unsteady viscous flow problems. Development of the boundary-layer equations. Similarity variables, numerical and integral techniques. Separation, boundary-layer control. Time-dependent boundary layers. Origin and nature of turbulence, phenomenological theories, calculation of turbulent flows with emphasis on naval engineering applications, and numerical models and CFD.

Prerequisite: ME3201 and consent of instructor.

ME4225 - Computational Fluid Dynamics and Heat Transfer (3 - 2)

This course presents numerical solution of sets, of partial differential equations, that describe fluid flow and heat transfer. The governing equations for fluid dynamics are reviewed and turbulence modeling is introduced. Discretization techniques are applied to selected model equations and numerical methods are developed for inviscid and viscous, compressible and incompressible flows. Individual term projects include application of CFD to thesis research and to current military problems.

Prerequisite: ME3201 or ME3450 or by consent of instructor.

ME4231 - Advanced Turbomachinery (3 - 2)

The underlying principles governing flow through and energy exchange in turbomachines are developed to provide a basis for understanding both design and advanced computational methods. Key considerations and procedures followed in the design of new aircraft engine

fans, compressors and turbines are introduced. Lectures are coordinated with experimental test experience at the Turbopropulsion Laboratory.

Prerequisite: ME3240.

ME4240 - Advanced Topics in Fluid Dynamics (4 - 0)

Topics selected in accordance with the current interests of the students and faculty. Examples include fluid-structure interactions, cable strumming, wave forces on structures, free-streamline analysis of jets, wakes, and cavities with emphasis on computational fluid dynamics.

Prerequisite: ME4220 and ME4211.

ME4251 - Engine Design and Integration (3 - 2)

The conceptual and preliminary component, subsystem, and systems design of military, or military related, air breathing engines, along with the integration of the engine in a platform, is experienced within student design teams. The course is focused on a team response for a Request-for-Proposal (RFP) for an engine meeting specific requirements. Performance, cost, supportability, deployment, manufacturing, product quality and environmental considerations may be included in the design process. The project draws on all of the mechanical engineering disciplines.

Prerequisite: ME3240.

ME4420 - Advanced Power and Propulsion (4 - 0)

This course presents an advanced treatment of power and propulsion topics, primarily for naval applications. Thermodynamic analysis of simple, advanced and complex cycles, such as combined and augmented cycles are presented along with new and direct energy conversion concepts. Design integration of single and multi-type (CODAG, CODOG, etc.) power and propulsion systems with vehicles. Engine installation considerations, including the design of auxiliary equipment and inlet/exhaust systems, are presented. Design and current research topics in fluid mechanics and of turbomachinery are presented. Repair, condition-based maintenance and machinery operation, including balancing techniques, are discussed.

Prerequisite: ME2101.

ME4424 - Combustion Fundamentals (3 - 2)

The goal of this course is to provide naval engineers with the background knowledge and skills necessary to properly analyze and evaluate combustion systems and processes. This will be accomplished by building upon knowledge acquired in prerequisite courses and developing knowledge of chemical kinetics and mass transport. This knowledge is then applied to analyses of combustion and flame phenomena relative to Naval applications (vehicles, infrastructure, ships, aircraft, etc.). Analytical, numerical and experimental techniques will be used to analyze combustion with both conventional and biofuels.

Prerequisite: Graduate courses or undergraduate equivalents in Chemistry, Thermodynamics (ME2101), and Fluid Mechanics (ME3201)..

ME4500 - Advanced Space Flight Mechanics and Orbital Robotics (3 - 2)

This course covers advanced topics in Space Flight Mechanics and Orbital Robotics. The class is designed to provide fundamental engineering and mathematical tools necessary to analyze and design emerging advanced Space Flight missions, such as: Distributed Space Systems, Constellations and Swarms, On-orbit Assembly, Servicing and Manufacturing (ASAM), Space Debris Remediation. Focus of the course is given to modeling the relative orbital and attitude mechanics and advanced guidance and control aspects of co-orbiting artificial satellites. Topics include relative orbital mechanics and orbital perturbations; linear and non-linear proximity maneuver dynamics and control in SE(3); formulation of relative motion using orbital elements; low-thrust propulsion for formation flying; untraditional space flight maneuvers such as those exploiting differential drag. The course teaches rigorous mathematical analysis methods. Numerical simulation experiments will be used to reinforce the learning and enable to case-study realistic mission scenarios. This course covers recent advances of Astronautical Engineering and emphasizing contemporary issues of high interest to DoD, NASA and US Space community at large.

Prerequisite: Orbital Mechanics SS3500, OR Classical Physics OR Engineering Mechanics OR Approval by Course Coordinator. Corequisite: None. Cross-Listed as: AE4500.

ME4522 - Finite Element Methods in Structural Dynamics (4 - 0)

This course provides an introduction to the principles and methods of computational structural dynamics and vibration analysis. Modern computational methods make use of the matrix structural models provided by finite element analysis. Therefore, this course provides an introduction to dynamic analysis using the finite element method, and introduces concepts and methods in the calculation of modal parameters, dynamic response via mode superposition, frequency response, model reduction, and structural synthesis techniques. Experimental modal identification techniques will be introduced.

Prerequisite: ME3521or by consent of instructor.

ME4525 - Naval Ship Shock Design and Analysis (4 - 0)

Characteristics of underwater explosion phenomena, including shock wave propagation, gas bubble behavior, pulse loading and bulk cavitation. Surface ship/submarine bodily response to shock loading. Application of shock spectra in component design. Dynamic Design Analysis Method (DDAM) with application to shipboard equipment design. Fluid Structure Interaction (FSI) analysis, including Doubly Asymptotic Approximation (DAA) and surface ship

response. Current design requirements for shipboard equipment are also included.

Prerequisite: ME3521 or equivalent or by consent of instructor.

ME4550 - Random Vibrations and Spectral Analysis (4 - 0)

Engineering application of spectral analysis techniques to characterize system responses under a random vibration environment. Characteristics of physical random data and physical system responses. Application of probability concepts to random data and response analysis. Correlation and spectral density functions. Transmission of random vibration. System responses to single/multiple random excitations. Failure due to random vibration.

Prerequisite: ME3521 or equivalent or by consent of instructor.

ME4612 - Advanced Mechanics of Solids (4 - 0)

Selected topics from advanced mechanics of materials and elasticity. Stress and strain tensors. Governing equations such as equations of equilibrium, constitutive equations, kinematic equations and compatibility equations. Two-dimensional elasticity problems in rectangular and polar coordinate systems. Airy stress function and semi-inverse technique. Energy methods with approximate solution techniques including Rayleigh-Ritz method. Buckling of imperfect columns. Introduction to plate and shell bending theory.

Prerequisite: ME3611 or by consent of instructor.

ME4613 - Finite Element Methods (4 - 0)

Introduction to the fundamental concepts of the finite element method. Weighted residual methods and weak formulation. Element discretization concept and shape functions. Generation of element matrices and vectors, and their assembly into the matrix equation. Application of boundary and initial conditions. Isoparametric elements and numerical integration techniques. Computer programming and application to engineering problems such as boundary value, initial value and eigenvalue problems.

Prerequisite: MA3132,MA3232, ME3450 (MA3132 and ME3450 may be taken concurrently as corequisites) or by consent of instructor.

ME4620 - Theory of Continuous Media (4 - 0)

Tensor analysis. Stress and strain tensors. Motion of continuum. Energy and entropy. Constitutive equations. Applications to elasticity and fluid dynamics.

Prerequisite: ME3201, ME3611.

ME4700 - Weaponeering (3 - 2)

This course is meant to describe and quantify the methods commonly used to predict the probability of successfully attacking ground targets. The initial emphasis will be on air launched weapons. These weapons include guided and unguided bombs, air-to-ground missiles, LGBs, rockets and guns. The course will outline the various methodologies used in operational products used widely in the USN, USAF and Marine Corps.

Prerequisite: ME2503 or MA2121 or equivalent, ME3410 or OS3104 or equivalent, or consent of the instructor.

ME4702 - Engineering Systems Risk Benefit Analysis (3 - 2)

This course emphasizes three methodologies, Decision Analysis (DA), Reliability and Probabilistic Risk Assessment (RPRA) and Cost-Benefit Analysis (CBA). The course is designed to give students an understanding of how these diverse topics can be applied to decision making process of product design that must take into consideration significant risk. The course will present and interpret a framework for balancing risks and benefits to applicable situations. Typically, these involve human safety, potential environmental effects, and large financial and technological uncertainties. Concepts from CBA and RPRA are applied for real world problems resulting in decision models that provide insight and understanding, and consequently, leading to improved decisions. Same course as OS4010.

Prerequisite: OS3104 or equivalent course in probability, or consent of instructor.

ME4703 - Missile Flight and Control (4 - 1)

Tactical Missile Flight Dynamics, Guidance and Control. Kinematics and dynamics of motion, forces and moments acting on the missile, coordinate frames and transformations, concepts of stability and control. Key principles of feedback control. Stability and performance specifications, Concept of controllability, PID control. Lateral autopilot design, classical and modern design approaches; agility in maneuvering trajectories. Homing loop design, operational requirements. Principles of missile guidance as a control task; stability of guidance laws. Pursuit guidance equation, constraints, and the associated performance specifications; firing envelope, "no-escape envelope." Proportional navigation guidance law, stability and performance specifications of PN guidance. Metrics of objective comparison of guidance laws and their applicability in specific scenarios of engagement. Additional topics are selected from the following areas to address the general interests of the class: advanced guidance laws, passive sensors, INS guidance, fire control and tracking systems.

Prerequisite: ME3205 and ME2801 or equivalent or consent of instructor..

ME4704 - Missile Design (3 - 2)

Conceptual missile design methodology centered around a student team design project, focused on a military need defined by a Request-for-Proposal. It stresses the application aerodynamics, propulsion, flight mechanics, cost, supportability, stability and control and provides the student with their application to design. Consideration is given to trade-offs among propulsion requirements, air

loads, quality sensors, guidance laws, quality, controls, and structural components.

Prerequisite: ME3205, ME4703 or equivalent, AE4452 or by consent of instructor.

ME4731 - Engineering Design Optimization (4 - 0)

Application of automated numerical optimization techniques to design of engineering systems. Algorithms for solution of nonlinear constrained design problems. Familiarization with available design optimization programs. State-of-the-art applications. Solution of a variety of design problems in mechanical engineering, using numerical optimization techniques.

Prerequisite: ME2601or by consent of instructor.

ME4751 - Combat Survivability, Reliability and Systems Safety Engineering (4 - 1)

This course provides the student with an understanding of the essential elements in the study of survivability, reliability and systems safety engineering for military platforms including submarines, surface ships, fixed-wing and rotary wing aircraft, as well as missiles, unmanned vehicles and satellites. Technologies for increasing survivability and methodologies for assessing the probability of survival in a hostile (non-nuclear) environment from conventional and directed energy weapons will be presented. Several in-depth studies of the survivability various vehicles will give the student practical knowledge in the design of battle-ready platforms and weapons. An introduction to reliability and system safety engineering examines system and subsystem failure in a non-hostile environment. Safety analyses (hazard analysis, fault-tree analysis, and component redundancy design), safety criteria and life cycle considerations are presented with applications to aircraft maintenance, repair and retirement strategies, along with the mathematical foundations of statistical sampling, set theory, probability modeling and probability distribution functions.

Prerequisite: Consent of Instructor.

ME4753 - Risk Analysis and Management for Engineering Systems (3 - 2)

This course covers three areas in the risk field - Qualitative Risk Analysis, Quantitative Risk Analysis, and Decision Risk Analysis. Qualitative Risk Analysis presents techniques for risk identification/evaluation, risk handling, risk monitoring and risk management. Quantitative Risk Analysis includes Probabilistic Risk Assessment (RPRA) of system performance and project cost/schedule. Decision Risk Analysis gives the students an understanding of how to apply risk and cost benefit techniques in decision making when one must deal with significant risk or uncertainty. The course will present a framework for balancing risks and benefits to applicable situations. Typically these involve human safety, potential environmental effects, and large financial and technological uncertainties. Concepts are applied toward representative problems resulting in risk and decision

models that provide insight and understanding, and consequently lead to more successful projects/programs with better system performance within cost and schedule. This is the same course as SE4353.

Prerequisite: OS3180/OS3104, or equivalent graduate level course in probability, or consent of the instructor.

ME4780 - Micro Electro Mechanical Systems (MEMS) Design II (2 - 4)

Same as EC4280 and PH4280. This is the second course in Micro Electro Mechanical Systems (MEMS) Design. This course will expose students to advanced topics on material considerations for MEMS, microfabrication techniques, forces in the micro- and nano- domains, and circuits and systems issues. Case studies of MEMS based microsensors, microactuators and microfluidic devices will be discussed. The laboratory work includes computer aided design (CAD) and characterization of existing MEMS devices. The grades will be based on exams, lab projects, and a group design project.

Prerequisite: EC/PH3280 or ME3780 or consent of instructor.

ME4800 - Machine Learning for Autonomous Operations (3 - 2)

This course covers the theory, computation and practical implementation of machine learning concepts for the design and autonomous operations of aerospace and marine engineering systems. Specific machine learning topics covered are: construction of meta-models using three- and six-degree-of-freedom Newtonian dynamical equations, design of experiments for end-to-end dynamical systems, generation of labeled training data, neural networks, and deep learning. These topics will be covered alongside the development of specific meta-models using physics-based simulations of aerospace and marine engineering systems. Examples will be drawn from a sample of DoD problems such as range prediction for a ballistic missile and predicting the damage from a simulated attack on an airfield. Relevant concepts from optimization theory will also be covered as part of the foundations of machine learning. MATLAB-based assignments will form the core of a student's learning experience. This course may also be used as part of the allowable electives for the Robotics Certificate program.

Prerequisite: ME3420 OR AE3830. Cross-Listed as: Please cross list the course as AE4800.

ME4811 - Multivariable Control of Ship Systems (3 - 2)

This course takes students through each stage involved in the design, modeling and testing of an unmanned system. The course is built around the creation of a fully functional command and control system for a typical robotic platform, e.g., unmanned aerial vehicle (UAV), unmanned surface vehicle (USV) or unmanned underwater vehicle (UUV). Students are presented with a challenge for applying unmanned systems to an authentic scenario of naval significance. Students are then guided through

development of equations of motion, control design and system performance in the context of solving a real-world problem. Final designs are evaluated in a combination of simulation and experimental environments as appropriate.

Prerequisite: ME3801 or by consent of instructor.

ME4812 - Fluid Power Control (3 - 2)

Fluids and fluid flows in high-performance actuators and controllers. Power flow and fluid power elements, valve and pump control, linear and rotary motion. State space descriptions. Design of electro-hydraulic position and velocity control servo-mechanisms for high performance with stability.

Prerequisite: ME3801.

ME4821 - Marine Navigation (3 - 2)

This course presents the fundamentals of inertial navigation, principles of inertial accelerometers, and gyroscopes. Derivation of gimbaled and strapdown navigation equations and corresponding error analysis. Navigation using external navigation aids (navaids): LORAN, TACAN, and GPS. Introduction to Kalman filtering as a means of integrating data from navaids and inertial sensors.

Prerequisite: ME3801or by consent of instructor.

ME4822 - Guidance, Navigation, and Control of Marine Systems (3 - 2)

The objective is to present a classical approach to the robust design of nonlinear GNC systems that accounts for both the stability and performance specifications. The course is built around the task of designing a robust autopilot for a typical robotic UxV platform; the class will be given an option of choosing the platform of interest. The robust autopilot integrates all parts of the GNC design process into one complete task. Development of the mathematical modeling skills is supported by intensive introduction to the advanced capabilities of MatLab/Simulink, therefore some prior familiarity with them are required. Students are asked to choose an autonomous system, model its dynamics in a nonlinear simulation package such as SIMULINK, define the uncertainty of the mathematical model, and then design a robust autopilot for this system. The design is to be tested on SIMULINK or a similar numerical computational platform integrated with a high-fidelity 6DOF motion dynamics engine; UAV class is supported by CONDOR simulator. Course notes and labs cover all the relevant material.

Prerequisite: ME3205 and ME2801 or equivalent or by consent of instructor.

ME4823 - Cooperative Control of Multiple Marine Autonomous Vehicles (4 - 0)

This course takes students through each stage involved in the design, modeling and evaluation of a multi-robot solutions to current and future naval challenges. The course provides students with an overview of the state-of-the-art in multi-robot control and the theoretical building blocks common to these methods. Students are presented with an authentic multi-robot control challenge which serves as the focus of the remainder of the course. Students are guided through a selection process to formulate multi-robot control techniques appropriate to the specific application. The course culminates with implementation of multi-robot control (in simulation and/or experiment) to quantitatively evaluate performance of student designs. PREREQUISITE: ME3801, ME3201

Prerequisite: ME3801 or consent of Instructor.

ME4824 - Applications of Deep Learning for Military Systems (3 - 2)

This course covers the applications of deep learning for military systems including satellite imagery processing and target detection, classification and aimpoint tracking for high energy laser beams. The coverage begins with introduction to computer vision, machine learning, and "shallow" neural networks. Then it expands to deep neural networks, Convolutional Neural Networks (CNN), network architecture design, training and validation, neural network databases, transfer learning, and CNN frameworks including TensorFlow. Laboratory sessions include network design, training, and inference for shallow and deep neural networks using Python programming language. Tailoring various existing CNN network structures for transfer learning will be included as well for satellite imagery processing and target object detection, classification, and tracking.

Prerequisite: Knowledge of controls and basic programming or consent of instructor. Cross-Listed as: Cross-listed with AE4824.

ME4825 - Marine Propulsion Control (3 - 2)

Introduction to dynamic propulsion systems modeling and analysis methods. Control design specifications and design strategies. Introduction to modern control design theory and multivariable methods. Theory and applications of optimal control and discrete-time control systems. Case studies of current naval propulsion control systems.

Prerequisite: ME3801, ME3240 (may be taken concurrently), and MA3132.

ME4828 - Fundamental GNC Algorithms of Autonomous Robotics (3 - 2)

This course presents the key concepts of the integrated Guidance, Navigation, and Control systems of autonomous vehicles and builds their most common algorithms. It defines the objectives of each GNC component and the combined closed-loop system. First, it develops a linear controller capable of vehicle stabilization and reference-following. The feedback design utilizes the concept of a noise-additive sensor model that is represented by a Gaussian probability density function. The course teaches how to design a calibration

experiment that identifies a sensor. The multiplexing of qualitatively different measurements is introduced using the Bayesian inference concept. The propagation of Gaussian noise through the linear and nonlinear systems develops the prediction-correction mechanism of the linear and extended Kalman filters and builds the path to modern unscented and particle filters. The path-planning considers a trajectory as a combination of the path and the velocity along the path. The trajectory generation assumes the partially known environment with obstacles.

The laboratory work utilizes general-purpose programming (Python/MatLab) and intermediate techniques specific to robotics, e.g., objects, multithreading, event-based programming, cyber-physical interface, real-time execution, etc. Students successfully completing the class will have an understanding and skills of onboard software design typical of real-life robotic applications. Since the basic programming review is accelerated, to succeed in the course, students should have previously learned a procedural programming language.

Prerequisite: Fundamentals of motion dynamics and linear systems control is required. The students should have previously learned a procedural programming language..

ME4881 - Aerospace Trajectory Planning and Guidance (2 - 4)

Same as AE4881. This course covers the theory, computation and practical implementation of integrated trajectory planning and guidance algorithms for aerospace vehicles. The theory is based on the next generation of dynamical systems in mechanical and aerospace engineering. Examples will be drawn from a sample of DoD problems in space systems, missile engineering and small munitions. After a review of the state of practice, a unified theoretical framework for solving practically constrained trajectory problems will be developed. The Karush-Kuhn-Tucker conditions will form the foundations of constraint violation and validating optimality conditions. Multiplier theory and its use in solving practical problems will be covered from a real-time computational viewpoint. No-fly zones and engineering requirements will be formulated as a mathematical mixture of state and decision-variable constraints. Extensive MATLAB-based mini-projects will form the core of the laboratory experience. These projects are designed for students to learn the process of constructing a flyable trajectory planning algorithm from first principles to an integrated guidance system.

Prerequisite: AE4850 or ME4703 or ME4822 or Consent of Instructor.

ME4901 - Advanced Topics in Mechanical (Aerospace) Engineering (V - V)

Same as AE4901. Advanced study in Mechanical (Aerospace) Engineering generally on a subject not covered in existing courses. May be repeated for credit with a different topic. This course number should be used to initiate new advanced courses. This course may not be taken on a Pass/Fail Basis.

Prerequisite: Permission of Department Chairman and Instructor.

ME4902 - Advanced Study in Mechanical Engineering (V - V)

Directed advanced study in Mechanical (Aerospace) Engineering on a subject of mutual interest to student and faculty member after most of a student's electives have already been taken. This is typically a "Reading" course directed by a faculty member. Graded on Pass/Fail basis only.

Prerequisite: Permission of Department Chairman and Instructor.

ME5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

ME5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council. Prerequisite: Advancement to Candidacy.

MN

MN0163 - Thesis Writing Workshop (0 - 1)

Guidelines for scientific writing for the thesis are given with examples and opportunities for practice.

Prerequisite: Consent of Instructor.

MN0810 - Thesis Research for Systems Management Students (0 - 8)

Every student conducting thesis research in Systems Management resident programs will enroll in this course.

MN0811 - Thesis Research for Non-Resident Business & Public Policy Students (0 - 4)

Every student conducting thesis research in the Distance Learning Contract Management (835) and Program Management (836) degree programs will enroll in this course.

MN2039 - Basic Quantitative Methods in Management (4 - 0)

This course introduces the mathematical basis required

for advanced management and cost-benefit analysis. Math topics include algebra, graphs, differential calculus, including both single and multiple variable functions, and indefinite and definite integrals. Management concepts include cost-benefit and cost-effectiveness analysis, marginal analysis, unconstrained and constrained optimization, and welfare analysis.

Prerequisite: College algebra or permission of instructor.

MN2111 - Navy Manpower, Personnel, and Training Systems I (2 - 0)

An introduction to the major issues, theory, and practice of the military MPT&E system. Graded on a Pass/Fail basis only.

Prerequisite: Consent of Instructor.

MN2112 - Seminar in Manpower, Personnel, and Training Issues II (2 - 0)

Continuation of MN2111. Graded on a Pass/Fail basis only.

Prerequisite: Open to thesis students.

MN3001 - Economics for Acquisition Managers (3 - 0)

Develops the fundamental tools of microeconomics and macroeconomics and applies them to topics in the management and allocation of resources in defense acquisition management with particular emphasis on the applications of economic theory to defense decision making. Topics covered include defense and the macro economy; markets and their effects on defense acquisition and contracting practices; the economics of corporate strategy; and efficiency in defense decision making. Prerequisite: None.

MN3010 - Leading Innovative Organizations and People (4 - 0)

Organizations, including defense organizations, are complex, purposive, open systems. As open systems, they face challenges of external adaptation and effectiveness and of internal coherence and efficiency. Our purpose is to understand the structures and processes that make up organizations in order to appreciate how they succeed and why they falter or fail. Our focus is on "organizational diagnosis", which requires us to apply relevant theories to evaluate organizational performance. To do this, we will examine topics that include: organizational structure, motivation and reward systems, organizational culture, power and conflict, effective teams, and the leadership characteristics involved in effectively managing today's organizations. Although these topics are relevant to all organizations, we will pay special attention to their application in the context of the Department of Defense and military organizations.

Prerequisite: Enrollment in DDM Degree Program.

MN3011 - Management of Teams (2 - 0)

Teams are a building block of today's organizations. Teams are evident throughout DoD in such forms as operational squads, integrated product teams (IPTs), R&D innovation teams, and Joint Task Forces. The course examines the differences between groups and teams, between leader-managed and self-managed teams, between virtual and face-to-face teams, and between effective and ineffective teams. Analysis of effective teams include such issues as team dynamics, decision making, rewards, commitment, and the management of conflict (inter-personal, intra-team, and inter-team) in which power, influence and negotiation play central parts.

MN3012 - Communications Strategies for Effective Leadership (3 - 0)

This course provides DoD military officers and civilians with the communication strategies and skills to manage and lead in the dynamic DoD environment. Instruction focuses on assessing various communication models, making strategic media choices, writing effective informative documents, developing associates' communication competencies through various feedback roles, and giving lucid briefings. Prerequisites: None.

MN3014 - Ethics (1 - 0)

An introduction to problem analysis and moral reasoning in the context of business, commerce, and government service. Ethics is distinguished from routine requirements of legal compliance by emphasizing how classical forms of moral reasoning (such as utilitarianism, and the ethics of duty) can address and help resolve practical problems and case studies drawn from recent practice about which the law itself is largely silent. Free enterprise conceptions of profit-making are compared with government and public service conceptions of acquisition and contracting. Enrollment limited to 30 students per course section. Written assignments and final exam required. Five weeks of instruction (10 hours: 1-0). Prerequisites: None.

MN3015 - Leading Teams (3 - 0)

This course focuses on leading teams, including team development, process analysis, and leadership skill-building. Students learn to design teams wisely, sustain positive team development, foster excellent problem-solving processes, catalyze innovation, and support a learning-focused and productive team environment. Students analyze DoD teams as systems of interrelated components working towards a common purpose, learn how design factors affect team processes and performance, and identify challenges and pitfalls of group decision making. They learn to plan interventions that will help teams think more critically and make better decisions. The course concludes with exercises in leading collaboration within culturally diverse teams. Knowledge and skills from the course will have immediate application in many organizational settings.

Prerequisite: none. Cross-Listed as: Cross-listed with GC3015.

MN3030 - Marketing Management (3 - 0)

Focuses on managerial skills, tools and concepts required to produce a mutually satisfying exchange between consumers/users/ organizations and providers of goods, services and ideas. Emphasis on understanding the marketplace, individual parts of the marketing program (product, pricing, distribution and communication), and strategic formulation (orientation, target segmentation, positioning).

MN3031 - Acquisition Management for International Students (3 - 0)

This is the core acquisition course for international students in non-acquisition curricula. It introduces principles of public procurement management by examining acquisition policy issues, management strategies, contracting decisions, and contract management processes. Major international procurement models and systems will be introduced, including the US Federal Acquisition Regulation, Transparency International's Integrity Pacts, the UN Model Law on Procurement, the EU Public and Defense Procurement Directives, the World Bank Procurement and Integrity Guidelines, and the World Trade Organization Agreement on Government Procurement. Concepts, strategies and tools for planning, organizing, staffing, directing and controlling acquisition programs are examined. Acquisition topical areas include: anti-corruption measures, acquisition planning, the competition requirements, source selection, risk management, quality assurance, protests, transparency and publicity mechanisms, research and development, and contracting management. While the US defense acquisition system may be examined for comparative purposes, the major emphasis through case studies and readings is on international perspectives and issues. Another major emphasis of the course is on Foreign Military Sales (FMS) and the application of international procurement law concepts to the FMS process. Prerequisite: None.

MN3040 - Data Management and Statistics for Manpower Analysis (4 - 0)

MN3040 introduces students to basic concepts and procedures in descriptive and inferential statistics and prepares them for subsequent statistical courses in Multivariate Data Analysis (MN4110 and MN4111), Applied Manpower modeling (MN4761), and beyond. This course bridges the gap between theoretical concepts and applied work in statistics in the context of answering manpower related policy questions. Topics include methods for deriving, describing and summarizing single-variable statistics followed by measures to analyze the relationship between two or more variables. The course then introduces probability theory as a background for understanding inferential statistics. Finally, methods are presented for drawing inferences from research samples to populations, including hypothesis testing and confidence intervals. A significant portion of the course will also be devoted to data collection, data manipulation, and data analysis using the statistical program Stata and utilizing data sets from PRIDE, DMDC, and MEPCOM. Prerequisites: None.

MN3041 - Managerial Data Analysis (4 - 0)

This course focuses on the descriptive and inferential statistical concepts and practical analytical skills useful for conducting basic managerial and policy analysis. Topics include descriptive statistics for quantitative and qualitative data, basic probability concepts and distributions, sampling theory and study design, and estimation and prediction using linear models. Prerequisites: College algebra and knowledge of Excel.

MN3042 - Operations Management (3 - 0)

This course provides an overview of operations in military and commercial systems. The course has three sections: (1) creating processes, including a survey of process types, capacity planning, and service system design; (2) controlling processes, including MRP/ERP systems and the role of information; and (3) coordinating processes, including inventory management, purchasing, and supply chain management. Prerequisite: None.

MN3044 - Logistics Community Seminar (0 - 2)

This seminar exposes students to current and emerging topics in Logistics and its role in National Security, and central tools and concepts of Logistics Analysis through readings, guest lectures, and focused class discussion.

Prerequisite: Open to students in Logistics Management curricula and others by permission of instructor.

MN3050 - Financial Reporting and Analysis (4 - 0)

This course covers theory, concepts, and practices underlying financial Accounting and Financial Reporting. The conceptual structure underlying the reporting of economic events in the form of the balance sheet, the income statement, and the statement of cash flows is first presented. Accounting recognition and measurement issues surrounding revenues, expenses, assets, liabilities and equity are introduced and analyzed. Finally, different forms of financial analysis based on financial report information are addressed. Throughout the course, emphasis is placed on the manager or user perspective. Attention is given to the federal government financial reporting model and standards. PREREQUISITE: Enrollment in the DDM Degree Program.

MN3051 - Cost Management (3 - 0)

This course introduces students to cost management concepts and theories which are used by managers to make decisions on the allocation of financial, physical, and human resources to achieve strategic as well as short-term organizational goals and objectives and evaluate performance using financial and non-financial measures. The course is designed for those having a prior course in financial reporting and analysis or financial accounting. Cost management includes traditional tools and techniques such as cost behavior for decision making, activity costing, cost allocation, and standard costing.

Prerequisite: MN3050.

MN3056 - Financial and Managerial Accounting (4 - 0)

MN3056 is designed for the graduate student who has had little or no exposure to accounting. In the beginning of the course, the student will be briefly introduced to financial accounting concepts and theory in order to build a basis for more detailed study of managerial accounting. Managerial accounting examines the internal information systems needed by managers to make decisions concerning the allocation of scare resources. Managers need information to carry out three essential functions in an organization: (1) planning operations, (2) controlling activities, and (3) making decisions. The purpose of this course is to show what kind of information is needed, where this information can be obtained, and how managers can use this information as they carry out their planning, controlling, and decision-making responsibilities.

Prerequisite: None.

MN3070 - Fundamentals of Cost Benefit Analysis (4 - 0)

This course introduces you to economics as a social science and teaches you the tools of micro-economic analysis that are necessary to understand and conduct economic policy analyses. One of the key tools of economic analysis is Cost-Benefit Analysis (CBA). You will learn the utility as well as the challenges of using CBA to study the role of the public sector in our market economy. After a brief introduction to CBA, which includes motivating the need for conducting CBA in the public sector, we study the fundamental tools of microeconomics, including supply and demand, elasticity, market equilibrium, social welfare, the effects of government interventions in the economy, and how firms make decisions in competitive and non-competitive markets. We then turn to the study of how to conduct CBA and how to be critical consumers of such analyses.

MN3108 - Leadership in Product Development (3 - 2)

A product development course providing a broad framework for the leadership of end-to-end product commercialization with a student hands-on design challenge, to give students perspective and appreciation for the critical success factors and inhibitors to successful commercialization of complex products and systems. The format includes lectures, guest speakers, case studies and a design challenge. Topics include product development strategy and leadership, the front-end process, product delivery, distribution and customer support. The Design Challenge is as a multi-disciplinary system design experience. Students work in teams to design, build, test and demonstrate a real product. The Design Challenge culminates with a prototype demonstration competition. PREREQUISITE: None

MN3109 - Ethics and Moral Development (3 - 0)

Offered to students in their first quarter: The objective of this course is to provide newly-enrolled students with an introduction to the ethical challenges of the global Defense business environment facing Navy corporate business leaders and resource managers. Through the use of case analyses and discussion, the course will explore the application of ethical thinking to contemporary issues in the private and public sectors. The course goals include: 1) introduce ethical concepts which are relevant to the moral and ethical dilemmas inherent in business decisions; 2) help students develop the critical thinking and analytical skills required to address complex issues; 3) identify the range of ethical problems facing senior leaders in business and government; and 4) encourage the students to develop a personal approach to achieve ethical outcomes in the corporate-level decision-making process. The students will use the managerial perspective and critical thinking skills developed in this course throughout the remainder of their studies to identify the ethical dimension in the process of formulating and implementing Navy policy and business strategies required to build and maintain the Fleet of the 21st Century. Prerequisite: None.

MN3111 - Analysis of Human Resource Management (4 - 0)

A broad coverage of human behavior in the work situation, with key emphasis on the issues of work in the Navy Manpower Personnel and Training Environment. Topical areas covered include selection, placement, training development, and evaluation of personnel; motivation, remuneration, morale, supervision, and working conditions in military organizations; job design and organization development within complex military bureaucracies; equipment design and man-machine interface, and the impact of technological programs within the military.

Prerequisite: GB3010.

MN3117 - Organizational Processes (4 - 0)

The purpose of this course is to provide the conceptual framework and skills needed to manage and lead organizations. The focus will be on three levels of skills

needed to manage modern organizations: skills needed to manage individuals, skills needed to manage teams, and skills needed to manage the organization as a whole. It focuses on the organization of the future, identifies its characteristics, and explores the implications for living in, managing, and leading such an organization. The course also focuses on skills such as negotiating, cross-cultural communication, and teamwork. It examines the creation of the structures needed within the firm and the alliances, learning, and change practices needed to maintain global leadership. PREREQUISITE: NONE

MN3118 - Negotiation and Consensus Building (4 - 0)

Negotiation and consensus building are fundamental skills that leaders and managers need to know. This course teaches principles of conflict management, consensus building, and interest-based negotiation among individuals and groups. Students practice applying the principles during role-plays, exercises, cases, and complex negotiations. Through these activities, students build expertise in small group meeting management, persuasion and influence, consensus building, productive negotiation, and developing mutually acceptable solutions in difficult situations. Scenarios relate to real-world organizational and military challenges. We focus particularly on security-related situations, including cross-cultural interactions among multiple stakeholders, such as Security, Stability, Reconstruction and Transition (SSTR) environments that bring together representatives from different nations and organizations. In order to accomplish their unique and joint goals, these varying representatives must cultivate mutual appreciation and ability to collaborate with each other in the absence of hierarchical controls. Students in the Negotiation and Consensus Building course develop relevant capabilities that contribute importantly to success in organizational and security situations, including ways to interact successfully and gain cooperation from others, navigate cultural differences, and negotiate mutually beneficial solutions to complex problems.

Prerequisite: None.

MN3121 - Organizational Design for Special Operations (4 - 0)

Principles of organizational design are critically examined and applied to special operations' missions and organizations. Focus is on the organizational level of analysis and includes such topics as organizational environments, key success factors, technology and information systems, configuration and structure, organizational learning, reward systems, and decision making. Case method is used to develop diagnostic skills and a systemic perspective.

Prerequisite: Enrollment in the SOLIC curriculum or consent of instructor.

MN3145 - Marketing Management (4 - 0)

This course takes a general management approach to marketing, examining (1) marketing as s process that creates and sustains customer value; and (2) the manager's role in assuring that the firm delivers products that are successful in the marketplace. The curriculum will emphasize approaches to market research (the "voice of the customer"), innovation, creating customer value in product development, product management, and general management of marketing activities. Topics include: market oriented strategic planning, the TQM marketing process, market research, segmentation, target markets, differentiation, product management, the marketing mix, customer satisfaction, and e-commerce. Case studies are used extensively. PREREQUISITE: NONE

MN3154 - Financial Management in the Armed Forces (3 - 0)

This course is designed for non-MBA students and focuses on financial management policies and practices in the DoD. It begins with a foundation including the origin of the Defense budget from national strategic planning through the PPBE system and the submission of the President's Budget to Congress. The Congressional Authorization and Appropriation processes and the flow of funds to the activity level complete the foundation. The course next explores the funding mechanisms for programs and activities, addressing the proper use and management of appropriated, reimbursable and revolving funds. Basic principles of fiscal law are explored. The course concludes with financial management and stewardship topics including budgetary accounting, management of cost drivers, and internal controls. Contemporary financial management issues are discussed. Exercises and case studies are used to develop the students' ability to apply financial management concepts to real life situations. Prerequisites: None.

MN3155 - Financial Management for Acquisition Managers (2 - 0)

This course is a study of financial management practices and issues associated with federal government acquisition programs. The course has emphasis on (1) the resource management process flow from initiation of a new acquisition program through execution of appropriated funds (procurement and research & development accounts) for that program, (2) the congressional approval and review process unique to procurement, and (3) cost estimation, analysis and evaluation as tools for sound acquisition management decision making, and long-term investment analysis. Prerequisites: None.

MN3156 - Financial and Managerial Accounting (4 - 0)

This course is designed as a first course in Business

Financial Management for graduate students. The course covers a range of topics in financial accounting, managerial accounting and business finance. All topics covered share a common theme in that they are related to the creation and use of financial models and information. The course requires critical thinking and the ability to analyze and apply financial models and reasoning in the context of case studies. The course is divided into two broad areas: Financial Information and Financial Management. Within these areas, specific topics include: financial accounting, financial reports, financial analysis, capital structure, costing systems, performance measurement and control, and investment analysis.

Prerequisite: None..

MN3172 - Resourcing National Security: Policy and Process (3 - 0)

This course analyzes federal policy-making with emphasis on resource decision making for national defense. The roles of principal budget participants are examined in detail. Executive (especially DoD) and congressional budget processes are assessed to indicate how national security policy is implemented through resource allocation. Spending for national security policy is tracked from budget submission through resolution, authorization and appropriation. The politics of budgeting for national defense is evaluated to indicate the dynamics of executive-legislative competition over scarce federal resources. Graded Course. Prerequisite: None.

MN3221 - Principles of Acquisition and Program Management I (3 - 0)

This is the first of two courses which provides the student with an understanding of the underlying concepts, fundamentals and philosophies of the Department of Defense systems acquisition process and the practical application of program management methods within this process. The course examines management characteristics and competencies, control policies and techniques, systems analysis methods and functional area concerns. Techniques for interpersonal relationships will be examined in team exercise settings. Topics, from a program management perspective, include the evolution and current state of systems acquisition management, the system acquisition life cycle, requirements analysis, systems engineering, contract management, test and evaluation, user-producer acquisition management disciplines and activities; and program planning, organizing, staffing, directing and controlling. Case studies are used to analyze various acquisition issues. This course offers DAU equivalencies. PREREQUISITE: None.

MN3222 - Principles of Acquisition and Program Management II (3 - 0)

This is the second of two courses which provides the student with an understanding of the underlying concepts, fundamentals and philosophies of the Department of Defense systems acquisition process and the practical application of program management methods within this process. The course examines management characteristics and competencies, control policies and techniques, systems analysis methods and functional area concerns. Techniques for interpersonal relationships will be examined in team exercise settings. Topics, from a program management perspective, include the evolution and current state of systems acquisition management, the system acquisition life cycle, requirements analysis, systems engineering, contract management, resource management, test and evaluation, user-producer acquisition management disciplines and activities; and program planning, organizing, staffing, directing and controlling. Case studies are used to analyze various acquisition issues. This course offers DAU equivalencies.

Prerequisite: MN3221 or permission of instructor.

MN3301 - Acquisition of Defense Systems (4 - 0)

This course introduces the principles and concepts that underlie successful defense acquisition management. The course focuses on management of the acquisition process for defense systems from the development of an initial desired capability or need through design, development, production, fielding, sustainment, and disposal. Students gain an understanding of successful acquisition as an interdisciplinary activity through contributions and applications of principles from business, management, and technical disciplines. The course also emphasizes the statutory, regulatory, and policy environment of acquisition. Numerous case studies illustrate the application of concepts and principles in actual acquisition programs. Prerequisites: None.

MN3302 - Advanced Project Management (3 - 0)

Builds on the student's experience in the acquisition workforce. Cases are used to examine each of the major disciplines in the acquisition process and bring each student to a current and common understanding of the acquisition environment, process, requirements and management approaches.

Prerequisite: None.

MN3303 - Principles of Acquisition and Contract Management (4 - 0)

This course is an introduction to the principles of government acquisition and contracting. It presents the fundamentals of the Federal Acquisition Regulation (FAR) and the DoD FAR Supplement; the federal acquisition and contracting processes, including requirements determination, acquisition strategies, government contract law, ethics, contract types, contracting methods, and acquisition/contract management techniques. This course offers DAU equivalencies. Prerequisite: None.

MN3306 - Enterprise Sourcing (3 - 0)

This course is a graduate-level seminar in category management and enterprise sourcing. The course will be taught through a combination of formal lecture, guided discussion, and case analysis. The primary goal of this course is to develop, structure, and execute sourcing, not as a functional activity, but rather as a strategic component of total supply chain management. The course emphasizes the concept that companies with world-class sourcing practices derive a competitive advantage in their industries from their procurement and sourcing strategies. The course develops the concept of competitive advantage through category management and enterprise sourcing as it relates to efficient and effective structure and management within the Department of Defense. The emphasis on world-class sourcing practices entails observation and analysis of commercial organizations and their sourcing practices. The student will investigate whether select commercial organizations' sourcing practices are useful to the DoD and determine practical implementation for use in the DoD acquisition environment. Prerequisite: None.

MN3307 - Enterprise Innovation Design (4 - 0)

MN3307 is a graduate level seminar on the entrepreneurial concept and management and its application to enterprise sourcing. Entrepreneurial thinking is designed to exploit opportunities in uncertain environments. The primary goal for MN3307 is to explore and develop strategic and critical thinking in entrepreneurial concepts and management along with specific methods for utilizing these concepts and tools within world-class sourcing organizations. Students will critically examine how the entrepreneurial mindset is applied in progressive business ventures and how DoD and the government can effectively apply these concepts and management tools for effective and efficient category management and sourcing operations. The foundation of MN3307 is an analysis of the process by which the entrepreneurial mindset generates new ideas, researches the likelihood of success, and successfully implements the idea. The course will also investigate the critical role of entrepreneurial leadership and scanning the environment for opportunity, and capitalizing on opportunities to benefit DoD category management and enterprise sourcing organizations. The course will be taught through a combination of informal lecture, guided discussion, case study, and student presentations. Prerequisite: None.

MN3309 - Software Acquisition Management for Defense Systems (3 - 2)

This course focuses on the key aspects of mission critical computer resources with particular emphasis on major weapon systems embedded software. The course analyzes software development, software risk management, software in the systems acquisition life cycle, software metrics, contracting methods for software, software test and evaluation, and software configuration management. Case studies, reports, software specifications and standards, and other similar documents/materials are used. The course addresses the underlying management principles involved in software acquisition. Significant software acquisition issues and problems are examined and solutions developed.

Prerequisite: MN3331/MN3301 or MN3222 or MN3302.

MN3312 - Government Contracts Law (4 - 0)

This course examines the fundamentals of major Congressional statutes, agency policies and regulations, and legal precedents which govern the Federal procurement process. The course contrasts the legal regimes of private and government contracting with strong emphasis on unique aspects of government contracts law, including: appropriations limitations; the power to contract; competitive and non-competitive methods of contract formation; contract administration issues such as changes and terminations; transparency and oversight; and bid protests, size protests and disputes. The course prepares students to identify and choose among legal tools, strategies, and processes which should control their decision-making as contracting professionals. This course offers DAU equivalencies.

Prerequisite: MN3303.

MN3315 - Acquisition Management and Contract Administration (4 - 0)

This course focuses on the management functions and decision-making techniques involved in the award and administration of Best Value competitively negotiated contracts. The first phase of the course concentrates on the source selection phase of the acquisition process; specific topics include acquisition planning, market research, source selection planning, proposal development, solicitation management, source selection evaluation, contract award, and contractor debriefings. The second phase of the course emphasizes the performance phase of the acquisition process; specific topic areas include organizing for contract administration, transitioning to performance, quality management, subcontract management, financial management, performance monitoring, change management, and contract closeout. Emphasis is on the use of legal case studies and practical exercises.

Prerequisite: MN3303.

MN3318 - Operational Contract Support & Contingency Contracting (3 - 0)

This course is a study of the principles of contingency contracting and the fundamental skills required to provide direct contracting support to joint tactical and operational forces participating in the full spectrum of armed conflict and military operations other than war, both domestic

and overseas. Topics include: Types of Contingencies, Cross-Cultural Awareness, Contingency Contracting Officer Authority, Roles and Responsibilities, Anti-Terrorism and Security, Planning, Contractual Methodologies and Instruments, Automated Tools, APEX and JOPES Deliberate and Crisis Action Planning, Annex W, Planning Synchronization and Integration, Phase Zero Contracting Operations, Funding and Execution, Contract Administration and Management (including terminations and closeouts), and Ethics/Standards of Conduct. Prerequisites: None.

MN3320 - Contract Cost and Price Analysis (3 - 0)

This course involves the study and application of pricing theory and strategies, costing methods, cost and price analysis, cost principles, Cost Accounting Standards, and related genres in examining proposed and incurred costs in Federal contracts in both pre-award and post-award contexts. This course offers DAU equivalencies. May not require this for MSCM students with extensive field experience and existing CON Level I DAU certification or higher.

Prerequisite: MN3303 or similar introductory contracting principles course.

MN3321 - Federal Contract Negotiations (3 - 0)

This course involves the study and application of the art and science of developing and conducting comprehensive government contract negotiations. Emphasis is placed on cost and price analytical techniques in the formulation and presentation of a pre-negotiation business clearance, strategy and actual conduct of negotiations in a simulated business environment. This course offers DAU equivalencies.

Prerequisite: MN3320.

MN3331 - Principles of Acquisition and Program Management (5 - 1)

This course provides the student with an understanding of the underlying concepts, fundamentals and philosophies of the Department of Defense systems acquisition process and the practical application of program management methods within this process. The course examines management characteristics and competencies, control policies and techniques, systems analysis methods and functional area concerns. Techniques for interpersonal relationships will be examined in team exercise settings. Topics, from a program management perspective, include the evolution and current state of systems acquisition management, the system acquisition life cycle, requirements analysis, systems engineering, contract management, resource management, test and evaluation, user-producer acquisition management disciplines and activities; and program planning, organizing, staffing, directing and controlling. Case studies are used to analyze various acquisition issues. MN3331 is offered both in resident and in a non-resident mode (distance learning),

and is equivalent to MN3221/MN3222 and GE3221/GE3222. MN3331 contributes to program management (PM) practitioner level fulfillment for Defense Acquisition University (DAU) training DAWIA requirements. PREREQUISITE: None.

Cross-Listed as: MN3221/MN3222 and GE3221/GE3222.

MN3352 - Cost Management (3 - 0)

This course will explore the development and use of cost information by managers. Its focus will be on management applications and analyses rather than on bookkeeping techniques and methodologies. The course will examine accounting measurements and analyses that provide relevant information for management decision-making, operational control, and productivity improvement. These internally-oriented processes are fundamentally different from those used to comply with external financial accounting requirements. The primary objectives of the course are as follows: reinforce skills in reporting and analyzing managerial accounting information; develop experience in analyzing this information from the perspective of its various users, especially management; develop the ability to identify and communicate relevant managerial accounting information; and develop an appreciation of the usefulness and limitations of managerial accounting information. Developed for Cost Management Certificate Program.

Prerequisite: Department of Army approval for enrollment.

MN3353 - Operations Management (3 - 0)

This course is about the fundamentals of managing manufacturing and service operations and about how DoD managers can effectively design and control operational processes. Helping students understand the concepts and techniques necessary for attaining a world-class performance in manufacturing and service operations is the main learning objective of this course. Analyzing and continuously improving enterprise-wide processes is critically important for achieving such a performance and hence the course will adopt a "process management" viewpoint while addressing a variety of operational and strategic issues. The course begins by introducing the operations function and its "mission" in terms of cost, quality, speed, service, and flexibility. Several exercises and cases are used here to illustrate the concepts fundamental to process analysis, including capacity, bottleneck, cycle time, and inventory, and their implications to cost management. The book by Goldratt, The Goal, is also discussed to provide a real-world context to the variety of issues addressed in the course, and to introduce the Theory of Constraints (TOC). At this point the course will cover the topics of capacity planning, inventory management, MRP/ERP and project management. The course will end with an introduction to supply chain management, a topic integrating a number of concepts covered earlier in the course. Developed for

Cost Management Certificate Program.

Prerequisite: MN3352.

MN3361 - Software Acquisition Management (2 - 0)

Advanced Acquisition Program. This course concentrates on the management of software products and software intensive systems. It is intended to focus essential program management techniques on the software element to ensure successful and timely system development. The course provides the student with knowledge of software acquisition management control processes and tools. Current software acquisition articles and caselets are analyzed for application of program leadership, software development techniques, and management tools applied. Topic areas include: DoD software environment; software acquisition strategies; impediments to successful software intensive system development; software oriented requirements development; contracting for software, software discriminate proposals; software test and evaluation management; Post Deployment Software Support; risk management; and software costing and budgeting. Integrative exercises involving software managerial problem solving and decision making in the program management environment are used.

Prerequisite: MN3331 or consent of instructor.

MN3362 - Acquisition Design Verification and System Assessment (2 - 0)

Advanced Acquisition Program. This course examines Developmental, Operational, and Joint Test & Evaluation as viewed from the Program Manager's perspective. The student will be able to distinguish the difference between the various testing types and the impact testing results will have on the decision makers thought process. Actual military and civilian test cases are used as examples for discussion purposes. Topics include the role of T&E in the Systems Engineering Process, T&E policy Structure and Oversight Mechanism, Requirements Generation, Modeling and Simulation, Alternative Acquisition Program T&E, Human systems Integration and Live Fire T&E. Integrative case studies involving managerial problem solving and decision making in the PMO environment are also used to provide application of concepts in both IPT teaming and multiple-role individual settings. Teamwork exercises are conducted to reinforce concepts and add real-world human dynamics. Upon completion, all exercises are evaluated with after-action reviews and assessments.

Prerequisite: MN3331 or consent of instructor.

MN3363 - Acquisition Manufacturing and Quality Management (2 - 0)

For AAAP program students. This course provides the student with knowledge and application of integrated management control processes with regard to performance, cost, and schedule, while examining higher-level and real world defense systems. Issue-oriented topic areas likely to affect Program Management Office personnel include: acquisition reform; acquisition strategy; industrial base; production and manufacturing; quality management; and risk management. Integrative case studies involving managerial problem solving and decision making in the PMO environment are also used to provide application of concepts in both IPT teaming and multiple-role individual settings. Teamwork exercises are conducted to reinforce concepts and add real-world human dynamics. Upon completion, all exercises are evaluated.

Prerequisite: MN3331 or consent of instructor.

MN3364 - Business Financial and Contract Management (2 - 0)

ADVANCED ACQUISITION PROGRAM. The course builds on the student's knowledge and experience in contracting, and contracting related fields, to address the more complex pre-award, award and post-award issues in the acquisition and contracting, and business and financial management arenas.

Prerequisite: MN3331 or permission of instructor.

MN3365 - Acquisition Logistics & Program Sustainment (2 - 0)

ADVANCED ACQUISITION PROGRAM. This course focuses on the logistics and sustainability planning for new major weapon systems in each phase of the DoD acquisition process. It links logistics and sustainability planning, in the early stages of system development, to the effects on the system's total ownership cost. The course describes sustainability planning and management through the Systems Engineering Process and supportability analyses techniques. The course addresses the following specific subject areas: Designing for Life Cycle Cost and Cost as an Independent Variable (CAIV); Logistics Supportability Elements; Supportability analyses; Logistics Open Systems; Software Support Planning; Supply Chain Management; and Post-Production Support Planning.

Prerequisite: MN3331 or permission of instructor.

MN3384 - Acquisition Production, Quality and Manufacturing Decision Science (3 - 2)

This course provides the student with an understanding of the principles and concepts of production and quality management in the DoD acquisition environment. Topics include production planning and control, "lean" production, and bottleneck analysis; quality management systems, statistical process control, and six sigma; cost estimating methods, activity based costing, and progress payments in support of production; productivity; environmental, safety and occupational health; warranties; specs & standards reform; and the Defense industrial base.

Prerequisite: MN3331 or MN3221/MN3222 or MN3301 or permission of instructor..

MN3392 - Systems and Project Management (4 - 0)

Management ensures progress toward objectives, proper deployment and conservation of human and financial resources, and achievement of cost and schedule targets. Topics include strategic project management, project and organizational learning, lean thinking, cost, schedule planning and control, structuring of performance measures and metrics, technical teaming and project management, information technology support, risk management, and process control. Course delivery consists of lectures, speakers, case studies, and experience sharing, and reinforces collaborative project-based learning and continuous improvement.

Prerequisite: MN3108.

MN3400 - Critical Thinking for Strategic Leadership (4 -)

This course is about thinking critically and its importance for national security. It will help students better understand how to use critical thinking as a tool for strategic leadership. The course will show why critical and strategic thinking is important, and how it can be used to understand competitive situations and trends in the strategic environment; and help better formulate and analyze ideas about complex problems (in both business and defense-oriented organizations), and the examination of cases of leaders, leadership and critical and strategic thinkers in the past and present. *The topic and the approach meets a timely need identified most recently in the Education for Sea-power Study which calls for (much) greater attention to educating for strategic and critical thinking and strategic leadership.* Open to both resident and DL students.

Prerequisite: NA. Corequisite: NA. Cross-Listed as: NA.

MN3401 - The Academy and the Brigade (4 - 0)

This course is designed to make you a more effective leader, teacher and role model. It covers a combination of topical leadership concerns, adult learning theory, and organizational psychology associated with service as a Company Officer at the United States Naval Academy. It will involve discussions with some of the Academy's key stakeholders and debates about the most effective means to produce highly capable Navy and Marine Corps officers. It will involve examining the principal institutional challenges and their potential solutions. Above all, this course will expose the student to the key issues facing the Academy and Brigade of Midshipmen.

MN3404 - LEAD Fellows Teaching Practicum (Part 1) (0 - 4)

This course is a field assignment to co-teach United States Naval Academy midshipmen a foundation course on the study of leadership. It focuses on the processes of teaching and learning at the United States Naval Academy. The central topic for the core curriculum of the Leadership, Ethics, and Law Division is leadership.

Therefore, as leadership instructors, officers have to be consistently strong role models. This course offers the first opportunity to interact with midshipmen as an instructor. The course is the first course in a two-course sequence.

MN3405 - LEAD Fellows Teaching Practicum (Part 2) (0 - 4)

This course is a field assignment to co-teach United States Naval Academy midshipmen a foundation course on the study of leadership. It focuses on the processes of teaching and learning at the United States Naval Academy. The central topic for the core curriculum of the Leadership, Ethics, and Law Division is leadership. Therefore, as leadership instructors, officers have to be consistently strong role models. This course offers the first opportunity to interact with midshipmen as an instructor. The course is the second course in a two-course sequence.

MN3406 - LEAD Fellows Counseling Practicum (Part A) (2 - 0)

This course addresses the study and practice of counseling. It explores the academic counseling resources available at the United States Naval Academy, the difference between counseling and coaching, and the elements of constructive counseling/coaching sessions. Students will work directly with midshipmen and engage in targeted counseling/coaching.

MN3407 - LEAD Fellows Counseling Practicum (Part B) (0 - 2)

This course addresses the study and practice of counseling. It explores the academic counseling resources available at the United States Naval Academy, the difference between counseling and coaching, and the elements of constructive counseling/coaching sessions. Students will work directly with midshipmen and engage in targeted counseling/coaching.

MN3420 - Supply Chain Management (3 - 0)

This course is designed to provide an introduction to supply chain management (SCM). A supply chain is a network of organizations that supply and transform materials, and distribute final products to customers. Supply chain management is a broadly defined term for the analysis and improvement of flows of material, information, and money through this network of suppliers, manufacturers, distributors, and customers. The objective of SCM is to deliver the right product to the right customer at the right time. SCM emphasizes inventory-service level tradeoffs across the chain of players that, together, provide the product to a customer. Logistics has traditionally focused on materials issues within and downstream from the factory while SCM looks

at the entire network of players, both up and down stream, and perhaps has more of an emphasis on information flows through the network. Logistics has traditionally been considered a more tactical topic while SCM has risen to prominence in recent years, attracting high-level attention. Ultimately, logistics and SCM activities are concerned with coordinating demand and supply. Common elements in that coordination are the management of materials (inventories), the location of materials (warehouses), and the movement of materials (transportation). As part of the coordination, an analyst must consider product and process designs as well as information flows between various players in the networks. These elements will form the basis of this course. This course is the Distributed Learning version of MN4480.

Prerequisite: MN3042, MN4043.

MN3441 - Technology for Managerial Data Analysis (3 - 0)

This course introduces students to several foundational data technology concepts and tools. Databases and fundamentals of data storage will be introduced. Students will learn to prepare, organize, compile, visualize and process data. Key computer programming concepts, such as variables, inputs, outputs, if-statements and for-loops will be covered, with a focus on applying these concepts to automate routine tasks. Students will gain hands-on experience with technologies and tools.

Prerequisite: N/A. Corequisite: N/A.

MN3442 - Process Analytics (4 - 0)

This course provides strong grounding in the analytical techniques necessary for analyzing, improving and managing operational processes that create and deliver an organization's primary products and services. Accordingly, this course provides DoD managers with the foundation to effectively design, manage and control operational processes. The course design consists of two inter-linked modules -- (1) process analysis, and (2) process improvement. Within these modules, the course covers concepts and analytical techniques such as bottleneck, capacity management, cycle time, critical path, Little's Law, linear programming, simulation, theory of constraints, inventory management, queuing models, and Lean Six Sigma. After successfully completing the course, the students earn a Yellow Belt Certificate in Lean Six Sigma. Prerequisite: None.

MN3500 - Strategic Thinking for Warfighters in the Cognitive Era (3 -)

Brief Course description

This course is about thinking strategically and improving strategic thinking for warfighters in the context of great power competition and the cognitive era. It will help students to use interdisciplinary frameworks as tools for

understanding how to think strategically for long term national competitive advantage, and build on lessons, insights and works from great strategic thinkers, extending and applying their ideas to current and future strategic environment. Blending concepts and cases from business and national security, the course will use active learning approaches and be case and project based, and students will also apply the concepts and ideas covered in class to real world strategic problems relevant to warfighters and warfighting organizations.

The course will be highly interdisciplinary, empirically driven and integrative. The course will help students understand the importance of strategy and strategic thinking; how to think through long term national security issues through the lens of net assessment (and the underlying approaches central to the framework); how to understand competitor thinking, and how to think through competitive situations (ill structured and ambiguous problems) in a national security context. Also, central will be to help students develop cognitive skills and attitudes central to strategy and strategic thinking (including but not limited to cognitive flexibility and active open-mindedness), and applying those to thinking about the strategic environment.

The topic and the approach meets a timely need identified most recently in the Education for Sea-power Study & Modly, calling for (much) greater attention to educating for strategic thinking; and NSS/NDS/Matts calling for the need to upgrade our national strategic thinking capabilities; as well as the call for education for mid career officers on strategy.

Prerequisite: NA.

MN3510 - Defense Financial Management Practice (3 - 0)

This course presumes the student has a foundation including the PPBE system and Congressional Authorization and Appropriation processes. This course concentrates on financial management practices within DoD as distinct from policy and budgeting theory. The course covers the actors and activities and mechanics of building and defending budgets. It covers funding mechanisms for programs and activities, addressing the proper use and management of appropriated, reimbursable, and revolving funds. Basic principles of fiscal law are explored. It then addresses financial management and stewardship topics including budgetary accounting, management of cost drivers, the relationship between comptrollership and contracting, and internal controls. Contemporary financial management issues are discussed. Exercises and case studies are used to develop the students' ability to apply financial management concepts to real life situations.

Prerequisite: MN4053.

MN3611 - Introduction to Business Law (4 - 0)

The course will focus on the legal, ethical and practical aspects of business law to prepare students for their roles

as leaders within the military and other government positions who necessarily interact with businesses. Key topics include the U.S. legal system, business organizations, agency, contracts, torts, real and intellectual property, and creditor-debtor relations. Class time is a combination of lecture and case-based discussion. Emphasis is placed on learning legal principles, analytical problem-solving based on those principles, and ethical decision making. Prerequisites: None.

MN3612 - Fraud Examination (3 - 0)

This course provides an overview of the basic concepts and principles of fraud theory and its implications to the federal government. The course is designed to provide insights into fraud awareness in industry as well as in the federal government. The major emphasis is on the nature of fraud, why people commit fraud, fraud risk assessment, fraud prevention and deterrence, fraud detection, fraud investigation, management fraud, and other types of fraud such as conflicts of interest, bribery, and corruption. A special emphasis will be on government procurement and contract fraud schemes. This course covers a wide range of topics related to fraud theory, which are applicable to DoD and public service. Prerequisite: None.

Prerequisite: None. Corequisite: None.

MN3811 - Innovation Adoption & Implementation (3 - 0)

This is an introductory course to basic issues in innovation adoption. The course helps students develop their knowledge about how the great new technologies, ideas and practices they research and talk about in other classes or in their workplaces actually get adopted by individuals and organizations. Students will learn that the adoption of innovations is mainly a management problem rather than a technical one, and it is not trivial: most innovators will tell you that in fact it is the hardest part of innovation, the messiest, and sometimes it never works at all. As a result, many good ideas wither on the vine, creating significant waste, frustrating those who want them adopted, and reducing organizational effectiveness and efficiency compared to what could be achieved. In this course we will get inside this phenomenon and understand why innovation adoption proceeds the way it does. The course will help you develop your ideas about innovation adoption so that you might do things better when your turn comes. Prerequisites: None.

MN3900 - Readings in System Management (V - 0)

An individualized program of readings and study in some area of the systems management, designed to meet the student's special educational needs. Graded on a Pass/Fail basis only.

Prerequisite: A background in the area of study and departmental approval.

MN3911 - Introduction to Data Analytics for Defense Management (3 - 0)

This course introduces students to foundational techniques for preparing and analyzing data. Each week, students will learn one or more concepts, and then apply acquired skills in a structured learning exercise. Topics include: pivot tables, visualization, data storage and retrieval, computer programming, summary statistics, and an introduction to probability and probability distributions.

Prerequisite: None.

MN4011 - Ethical Leadership in Public Organizations (3 - 2)

Given the regular calls from the Navy for better prepared leaders with a strong moral compass, this course focuses on advanced concepts of leadership development in public organizations:
1. That are directly and immediately applicable for NPS students;
2. That will serve them for the rest of their careers, spanning both military and other public service roles;
3. That will enable them to build character and competence within the units they lead while establishing positive, empowering relationships with their followers.

Our students will become more effective leaders and make more ethically sound decisions as they: (a) assess their own abilities, values, strengths, and weaknesses; (b) take responsibility for their own ethical and leadership development; and (c) work consciously on developing character alongside leadership competence. This course is designed to *consolidate* the leadership skills that students have already developed, and *propel* students to the next level of advanced leadership capabilities.

Prerequisite: Prerequisite: GB3010, GE3010, MN4474, or another course that introduces organizational behavior, processes, and leadership.. Cross-Listed as: GC4011: Online version of MN4011. Given the regular calls from the Navy for better prepared leaders with a strong moral compass, this course focuses on advanced concepts of leadership development in public organizations: That are directly and immediately applicable for NPS students;   That will serve them for the rest of their careers, spanning both military and other public service roles;   That will enable them to build character and competence within the units they lead while establishing positive, empowering relationships with their followers Our students will become more effective leaders and make more ethically sound decisions as they: (a) assess their own abilities, values, strengths, and weaknesses; (b) take responsibility for their own ethical and leadership development; and (c) work consciously on developing character alongside leadership competence. This course is designed to consolidate the leadership skills that students have already developed, and propel students to the next

level of advanced leadership capabilities..

MN4012 - Maneuver Warfare for the Mind: The Art and Science of Interdisciplinary Learning for Innovation and Warfighting Leaders (4 - 0)

Brief Course Description/Abstract

This course is about thinking, learning, and leading in the context of US Navy and US Marine Corps history, emerging naval warfighting concepts, interdisciplinary thinking and learning and tactical decision making in the post-industrial era. The course is interdisciplinary and integrative and focuses on understanding, contextualizing, developing, and integrating the ideas of John Boyd and other leaders, especially as it relates to maneuver warfare, as a means to cultivate learning leaders who can build and lead learning organizations; develop more effective integrative learning with regard to concepts, research, and experimentation for warfighters and warfighting – themes central to supporting the implementation and future development of MCPD-7, the 38th CMC's Planning Guidance, the NDS, and other key strategic documents.

In particular, the course will focus on understanding and applying the central ideas and intellectual foundations of maneuver warfare. Maneuver Warfare is central to emerging naval operating concepts such as DMO and EABO, it is critical for understanding the forces that shape the future security environment, and it provides tenets for developing thinking and learning leaders. In doing so, the course will build understanding and support for current service-level change by using the ideas in (and underlying) FMFM-1 "Warfighting" and then understanding and applying maneuver warfare as an approach to leading organizational change in both USMC, Navy, and beyond. It will also support central ideas in MCDP-7 "learning" and explicate additional insights from literature on thinking, learning, and leadership and discuss their implications for warfighting leaders.

(Open to both resident and DL students.)

Prerequisite: none.

MN4014 - Competitive Strategy and Innovation (4 - 0)

Strategic Management entails the establishment of an organization's direction and the implementation and evaluation of that direction in view of the organization's external environment and its internal capabilities. The principal aim of this course is the transfer and adaptation of the principles of business strategic management to the Department of Defense and other government agencies. In previous courses, students concentrated on the functional elements of management (e.g., accounting, finance, acquisition, logistics, contracting, etc.). This course addresses the challenges of setting direction and implementing strategies for the total system or whole organization. Cases and approaches from the public and private sectors enable students to develop the knowledge, skills, and abilities to strategically think, plan, and manage.

Prerequisite: GB3010, GB3012.

MN4015 - Management of Change (4 - 0)

This course recognizes and describes the dilemmas inherent in any effort to change a human system. Emphasis is placed on strategies and technologies for planning, managing, and implementing change. The course emphasizes approaches to planning and managing change that reflect the complexity of organizations comprised of several interdependent systems-- technology, structure, task, culture, and people. The course is application oriented and intended to enhance skill development.

Prerequisite: GB3010, GB4014.

MN4017 - High-performance Decision Practices (3 - 0)

This advanced course helps the student to master social, psychological, and organizational aspects of successful decision making. The focus is on principles and processes that facilitate effective decision making and support collaborative relations among stakeholders. Students learn and apply these principles at the individual, group, and inter-group levels, experimenting with distinct approaches to decision making and analyzing the usefulness of each approach. The course addresses creativity and brainstorming, cognitive biases and mitigation strategies, ethics in ambiguous situations, group decision dynamics, approaches to improve group decision making, stakeholder analysis, judgment under uncertainty, and development of cooperative solutions.

Prerequisite: none. Cross-Listed as: Cross-listed with GC4017.

MN4021 - Strategic Management of IT (4 - 0)

The management of Information Technology (IT) within the government and corporate environments has become a critical knowledge area for both IT specialists and General Managers. With so many business functions dependent on IT support, it is imperative to understand the importance of and unique issues related to technology. Network Centric Warfare has been deemed mission critical to the success of the military now and in the future. This course provides the student with a general understanding of the key components and underlying concepts related to the valuation of technology within organizations. Topics include e-business, e-government, strategic outsourcing, software make vs. buy decisions, business process, re-engineering with technology, and the impacts of technology on force transformation. A special emphasis is placed on Enterprise IT support for Supply Chain Management. The course does not focus on the technical aspects of technology, but rather on the impact and importance of technology to support mission critical business functions.

Prerequisite: MN3442 or consent of instructor.

MN4043 - Business Modeling and Analysis (3 - 0)

This course introduces mathematical modeling for a

sound conceptual understanding of the decision-making process. This course familiarizes the students with applications, assumptions, and limitations of the quantitative methods in modeling. It focuses on the development of mathematical and spreadsheet models, the verification of those models, sensitivity analysis of the solutions generated from a model, and the implementation of those solutions. Some of the topics covered include linear programming, non-linear and integer programming, simulation, and forecasting. The process of modeling and particular modeling tools are applied to business problems in finance, acquisition, logistics and manpower planning. Prerequisites: None.

MN4044 - Defense-Focused Managerial Inquiry and Innovation Lab (3 - 2)

This course is designed to meet a very specific requirement to prepare students to understand and navigate the capstone requirement for DDM (Department of Defense Management) MS degrees. The course is part of a 3-block DDM capstone sequence (MN4044, MN4090, MN4090). It is a hands-on course where students will: (a). Work through the initial set of tasks each capstone has to successfully navigate in order to become established, and (b) Gain essential knowledge on how to manage their capstone through to completion using their MN4090 capstone blocks.

MN4045 - Defense-Focused Managerial Inquiry (3 - 0)

Fundamentally, this is a course in thinking critically and analytically. It is also a unique, practical opportunity for students to develop a research question, methodology, and proposal for their master's thesis. Indeed, many students can expect to complete the initial stages of their MBA project or thesis by fulfilling the course requirement for a team-based research report. As Cooper and Schindler write: "Research is any organized inquiry carried out to provide information for solving problems. Business research is a systematic inquiry that provides information to guide business decisions. This includes reporting, descriptive, explanatory, and predictive studies. The managers of tomorrow will need to know more than any managers in history. Research will be a major contributor to that knowledge. Managers will find knowledge of research methods to be of value in many situations. They may need to conduct research either for themselves or for others. As buyers of research services, they will need to be able to judge research quality. Finally, they may become research specialists themselves." Punch prefers to describe research as "organized common sense," since it "supports the idea that good research is within the grasp of many people." In this way, we can "simplify the more technical aspects of research methods, and enhance understanding, by showing the logic behind them." This course similarly seeks to examine the logic of research methods--recognizing that these methods may differ

across disciplines and subspecialties--rather than focus on detailed models or procedures that may hold little meaning for the military's managers. It is not a course in rules or required steps; rather, it is a course in understanding the principles, concepts, and range of techniques that define the craft of research. Prerequisite: None.

MN4047 - Economics for the Professional Military Officer (3 - 0)

The primary purpose of this course is to provide students with a thorough introduction to the economics of defense, not merely for its own sake, but with the intent of making them more effective officers. The economic way of thinking is a powerful tool with which to make sense of the world, and matters of national defense are no exception. Mastery of the material presented will enhance students' ability to analyze important social relationships and institutions, both with respect to the nature of information available to the relevant stakeholders and the incentives they have to act on that information. With such knowledge comes a greater understanding of the process through which the military provides for the nation's defense, as well as a better understanding of the strengths and weaknesses of that process. Mastery of the material will very likely make them a more effective officer for a variety of reasons.

MN4052 - Managerial Finance (3 - 0)

This course provides an overview of the basic concepts and principles of financial management in the private sector and its implication on government contracting. It is designed to provide insights into the financial decision-making process encountered by commercial enterprises. The major emphasis is on financial environment, risk and return analysis, valuation models, cost of capital determination, optimal capital structure, and short-term and long-term financing.

Prerequisite: MN3050.

MN4053 - Defense Budget and Financial Management Policy (4 - 0)

This distance learning course analyzes the resource requirements process within the Department of Defense (DoD) and in the executive and legislative branches of the federal government. It begins with a summary of the current threat situation and potential changes to it. Once the threat is defined, the study of the resource allocation process to meet the threat begins. The course covers the resource planning and budgeting processes of the Department of the Navy, DoD and the federal government. It includes the politics of executive and congressional budgeting, and DoD budget and financial management processes and procedures including budget formulation and execution. It also includes analysis of the Planning, Programming, Budgeting and Execution system

(PPBES) used by DoD to plan, budget and implement national defense resource management policy and programs. Other areas included are budget process and fiscal policy reform and the dynamics of internal DoD competition for resources. Executive and congressional budget processes are assessed to indicate how national security policy is resourced and implemented through the budget process. Spending for national security policy is tracked from budget submission through resolution, authorization and appropriation. Budget formulation, negotiation, and execution strategies are evaluated to indicate the dynamics of executive-legislative competition over resource allocation priorities. Supplemental appropriation patterns and current year budget execution patterns and problems are also considered. Prerequisite: None.

Cross-Listed as: GE4053.

MN4070 - Energy Economics (4 - 0)

This is an applied economics course in which microeconomic analysis will be applied to energy-related phenomena. The course begins with an introduction to basic microeconomic theories and tools, including the forces driving supply, demand, and market equilibrium. With these tools, the student will explore the fundamental issues surrounding the economics of energy production and use, and how government intervention, both at the domestic level and at the international level, influences energy markets. Specific attention is paid to the ways in which energy is similar and dissimilar to other goods and services that are traded in the economy. Throughout the course, emphasis will be placed on the practical application of economic theories and concepts to important public policy issues. The defense department is the largest consumer of energy in the federal government, and this course will equip students to be better stewards of energy resources. Prerequisites: None.

MN4071 - Advanced Economic and Defense Policy Analysis (4 - 0)

MN4071 is an applied microeconomics course that further augments the economic toolkit of policy analysts to understand the effects of government intervention in the economy. Building on the microeconomic foundations taught in MN3070, MN4071 is a follow-on course providing tools for conducting thoughtful economic public policy analysis. The goal of the course is for you to be able to evaluate and compare alternative public policies in both DoD and civilian environments using the theoretical and empirical tools of economic analysis.

Prerequisite: GB3070 or MN4070.

MN4076 - Economics for the Professional Military Officer (3 - 0)

The primary purpose of this course is to provide students with a thorough introduction to the economics of defense, not merely for its own sake, but with the intent of making them more effective officers. The economic way of thinking is a powerful tool with which to make sense of the world, and matters of national defense are no exception. Mastery of the material presented will enhance students' ability to analyze important social relationships and institutions, both with respect to the nature of information available to the relevant stakeholders and the incentives they have to act on that information. With such knowledge comes a greater understanding of the process through which the military provides for the nation's defense, as well as a better understanding of the strengths and weaknesses of that process. Mastery of the material will very likely make them a more effective officer for a variety of reasons.

Prerequisite: GB3070.

MN4090 - Capstone Applied Project (0 - 6)

Course reflects laboratory hours dedicated to presenting research techniques and independent/team efforts needed to conduct Joint Applied Project research and analysis and to produce the Professional Report. These laboratory hours will be used by students and student teams for interactions with their Joint Applied Project advisors, Academic Associate(s), editors, and thesis processors in producing high quality, disciplined research products for publication as appropriate. Prerequisite: None.

MN4101 - Collaborative Problem Solving I (3 - 3)

GE4101 is the first part of the capstone project which uses a collaborative approach to integrate the knowledge and skills gained in the degree program. Participants are introduced to an applied research framework designed to enable them to work from theory to identify a business problem to be solved for a command; create a research design for data collection and analysis; and form conclusions and recommendations. Prerequisite: Completion of the previous seven quarters of the degree program.

MN4102 - Collaborative Problem Solving II (3 - 3)

MN4102 is the second part of the capstone project which uses a collaborative approach to integrate the knowledge and skills gained in the degree program. Participants work in small teams to prepare a project proposal, a final report, and a presentation containing recommendations to solve one of the command's business problems. Prerequisite: Completion of the previous seven quarters of the degree program.

MN4105 - Strategic Management (3 - 0)

Strategic Management entails the establishment of an organization's direction and the implementation and evaluation of that direction given the organization's external environment and its internal capabilities. The

principal aim of this course is the transfer and adaptation of the principles of business strategic management to the Department of Defense and other federal agencies. In previous courses, students concentrate on the functional elements of management (e.g., accounting, finance, acquisition, logistics, contracting, etc.). This course addresses the challenges of setting direction and implementing strategies for the total system or whole organization. Cases and approaches from the public and private sectors enable students to develop the knowledge, skills, and abilities to strategically think, plan, and manage.

Prerequisite: MN3012.

MN4106 - Manpower/Personnel Policy Analysis (4 - 0)

Study and analysis of military manpower/personnel policy alternatives with emphasis on identifying the trade-offs involved, the dynamic impact of major policy decisions and the short-term and long-term consequences of decisions. Review, use and evaluation of tools to aid in selecting policy alternatives. Analysis of issues in the DoD and military services.

Prerequisite: MN4111.

MN4107 - Systems Thinking and Modeling for a Complex World (4 - 0)

This course introduces you to System Dynamics modeling for the analysis of organizational policy and strategy. You will learn to visualize an organization in terms of the structures and policies that create dynamics and regulate performance. The goal is to use the analysis and modeling techniques of System Dynamics to improve understanding of how complex organizational structures drive organizational performance, and then to use that understanding to design high leverage interventions to achieve organizational goals. We use role playing games and computer-based simulations called "microworlds," where space and time can be compressed, slowed, and stopped so we can experience the long-term side effects of decisions, systematically explore new strategies, and develop our understanding of complex systems (analogous to the "flight simulators" that pilots use to learn about the dynamics of flying an aircraft). The course presents system dynamics with a minimum of mathematical formalism. The goal is to develop the students' intuition and conceptual understanding, without sacrificing the rigor of the scientific method (No prior computer modeling experience is needed.). Prerequisites: None.

MN4110 - Multivariate Manpower Data Analysis I (4 - 1)

An introduction to multivariate data analysis. This section will focus on the tools necessary to perform data analysis. The primary goal of this course is to introduce multiple linear regression models. The second goal involves making correct inferences and interpretations of the findings. Special topics include hypothesis testing, model specification issues, multicollinearity, dummy variables, and research methodology.

Prerequisite: MN3041 or permission of instructor.

MN4111 - Multivariate Manpower Data Analysis II (4 - 1)

An introduction to the specialized multivariate techniques used for analysis of military manpower data. Topics include advanced linear estimation techniques, such as panel data analysis and two-stage models. In addition, nonlinear methods are introduced, such as binary choice models and survival analysis. The course also covers special techniques for policy evaluation and reduction of estimation bias due to omitted variables or sample selection. Students apply techniques to manpower databases.

Prerequisite: MN4110 or permission of instructor.

MN4114 - Sociological and Psychological Perspectives on Military Service (4 - 0)

Exploration of the concepts, theories, and methods of military sociology and military psychology as applied historically and in the current setting. Study of the military as a social institution, focusing on the internal organization and practices of the armed forces as well as the relationship between the military and society. Review and evaluation of the psychological principles employed in a variety of military areas such as health care, selection and job classification, human factors, organizational systems, personnel security, and performance appraisal. Emphasis on representative cases in DoD and the armed forces.

Prerequisite: GB3010.

MN4115 - Foundations of Education and Learning in DoD Organizations (3 - 0)

Analysis of issues in DoD education, learning and training (ELT). Major course themes focus on understanding adult military ELT from a strategic systems perspective; analyzing instructional program design, implementation, and technologies and applying methods of needs analysis and program evaluation. Examination of how DoD can become a learning organization to respond to the dynamic demands of both the organization and its military members. Guest speakers, military publications, student cases, and discussion based on the experience of the instructor and the students are utilized to maintain the necessary focus on current military applications.

Prerequisite: GB3010.

MN4116 - Society of Human Resource Management (0 - 3)

This course prepares students for taking the Human Resource Certification Institute (HRCI) certification examination.

Prerequisite: Enrollment in the MSA curriculum and permission of the instructor.

MN4119 - Navy Manpower Requirements Process (3 - 0)

An in-depth analysis of fleet and shore unit Manpower

requirements and personnel documents. The course will cover the determination and validation of fleet requirements as they pertain to an operational unit's Required Operational Capabilities and Projected Operational Environment and the resulting Ship Manpower Document (SMD), Squadron Manpower Document (SQMD), and Fleet Manpower Document (FMD); and how the Shore Manpower Requirements Determination Process (SMRDP) links the Mission, Function and Task statement to the resulting Statement of Manpower Requirements (SMR). The course covers how fleet and shore manpower documents link with the Activity Manpower Document (AMD). The Personnel sub-process will be studied as it relates to the Enlisted Distribution and Verification Report (EDVR) in support of fleet readiness.

Prerequisite: Enrollment in the MSA curriculum and consent of instructor.

MN4123 - Organizing and Planning in Complex Networks (4 - 0)

In 21st century operational and policy settings, people are expected to work in networks to get things done. Operating beyond the boundaries of any one organization in an inter-organizational domain, network members are called upon to join forces and work collaboratively with others. Network collaborations are difficult, however, because they challenge traditional management assumptions. Members must coordinate without hierarchy, lead without formal authority, and solve problems and make decisions without someone being "in control:" or "in charge." This course provides the basic knowledge, skills, and abilities to enable students to work collectively in networks, especially those with members who come from different cultural, ethnic and national organizations. With the use of cases, experiential exercises, and simulations, students learn how to craft and execute collaborative strategies to improve network performance.

Prerequisite: Consent of Instructor.

MN4125 - Managing Planned Change in Complex Organizations (4 - 0)

Examination of the approaches to planning and managing change efforts in complex social systems made up of the interdependent components of technology, structure, task, and people; and of the role of the manager or staff specialist; and the process of helping. Emphasis is placed on strategies and technologies for diagnosis and planning aimed at effective implementation. Course provides opportunities for practice using both simulations and actual organizational cases. Particular emphasis is placed on the DoD/ DoN organizations and the special problems they have in bringing about change. Prerequisites: None.

MN4128 - Advanced Topics in Manpower Policy Evaluation (3 - 0)

The DoD is constantly evaluating the feasibility and likely consequences of various policy proposals. Typically, however, these analyses must be executed in a short period of time. This course prepares students to conduct real-time policy analysis in the DoD, focusing on the inevitable tradeoffs between depth of analysis and speed of completion. Students will practice using the theoretical and analytical skills learned in pre-requisite courses to derive data-driven solutions to policy questions. Students will also learn new data-presentation and data-visualization techniques that enable them to present those solutions to decision makers in a robust and coherent manner.

Prerequisite: This is a follow on course to the MSA curriculum econometric sequence. Students should be familiar with the topics and statistical software used in MN4110 and MN4111.

MN4130 - Marine Manpower Management (3 - 0)

Upon completion of this course, the student will have an in-depth understanding of USMC Manpower Management and implementation of management policy techniques through analysis, procedures, organizational and administrative actions to better staff Headquarters Marine Corp management policy issues. USMC officers will gain insight into management actions that support budget requirement requests and the resource allocation efforts subsequent to budget approval. Each officer will develop an understanding of the relationship between the Table of Organization (T/O), Troop List (TL) and the Authorized Strength Report (ASR). Each officer will complete an UNS report. Graded (3-0).

Prerequisite: MN2111 or consent of instructor.

MN4157 - Seminar in Management Accounting I (3 - 0)

This course complements the financial management program by covering significant topics not otherwise included in the program to prepare students to obtain the Certified Management Accountant (CMA) and/or Certified in Financial Management (CFM) designation. This course covers topics in business analysis, corporate financial management, management accounting and reporting, and strategic management. This course reviews, in more depth, topics covered in the introductory financial and cost management course. Specific topics addressed in the course may vary.

Prerequisite: MN3050 and MN3051.

MN4304 - Defense Systems Contracting (3 - 0)

This course is the study of the DoD's major systems contracting policies, processes, procedures, and practices. A review of major systems acquisition and program management is provided but the primary focus is on the contracting process used to acquire defense systems for the various services. The topics covered include:

acquisition environment, acquisition strategy, source selection, incentive contracting, alpha contracting, multi-year procurement, and requirement/capability specifications.

Prerequisite: MN3331 or MN3222.

MN4307 - Defense Acquisition Program Management Case Studies (4 - 0)

This course provides the student with knowledge and understanding of major systems management control processes and tools, application of program management control systems and the use of computer-based management information systems with strategic media choices so as to develop effective media campaigns, interact effectively with the print and broadcast news media, and handle press conferences and similar media events. Particular attention is focused on anticipating and handling crisis communication. Specifically, students will learn to organize crisis management teams, develop crisis management plans, and create communication plans to manage information and public perception. Case studies involving program management problem solving and decision making in the acquisition environment are used.

Prerequisite: MN3331 or MN3221 and MN3222 or MN3301 or consent of Instructor..

MN4311 - Contracting for Services (3 - 0)

This course studies the DoD's major services contracting policies, processes, procedures, and practices. Detailed and critical examination of current policies, issues, and practices in services contracting, to include performance based services contracting (PBSC), is accomplished through extensive case, policy, and report analysis requiring synthesis of concepts, processes and best practices. A review of major services acquisition and program management is provided but the primary focus is on the contracting process used to acquire major services for the DoD. Topics include: information technology services, base operating support services, environmental services, construction services, and contractor logistics support. This course offers DAU equivalencies.

Prerequisite: MN3331 and MN3303 or by permission of the instructor.

MN4313 - Innovative Contract Design (3 - 0)

This course is the study of the Department of Defense's non-Federal Acquisition Regulation (FAR) contracting policies, processes, and practices. The primary focus is on structuring innovative contract agreements to acquire emerging technologies for the Department of Defense. The topics covered include Other Transactions, Procurement for Experiments, and R&D Agreements such as Cooperative Research and Development Agreements (CRADA), Partnership Intermediary Agreements (PIA), Technology Investment Agreements (TIA). In addition, the use of challenge-based acquisitions, incentive prizes, modular contracting, parallel contracts, staged contracts and other innovative contracting approaches will be discussed.

Prerequisite: MN3331 (or MN3221 and MN3222) and MN3303, or as allowed by the instructor..

MN4314 - Space Systems Acquisition and Contract Management (3 - 0)

This course is the study of the Department of Defense space systems acquisition and contract management policies and processes. A discussion of space systems acquisition management is provided along with the contract management processes used to acquire space systems for the Department of Defense. Course topics include space industry and spacecraft systems, space acquisition environment, and space systems acquisition and program management.

Space systems acquisition contract management processes and the contract management life cycle are also discussed, as well as a review of selected DoD space acquisition programs. The course concludes with a discussion of the future of space acquisition and contract management challenges and the future of space contract management. Prerequisites: MN3331 (or MN3221 and MN3222) and MN3303, or as allowed by the instructor.

Prerequisite: MN3331 (or MN3221 and MN3222) and MN3303, or as allowed by the instructor..

MN4354 - Financial Analysis and Cost Management (3 - 0)

Provides an understanding of management control, management control structures and processes and how they are designed to control costs while also organizing work processes and motivating employees to work productively. Course objectives are understanding of (i) management control principles and processes, (ii) the application of cost management principles and processes, (iii) defense management control process events and timing, (iv) cost control and accounting data independence, (v) application of case study method to study of management control and cost management, (vi) cost control dynamics in budget execution, (vii) management and cost control reform initiatives and (viii) contemporary defense cost and resource policy issues. Available: Per sponsor requirements.

Prerequisite: MN3353.

MN4366 - Defense Acquisition Case Studies (4 - 0)

This course provides the student with knowledge and understanding of major systems management control processes and tools, application of program management control systems and the use of computer-based management information systems with strategic media choices so as to develop effective media campaigns, interact effectively with the print and broadcast news media, and handle press conferences and similar media events. Particular attention is focused on anticipating and handling crisis communication. Specifically, students will learn to organize crisis management teams, develop crisis

management plans, and create communication plans to manage information and public perception. Case studies involving program management problem solving and decision making in the acquisition environment are used.

MN4371 - Acquisition and Contracting Policy (4 - 0)

This course uses case studies and current acquisition issues to analyze government and business acquisition/contracting policies. Emphasis is on acquisition decision making and policy formulation/execution. This course offers DAU equivalencies.

Prerequisite: MN3304, MN3312, MN3320.

MN4374 - Capstone Seminar in Enterprise Sourcing (2 - 2)

This course is a graduate-level seminar in category management and enterprise sourcing. The primary purpose and objective of MN4374 is to provide the student with an opportunity to review and analyze the concepts and disciplines of category management and enterprise sourcing, to demonstrate critical analysis and thinking skills in applying category management and enterprise sourcing techniques to make DoD and other federal agencies "world-class" buying organizations. A second purpose is to investigate the specific topics, concepts and theories that are projected to be of high interest to DoD acquisition activities of the future. The course is designed to capitalize on the foundations provided by MN3306 and MN3307, although MN3306 is the only required prerequisite. Critical thinking and analytical skills are developed in designing and executing the most efficient and effective category management and enterprise sourcing organizations and associated business processes.

Prerequisite: MN3306.

MN4379 - Operations Management (4 - 0)

This course introduces students to problems and analysis related to the design, planning, control, and improvement of manufacturing and service operations. It will extensively utilize case studies and analytical problem sets. Topics include operations strategy, process analysis, project analysis, materials management, production planning and scheduling, quality management, computer-aided manufacturing, capacity and facilities planning, and theory of constraints applied to product development. The course will equip students with the basic tools and techniques used in analyzing operations, as well as the strategic context for making operational decisions.

Prerequisite: MN3108, MN3117, and OS3211, or consent of instructor.

MN4402 - Advanced Process Analytics (3 - 0)

This three-unit, elective course provides strong grounding in advanced analytical techniques necessary for analyzing, improving, and managing processes that create and deliver an organization's primary products and services.

The process management topics covered in the course include product/service design, process design, capacity planning, service operations, supply chain management, and lean Six Sigma. In covering these topics, the course will introduce and provide hands-on understanding of advanced analytical techniques such as Linear and Integer Programming models, Network models, Simulation, Decision Analysis, and Statistical Process Control. After successfully completing the course the students earn a certificate for having completed the educational requirements for Green Belt in Lean Six Sigma.

Prerequisite: MN3442 and GB4043 or permission from instructor.

MN4410 - Logistics Engineering and Sustainment (3 - 0)

This course covers the concept of integrated logistics support in the design and maintenance of weapon systems. Operational requirements, reliability, system maintenance concept, functional analysis, life cycle costs, logistics support analysis, systems design, test and evaluation, production, spare/repair parts management are discussed. This course also covers topics in logistics information technology, inventory management culture and commercial-sector best practices for military. Case studies include logistics life-cycle cost, reliability and readiness analysis for major weapon systems.

Prerequisite: MN3042.

MN4430 - Defense Distribution System (4 - 0)

This course examines the policies and management practices that determine how facilities, installations, vehicles, and programs are synchronized to receive, store, maintain, distribute, and control the movement of military materiel using organic and commercial resources. Prerequisites: None.

MN4440 - Simulation Modeling for Management Decision Making (4 - 0)

Modeling and risk analysis for managerial decision making. Case studies of simulation modeling applications to weapon system acquisition, logistics, transportation, distribution, communications and production systems.

Prerequisite: MN3041 or other introductory probability and statistics (may be taken concurrently).

MN4443 - Critical Thinking for Data-Informed Decisions (3 - 0)

Course Description: Bigger, better, faster data and analytic tools can seem to have almost magical powers, and access to data, analysis tools, and data-driven business processes are proliferating. Unfortunately, the magic doesn't eliminate the need for critical thinking, especially in defense management. This course teaches how to think critically about the vulnerabilities of data analysis and how to design and interpret data-driven analysis to get the most out of it. We ask and answer questions including:

- Where and how does human judgement enter into data-based decision making---including traditional statistical analyses?
- How do known cognitive biases and motivational biases affect data collection, design of analyses, and interpretation of results, and how can we counteract these biases?
- How can we derive useful insights about the future from data about the past? How do blue-team and red-team reactions to our analyses and policies complicate the interpretation of our analysis, and how do we adjust for that?
- How do consumers of data-informed analysis interpret the answers it produces? What does the user need to know about the quality and limitations of an analysis? What does a user need and want to know about the roles of humans and computers in the production of an analytic result?

MN4450 - Logistics Strategy (3 - 0)

This is the logistics capstone course. The course is concerned with the linkage between strategic objectives and how to enable and support those objectives, and explores how fundamental aspects of logistics planning and execution provide input to and shape "big decisions." It expands the understanding of logistics strategy as a concept within the area of operations, logistics and supply chain management. The course examines and critiques both established and emerging logistics practices in terms of costs and benefits, and it explores how to develop and advocate alternative logistics approaches to support current and future institutional goals while mitigating associated risks.

Prerequisite: GE3042 and MN4480 or equivalents, or instructor permission..

MN4460 - Business Risk Management (4 - 0)

Addresses the risk management issues that are inherent in business decisions. Students will learn to manage Schedule Risk, Supply Risk, Capacity (Readiness) Risk and Budget Risk; how to use metrics such as Value-At-Risk and Conditional Value-At-Risk to quantify exposure; how to combine risk sources; account for correlation, and use Bayesian Updating to modify risk estimates. Monte Carlo Simulation will be used extensively, and will be contrasted with other approaches (e.g., Discounted Cash Flow). Descriptive approaches to the study of risk judgments such as prospect theory will be examined, so that students can better predict risk-related behavior of others.

Prerequisite: MN3041 and MN3442 or permission of instructor.

MN4470 - Strategic Planning and Policy for the Acquisition Logistics Manager (4 - 0)

The course explores and analyzes the concepts, processes and methods of strategic logistics planning and execution, emphasizing proactive techniques to ensure maximum logistics influence on major weapon systems acquisition as well as optimum life cycle management of fielded systems. The course will examine and analyze key opportunities for maximum logistics influence in requirements development, contracting, test and evaluation, reliability and maintainability, as well as financial management and communications. The course will feature logistics management relevance to service roles and missions. The course will employ lectures, guided discussions, case studies, role-playing, panel discussions and lessons learned in the DoD acquisition environment.

Prerequisite: MN3331 or MN3301 or MN3221/MN3222 or consent of instructor.

MN4474 - Organizational Analysis (3 - 1)

This course prepares leaders to analyze, understand, and influence organizations and organizational processes. The focus is on principles and techniques for diagnosing managerial problems and developing solutions. The course combines theoretical and practical knowledge to prepare students for situations that commonly arise and give them the tools to deal with unexpected or unusual situations. First, we build foundational understanding of how organizations work, viewing people, technologies, tasks, and structures as interrelated components of complex systems. Then we apply this understanding to real organizations. From a leadership perspective, we identify ways to improve an organization's efficiency and effectiveness, motivate subordinate and peer performance, manage organizational boundaries, and increase the likelihood that evidence-based decisions and actions will be taken. Students complete a course project analyzing the structures, processes, boundary-spanning activities, and environment of an organization. MN4474 is a distributed learning course that meets via online communications. Prerequisite: none.

MN4480 - Supply Chain Management (3 -)

This course is designed to provide a broad discussion about the various issues impacting the supply chain of organizations. A supply chain is a network of organizations that supply and transform materials, and distribute final products to customers. Supply chain management (SCM) is a broadly defined term for the analysis and improvement of flows of material, information, and money through this network of suppliers, manufacturers, distributors, and customers. SCM emphasizes inventory-service level tradeoffs across the chain of players that together deliver a product at the right time for a fair cost to the right customer. There is probably no universal agreement on the distinction between logistics and supply chain management. However, we might say that logistics has traditionally focused on materiel issues within and downstream from the factory while SCM looks at the entire network of players, both up and down stream, and

perhaps has greater emphasis on information flows through the network. Logistics has traditionally been considered a tactical subject, less likely to capture the attention of upper management. SCM has attracted the attention of top management because of its strategic approach and integration with other functions in the organization. Many companies and/or divisions have added Supply Chain Analyst positions that frequently report to high-level managers. Ultimately, logistics and SCM activities are concerned with coordinating demand and supply. Common elements in that coordination are the management of materials (inventories), the location of materials (warehouses), and the movement of materials (transportation). As part of the coordination, an analyst must consider product and process designs as well as information flows between various players in the network. These elements will form the basis of this course. We will review some elements of basic theory and consider applications of the theory in cases that span operational and strategic concerns.

Prerequisite: The course requires prior understanding of basic statistics and process analysis..

MN4485 - Supply Chain Strategy (3 - 0)

This course is concerned with the development of managerial, economical, and sociological thinking in the context of supply chain management. Most people consume products without thinking about the vast networks of supply chains that brought that cold can of soda into your hand. These networks include people, products, money, information, and transportation. The principal objective of SCM is to deliver the right product to the right customer at the right time while incurring the lowest cost possible. In the context of defense supply chain scholars going as long ago as Sun Tzu in his book the Art of War stresses the importance of good SCM in ensuring dominance in wars and conflicts. Mathematics, economics, and sociology all come together in SCM. Critically thinking about all three of these areas will be essential in your development into becoming an expert.

Prerequisite: GE3040 and GE3042.

MN4490 - Topics in Special Supply Chain Networks (4 - 0)

This course focuses on conceptual understanding of the Special Supply Chain Networks for decision-making. The course builds the knowledge for identifying distribution and transportation networks and to optimize it using advanced analytical tools. To incorporate the bigger picture of network optimization problem, the course includes real applications in private sector as well as in military and non-governmental organizations. The course objective is to build the knowledge and analytical tools for operational issues such as inventory, transportation, distribution and the other issues such as strategies in logistics as well as competency and capability of the key players in the supply chain.

MN4510 - Strategic Resource Management (4 - 0)

The objective of this course is to integrate business analysis, financial analysis, and strategic analysis in solving complex management problems involving the allocation of scarce resources to achieve overall organization objectives. Resources here are not limited to financial resources but also include human and physical resources. The course will make use of a wide variety of management tools such as value chain analysis, competitive strategy, market positioning, supply chain management, activity analysis, target costing, cost of quality, and business process improvement techniques.

Prerequisite: MN3156.

MN4520 - Internal Control & Audit (3 - 0)

This course provides an introduction to the objectives of and activities related to internal control and audits, including design and evaluation of internal controls, auditing standards, audit reports, audit evidence, and audit tests. The course includes an overview of audits of financial reports and records and of government operations, with attention given to Government Auditing Standards.

Prerequisite: MN3051 or MN3056 or MN3156.

MN4530 - Management Control Systems (4 - 0)

Overview of internal controls processes. Study of the design, implementation, and evaluation of management planning and control systems in Navy and Defense organizations with comparisons to large, complex private sector organizations. Specific topics include the need for planning and control, strategic planning, the resource allocation process, organization of the management control function, measurement of inputs and outputs, budgeting, reporting, and performance evaluation.

Prerequisite: MN3051 or MN3056 or MN3156.

MN4540 - Conrad Seminar (2 - 2)

This course provides DoD military officers with an awareness of real life implementation of the education they have received in the MS (FM) curriculum. There are lectures on the Budgeting process Senior level guest speakers from the Department of the Navy and Department of Defense discuss current Financial Management issues with the students. International Students are welcomed to participate as an elective. The lab sessions task students with applying knowledge from class lectures/discussions. Examples of application include solving cases or analyzing actual outcomes from the budgeting process. The intent is to better prepare students for actual tasks they may expect in their first assignment. This course is graded pass/ fail.

Prerequisite: MN3510.

MN4550 - Advanced Financial Reporting (4 - 0)

This course explores both underlying theory and practical applications of financial reporting and analysis. The course

builds on financial accounting foundations presented in an introductory course and on fundamental concepts covered in auditing, economics, and finance courses. The course develops an understanding of alternative accounting measurements, examines how alternative accounting policies are selected in a dynamic financial reporting environment, helps to determine how best to communicate financial performance and financial position to users and emphasizes techniques for analyzing financial reports.

Prerequisite: MN3051 and MN4052; MN3510 is recommended unless enrolled in MBA Energy Program.

MN4560 - Defense Financial Management (3 - 0)

This course focuses on the competencies required of a Defense Financial Manager. It examines the diverse concepts, theories, and practices addressed in numerous specialty courses and ties them together in the framework of Defense Financial Management. The areas of coverage include: the Government Resource Management Environment, the Defense Resource Management Environment, Personnel Management, Manpower Management, Management and Internal Controls, Fiscal Law, the Planning, Programming, Budgeting, and Execution System (PPBE), Cost and Economic Analysis, Business Management Process Improvement, Accounting, Finance, and Auditing.

Prerequisite: MN3510, GB4053.

MN4570 - Advanced Finance (3 - 0)

This course is designed to provide insights into advanced topics in financial decision making process encountered by commercial enterprises. Major topics covered include long-term financing, lease financing, optimal capital structure determination, dividend policy, security issues and refunding, risk analysis and real options, derivatives and risk management.

Prerequisite: MN4052.

MN4602 - Acquisition Test and Evaluation Decision Science (3 - 2)

Designed to cover Developmental, Operational and Joint Test and Evaluation, including planning concepts and procedures frequently used in test and evaluation programs. Taught from the perspective of the Program Manager, Test Project Officer and Test Engineer. Actual military cases are used for examples. Topics include the role of Test and Evaluation in Systems Engineering and Acquisition Management, DT and OT test planning, introduction to test design, conduct of tests, live fire testing, modeling and simulation, human systems integration (HSI), reporting of test results, range and resource issues, and lessons learned. Student teams will write a detailed test plan. This course offers DAU equivalencies.

Prerequisite: MN3331 or MN3221/MN3222 or MN3301 or permission of instructor.

MN4612 - Federal Taxation (4 - 0)

This course covers a wide range of federal taxation topics, federal tax policy, current tax issues, and will focus on the statutory framework of the U.S. federal tax laws. The overall objective of this course is to assist students in developing an understanding of federal taxation concepts, with an emphasis on federal tax research skills using the U.S. Treasury Department's Internal Revenue Service (IRS) documents as well as DFAS, FMR, FAR, and GAO documents related to defense contractors' responsibility for tax compliance. Special emphasis will be on the impact of federal taxation on the DoD and DoN related to the use and accountability of taxpayer funds and public trust and on the consequences of defense contractors not complying with the federal tax policies.

Prerequisite: MN3156 or MN3056 or MN3050 or Consent of Instructor.

MN4760 - Manpower Economics I (4 - 0)

An introduction to the theoretical aspects of labor economics. Concepts covered include the supply of labor, the demand for labor, wage determination, internal labor markets, human capital, earnings functions, turnover, compensation systems, and compensating wage differentials. Special readings are used that apply the principles to military manpower.

Prerequisite: MN4071.

MN4761 - Applied Manpower Analysis (4 - 0)

This course examines various Navy and DoD manpower issues and policies using different quantitative techniques. The manpower issues examined include predicting outcomes and analyzing policies related to recruiting, attrition, reenlistment, and other manpower outcomes. Students will further develop skills to properly scrutinize empirical studies and develop sound empirical analysis.

Prerequisite: MN4110 and MN4760. Corequisite: MN4111.

MN4900 - Readings in Management (V - 0)

An individualized program of advanced readings and study in some area of Systems Management. Graded on a Pass/Fail basis only.

Prerequisite: A background of advanced work in the area of study and departmental approval.

MN4912 - Multivariate Data Analysis (3 - 0)

This course introduces concepts and skills that are necessary to use data for inference, prediction, and to identify causal relationships. Students will build on skills and analytic techniques which were introduced in MN3911 and they will use real-world DoD data and managerially relevant examples. Topics include linear and logistic regression, sampling distributions, estimation, prediction and hypothesis testing and study design.

Prerequisite: MN3911 or consent of course coordinator.

MN4913 - Advanced Model Building for Causal Inference and Prediction (3 - 0)

This course introduces students to a range of advanced techniques for prediction and inference that can be used to solve real-world defense problems and inform policy. The first half of the course will be dedicated to developing predictive methods that can be applied in many real-world scenarios. In the second half of the course, students will be introduced to program evaluation methods.

Prerequisite: MN4912 or consent of course coordinator.

MN4914 - Applications of Data Analytics in Defense Management (3 - 0)

This course introduces students to a wide range of defense management applications which use data and analysis to help solve problems and inform policy. Each week, students will learn about an application from a different DDM faculty member who specialized in the given area, and then apply their data analysis skills in a structured learning exercise. Topics include: finance, personnel, manpower, cost-benefit analysis, acquisitions, budgeting, operations, logistics, and content analysis.

Prerequisite: GE4913 or consent of course coordinator.

MN4970 - Seminar in Systems Management (V - 0)

Study of a variety of topics of general interest in the systems management, to be determined by the instructor.

Prerequisite: A background in systems management and permission of instructor.

MN4999 - Elective (4 - 0)

COURSE ELECTIVE.

MO

MO designated courses are intended for students in operational curricula only. They do not satisfy the mathematics course requirements for accredited engineering curricula, nor do they satisfy the prerequisites for any of the MA designated courses.

MO1180 - Topics in Mathematics for Systems Analysis (3 - 2)

A one quarter course in logic, elementary mathematics, combinatorics, and matrix algebra, plus a review of selected topics from single variable calculus with extensions to two variables. This course is intended for first-quarter students in the distributed learning Master of Systems Analysis curriculum. Logic places emphasis on the Propositional and Predicate Calculus. Elementary mathematical topics include sets, functions, and relations. Coverage of combinatorics includes an introduction to basic principles of counting (sum and product rules), permutations, and combinations. The fundamental algebra of matrices includes addition, multiplication of matrices, and multiplication of a matrix by a constant, and a column (vector) by a matrix; elementary matrices and

inverses, together with the properties of these operations; solutions to m x n systems of linear algebraic equations using Gaussian elimination. Selected topics from single-variable calculus are extended to functions of two-variables, including double integrals over rectangles and general regions. (This course may not be taken for credit by students in an engineering or science degree program, nor may it be used as a prerequisite for any other mathematics course).

Prerequisite: Single-variable Calculus.

MO1901 - Mathematics for ISSO (4 - 0)

A brief survey of selected calculus and post-calculus topics -- single variable derivatives and integrals, infinite series and sequences, complex numbers, and Fourier series and transforms. (This course may not be taken for credit by students in an engineering or science degree program, nor may it be used as a prerequisite for any other mathematics course.) PREREQUISITE: None.

MO1903 - Mathematics for ISSO Space Systems Operations Specialization (3 - 0)

The course consists of a brief survey of the following topics: Complex numbers, Fourier series and transforms, and Ordinary Linear Differential Equations. (This course may not be taken for credit by students in an engineering or science degree program, nor may it be used as a prerequisite for any other mathematics course.) Taught at the rate of seven hours per week for five weeks.

Prerequisite: MA1113. Corequisite: MA1114.

MR

MR0001 - METOC Colloquium (0 - 1)

(No credit.) Departmental lecture series covering topics of current interest by NPS and outside guest speakers. Graded pass/fail. Prerequisites: none.

MR0002 - METOC Colloquium (0 - 1)

No credit) Departmental lecture series covering topics of current interest by NPS and outside guest speakers. Graded pass/fail. Prerequisites: none.

MR0810 - Thesis Research (0 - 8)

Every student conducting thesis research will enroll in this course.

MR0999 - Seminar in Meteorology (2 - 0)

(NO CREDIT) Students present results of thesis or other approved research investigation. PREREQUISITE: Concurrent preparation of thesis or other acceptable research paper.

MR2020 - Computer Computations in Air-Ocean Sciences (2 - 2)

Introduction to the programming languages, operating systems, and computing facilities which METOC students use in MR and OC courses. Laboratory assignments are elementary problems in oceanography and meteorology.

Prerequisite: Calculus and college physics.

MR2200 - Introduction to Meteorology (4 - 0)

An introductory course that treats the composition and structure of the atmosphere, thermodynamic processes, forces and related small-and large-scale motions, air masses, fronts, tropical cyclones, solar and terrestrial radiation, general circulation and weather forecasting.

Prerequisite: Department approval.

MR2210 - Introduction to Meteorology/Laboratory (4 - 2)

Same course as MR2200 plus laboratory periods illustrating lecture material, including Navy Operational Global Atmospheric Prediction System (NOGAPS) analysis over oceanic areas, plus satellite imagery interpretation.

Prerequisite: Department approval.

MR2230 - Meteorology, Oceanography, and Military Operations (4 - 0)

This course is an introduction to meteorology and oceanography (METOC) from a military operations perspective. The course examines the basic patterns and processes of the atmosphere and ocean, and their impacts on the planning and conducts of military operations. Topics include: METOC and Military Planning; Winds, Waves, and Ship Operations; Coastal Processes and Amphibious Operations; Clouds, Visibility, and Aviation Operations; Electromagnetic Radiation and Tactical Warfare; Forecasting and Special Operations. Military case studies are extensively used. Major METOC products that aid in planning and conducting operations are introduced. A previous undergraduate course in a physical science is desirable but not required.
Prerequisites: None.

MR2262 - Elements of Weather Forecasting (1 - 2)

Survey of subjective and objective methods of atmospheric prognosis. Weather briefings illustrate applications of forecasting principles and use of satellite imagery.

Prerequisite: MR3222, MR3230 or consent of instructor.

MR2416 - Meteorology for Electronic Warfare (2 - 0)

A survey of environmental factors affecting the propagation and attenuation of electromagnetic waves. Synoptic and climatological conditions associated with anomalous refraction are studied. Ionospheric phenomena associated with longer wavelength (Hf) propagation. Layers associated with high aerosol concentration and optical turbulence are identified. Hands-on experience with existing environmental effects assessment models.

Prerequisite: Differential and Integral Calculus(may be taken concurrently).

MR2520 - Survey of Air-Ocean Remote Sensing (3 - 0)

Overview of systems for remote sensing of the atmosphere and oceans from space, and operational applications.

Prerequisite: Undergraduate physics and calculus, or consent of instructor.

MR3140 - Probability and Statistics for Air-Ocean Science (3 - 2)

Basic probability and statistics, in the air-ocean science context with emphasis on techniques of statistical data analysis. Histograms, boxplots, empirical distributions and associated characteristics such as moments and percentiles. Structure of a probability model, density distribution function, expectation and variance. Binomial, Poisson and Gaussian distributions. Conditional probability and independence. Joint distributions, covariance and central limit theorem. Standard tests of hypotheses and confidence intervals for both one-and two-parameter situations. Regression analysis as related to least squares estimation.

Prerequisite: Calculus.

MR3150 - Analysis of Air/Ocean Time Series (3 - 2)

Analysis methods for atmospheric and oceanic time series. Fourier transforms applied to linear systems and discrete data. Correlation functions, power density spectra and cospectra. Optimal design of air-ocean data networks. Laboratory work involves analysis of actual atmospheric and oceanic time series using principles developed in class.

Prerequisite: A probability and statistics course.

MR3212 - Polar Meteorology/Oceanography (4 - 0)

Operational aspects of arctic and antarctic meteorology. Polar oceanography. Sea-ice: amount, its seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions.

Prerequisite: OC3240, MR3222 or consent of instructor.

MR3220 - Meteorological Analysis (4 - 0)

Techniques of evaluation, interpretation and analysis of pressure, wind, temperature and moisture data, including weather satellite observations, with emphasis on the low and middle troposphere. Synoptic models of extratropical vortices, waves and frontal systems, with emphasis on three-dimensional space structure and time continuity, including isentropic surfaces and vertical cross-section analysis. Introduction to analysis in the troposphere and low stratosphere, including daily exposure to Navy Operational Global Atmospheric Prediction System (NOGAPS) analysis, and satellite imagery interpretation.

Prerequisite: MR3420 or MR3480, MR/OC3321.

MR3222 - Meteorological Analysis/Laboratory (4 - 3)

Same as MR3220, plus laboratory sessions in the IDEA lab on the concepts considered in the lectures, with emphasis on the analysis of the low and middle troposphere, streamline and isotach analysis techniques, satellite interpretation, and vertical cross-section analyses.

Prerequisite: MR3420, MR3480, OC3321.

MR3230 - Tropospheric and Stratospheric Meteorology (4 - 0)

Development and application of conceptual models of the evolution of various tropospheric and stratospheric circulation systems. Extratropical cyclones, jet streams and fronts are examined through application of dynamical concepts with particular emphasis on aspects associated with the marine environment.

Prerequisite: MR3222, MR4322 (may be concurrent).

MR3234 - Tropospheric and Stratospheric Meteorology/Laboratory (4 - 4)

Same as MR3230 plus laboratory sessions utilizing the IDEA Lab to facilitate the physical understanding of dynamical relationships inherent to the conceptual models of the various weather systems. Exercises utilize various case studies including material from recent marine cyclogenesis field experiments.

Prerequisite: MR3222, MR4322 (may be taken concurrently).

MR3240 - Radar Meteorology (3 - 0)

Principles of radar meteorology. Topics covered include radar systems, meteorological radar equation, doppler radar basics, propagation, attenuation, precipitation and velocity estimation, and characteristic echoes.

Prerequisite: MR3222, MR3522.

MR3250 - Tropical Meteorology (3 - 0)

Structure and mechanisms of synoptic-scale wave disturbances, cloud clusters, upper-tropospheric systems, the intertropical convergence zone; structure, development and motion of tropical cyclones; monsoon circulations. Emphasis on analysis and energetics.

Prerequisite: MR4322 and MR3230 or MR3234 (may be taken concurrently).

MR3252 - Tropical Meteorology/Laboratory (3 - 4)

Same as MR3250 plus laboratory sessions on analysis of tropical systems emphasizing streamline and isotach analysis and incorporating aircraft and satellite observations. Exercises stress tropical cyclone regimes. Satellite imagery is used as an analysis tool and also in forecasting tropical cyclone intensity. A track forecasting exercise provides an exposure to the use of various dynamic, climatological and statistical forecast models.

Prerequisite: MR4322 and MR3230 or MR3234 (may be taken concurrently).

MR3260 - Operational Atmospheric Prediction (3 - 0)

Subjective and objective methods of atmospheric prognosis and techniques for forecasting operationally-important weather elements from surface to 100 mb. Interpretation, use and systematic errors of computer-generated products. Weather satellite briefs and applications of forecasting principles to current situations.

Prerequisite: MR3230, MR3234, OC4323.

MR3262 - Operational Atmospheric Prediction/Laboratory (3 - 5)

Same as MR3260 plus laboratory sessions on the application of lecture material. Also, practice in weather briefing, including diagnosis and forecasting of current weather briefing, including diagnosis and forecasting of current weather situations using weather satellite observations, and Fleet Numerical Oceanography Center and National Meteorological Center products.

Prerequisite: MR3230, MR3234, OC4323.

MR3321 - Air-Ocean Fluid Dynamics (4 - 0)

A foundation course for studies of atmospheric and oceanographic motions. The governing dynamical equations for rotating stratified fluids are derived from fundamental physical laws. Topics include: the continuum hypothesis, real and apparent forces, derivations and applications of the governing equations, coordinate systems, scale analysis, simple balanced flows, boundary conditions, thermal wind, barotropic and baroclinic conditions, circulation, vorticity, and divergence.

Prerequisite: Multivariable calculus and vectors; ordinary differential equations (may be taken concurrently).

MR3413 - Boundary Layer Meteorology (3 - 0)

This course covers the basic concepts, description, and quantification of the main features of the atmospheric boundary layer (ABL) and atmospheric dispersion. The characteristics of turbulent flow will be introduced at the beginning of the course followed by a detailed discussion of the flux-profile relationship and the bulk aerodynamics surface flux parameterization for the surface layer. The course also covers the main features and dominant physical processes in the stable, clear, and convective boundary layers and an overview of the surface energy budget over various surface types.   For dispersion modeling, the basic concepts of dispersion modeling and the Gaussian plume and puff models will be introduced. During the course, the statistical and dimensional analysis methods, which are the main tools to analyze the ABL observational and numerical modeling data, are introduced and used to reveal the characteristics and structure of the ABL.

Prerequisite: MR3222, MR3480.

MR3419 - Assessment of Atmospheric Factors in EM/EO Propagation (2 - 1)

The course addresses atmospheric parameters and their

distribution that affect propagation of electromagnetic and Electro-optical (EM/EO) waves and describes their assessment with in situ and satellite borne sensors. It relates propagation phenomena to wavelength-dependent controlling atmospheric influences. Students receive demonstrations of obtaining web-site available atmospheric descriptions. There are demonstrations and exercises with computer based assessment codes that relate EM/EO propagation to measured and predicted atmospheric properties: PROPHET (HF), AREPS (UHF VHF-SHF), EOTDA&NOVAM (IR). Discussions will occur on display/distribution of global atmospheric and oceanic conditions supporting specific operational systems. Satellite sensor retrieval procedures will be described and demonstrated.

Prerequisite: Calculus based physics and math through multivariable calculus. Enrollment in International Electronic Warfare and Electronics/Communication..

MR3420 - Atmospheric Thermodynamics (3 - 0)

The physical variables; the equation of state; the first law of thermodynamics and its application to the atmosphere; meteorological thermodynamic diagrams; adiabatic processes and potential temperatures; moist air processes; hydrostatic equilibrium, vertical motion in the atmosphere, stability methods and criteria.

Prerequisite: Multivariable Calculus.

MR3421 - Cloud Physics (3 - 0)

Basic principles of cloud and precipitation physics and application to cloud formation and optical properties.

Prerequisite: MR3420 or MR3480.

MR3445 - Oceanic and Atmospheric Observational Systems (2 - 2)

Principles of measurement: sensors, data acquisition systems, calibration, etc. Methods of measurement for thermodynamic and dynamic variables in the ocean and atmosphere, including acoustics and optics.

Prerequisite: MR3420, OC3150, OC3230.

MR3455 - Measurement Systems for the Marine and Coastal Atmospheric Boundary Layer (2 - 2)

The course treats a broad spectrum of measurement techniques for atmospheric dynamic and thermodynamic variables. Laboratory sessions provide hands-on experience with various state-of-the-art sensing systems, including NPS's Doppler Radar Wind Profiler. Topics include sensor static and dynamic characteristics; calibration; in situ measurements of wind, pressure, temperature, humidity, aerosols and radiation on the surface, on balloon-borne sounding systems and on aircraft; and surface-based remote sensing systems, including wind profilers, SODAR and LIDAR.

Prerequisite: MR3150 and MR3222 or consent of the instructor.

MR3480 - Atmospheric Thermodynamics and Radiative Processes (4 - 1)

The physical variables; the equation of state; the first law of thermodynamics and its application to the atmosphere; meteorological thermodynamic diagrams; adiabatic processes and potential temperatures; moist air process; hydrostatic equilibrium, vertical motion in the atmosphere, stability methods and criteria. Basic radiative transfer including absorption and scattering by atmospheric constituents; solar and terrestrial radiative heating; radiative energy budgets; climate change; radiative effects of clouds and aerosols; optical phenomena.

Prerequisite: Single variable calculus.

MR3520 - Remote Sensing of the Atmosphere and Ocean (4 - 0)

Principles of radiative transfer and satellite sensors and systems; visual, infrared and microwave radiometry and radar systems; application of satellite remotely-sensed data in the measurement of atmospheric and oceanic properties.

Prerequisite: Undergraduate physics and differential/integral calculus, ordinary differential equations and MR3480, or consent of instructor.

MR3522 - Remote Sensing of the Atmosphere and Ocean/Laboratory (4 - 2)

(SS3525 is used for non Air-Ocean students.) Same as MR3520 plus laboratory sessions on the concepts considered in the lecture series. Prerequisites: Same as MR3520.

Prerequisite: MR3520.

MR3540 - Radiative Processes in the Atmosphere (3 - 0)

Applications of radiation theory to atmospheric energy budgets, general circulation and anthropogenic climate changes. Radiational imbalance at the surface leading to heat fluxes and temperature changes in atmosphere and earth. Upper atmosphere phenomena (ozonosphere and ionosphere). Radiative effects of clouds and aerosols, and optical phenomena.

Prerequisite: MR3420, MR3520, MR3522.

MR3570 - Operational Oceanography and Meteorology (2 - 4)

Experience at sea acquiring and analyzing oceanographic and atmospheric data using state-of-the-art instrumentation. Integration of satellite remote sensing and other operational products with in situ data. Includes survey of instrumentation, pre-cruise planning, operations at sea and post-cruise analysis.

Prerequisite: OC3240, MR3220, or consent of instructor.

MR3571 - Operational Oceanography and Meteorology Lecture (2 - 0)

Introduction to the core oceanographic and atmospheric

instruments used in support of environmental monitoring and modeling. Principles of instrument design and sampling protocols will be covered. Emphasis will be placed on the capabilities and limitation of autonomous platforms, on aircraft- and shore-based remote sensing, and on the major systems in place to organize and distribute environmental data. A brief introduction to data assimilation will be included to illustrate the critical link between observations and oceanic and atmospheric circulation models.

Prerequisite: OC3230 or consent of instructor.

MR3572 - Operational Oceanography and Meteorology Lab (0 - 4)

This course is intended to insure a flexible hands-on experience deploying equipment in a realistic environment. Students will be required to design their individual field programs working with the instructor and the curriculum's program officer. Approved programs include: 1) design and implementation of coastal ocean or atmosphere sampling protocols using unmanned vehicles, 2) design and implementation of monitoring plans for the surf zone or estuarine environments (in this case OC4210 may be taken as an alternative), 3) design and implementation of sampling protocols for the atmosphere using fixed-location or aircraft-based sensors, 4) design of and participation in upper-ocean or lower-atmosphere sampling protocols at polar ice camps, and 5) design of and participation in deep-water surveys onboard ocean-going research vessels using NPS vessel time or faculty-mentored cruises of opportunity.

Prerequisite: MR3571 (may be taken concurrently) or consent of instructor.

MR3610 - Modern Climatology (4 - 0)

An introduction to physical climatology and its applications. This course examines Earth's climate system, especially major long-term global and regional patterns, and the physical processes that create them, with focus on the application of physical climatology to solve operational DoD problems and analyze and forecast climate variations at intraseasonal and longer time scales. Emphasis placed on support of military operations, past, present and future.

Prerequisite: MR3480, MR3321, MR2200.

MR4234 - Advanced Topics in Mid-Latitude Weather Systems (4 - 0)

The course examines the classic conceptual models of mid-latitude weather systems and their associated dynamics. From this classic perspective, recent advances in our theoretical and observational understanding of cyclones and fronts are examined to extend our conceptual models of mid-latitude weather systems over a broad range of scales. It is expected that students have a working knowledge of the quasigeostrophic dynamics of cyclones, fronts, and jet streaks as taught in MR3234 (Trop and Strat) and MR4322 (Dynamic Met) or their equivalents.

Prerequisite: MR3234 and MR4322 or similar undergraduate course on mid-latitude weather systems.

MR4240 - Coastal Meteorology (3 - 1)

Mesoscale circulations of the coastal atmosphere are examined from theoretical, observational, and model perspectives. Thermally-driven circulations, orographically-driven circulations and mesoscale circulations due to the interaction of synoptic-scale weather systems with coastlines are studied to develop useful conceptual models of coastal meteorological phenomena.

Prerequisite: MR4322, MR3234 taken concurrently or consent of instructor.

MR4241 - Mesoscale Meteorology (3 - 0)

Descriptive and physical understanding of subsynoptic-scale weather systems including fronts, squall lines, mesoscale convective systems, tornadoes, etc., and their relation to the synoptic-scale environment. Applications to short-range and local-area forecasting utilizing satellite and numerical-model products relevant to mesoscale weather phenomena.

Prerequisite: MR3230, MR4322 with consent of instructor.

MR4242 - Advanced Tropical Meteorology (3 - 0)

Theories and observations of tropical motion systems. Equatorial wave theory; stratospheric biennial oscillation; tropical intraseasonal oscillations; monsoon circulations; tropospheric biennial oscillation; El Nino and Southern Oscillation; other climate variations. Tropical cyclone dynamics; influence of environmental flow on formation and motion; advanced models and forecasting of tropical motion. Emphases among these topics will depend on the interest of the students.

Prerequisite: MR3252 or consent of instructor.

MR4250 - Atmospheric General Circulation (3 - 0)

The observed circulation. Zonal mean and eddy motions. Balances of momentum, heat and moisture. Energetics. Maintenance of circulation. Zonally asymmetric circulations. Other selected topics of the general circulation of the atmosphere.

Prerequisite: MR4322 and consent of instructor.

MR4262 - Advanced Meteorological Prediction (3 - 2)

The course requires previous weather forecast experience and covers advanced forecasting topics. A sample of topics covered include dust forecasting, orographic precipitation, mountain waves and downslope winds, cold-air damming and coastal frontogenesis, marine fog and stratus, ocean wind waves and swell, thunderstorms, and others. The focus is on the mesoscale aspects of forecasting and how to appropriately use observational and model tools for short-range to longer range forecasts of these phenomena. Hands-on practical forecast labs and briefings are used to demonstrate and practice the theory

and techniques covered in the lectures.

Prerequisite: MR3262, MR3234, MR3522.

MR4322 - Dynamic Meteorology (4 - 0)

Pressure coordinates, quasi-geostrophic scale analysis, perturbation method; solutions of equations of motion for sound, gravity and synoptic waves; baroclinic and barotropic instability; energetics; geostrophic adjustment.

Prerequisite: MR3420, OC3321, calculus and ordinary differential equations.

MR4323 - Air and Ocean Numerical Prediction Systems (4 - 2)

Numerical models of atmospheric and oceanic phenomena. Major components and sources of error for operational primitive equation prediction systems. Data assimilation concepts, techniques, and limitations. Finite difference, spectral, and finite element methods, computational instability, and approximation error. Horizontal grid variants, vertical coordinate systems, and factors affecting resolution. Overview of subgridscale processes and boundary conditions: physical parameterizations of moisture and convection; land surface models; air-ocean coupling; ocean surface forcing; topography and bathymetry; hydrostatic and nonhydrostatic ocean models. Verification methods and model output. Introduction to uncertainty, chaos, and ensembles.

Prerequisite: MR4322, OC4211, partial differential equation, MA3232 desirable.

MR4324 - Advanced Numerical Weather Prediction (2 - 2)

Operational weather prediction is evolving from a deterministic forecasting focus, based on single-solution numerical weather prediction (NWP) output, to a focus on ensemble-based forecasting. This course introduces the fundamentals of chaos theory (as the scientific basis for ensemble forecasting), describes the behavior of an ideal vs. a practical ensemble, and covers details of the various components of an ensemble prediction system (EPS). The course goal is to develop weather officers knowledgeable in EPS capabilities, strengths, weaknesses, etc., so that the DOD can effectively incorporate the technology into its weather support process.

Prerequisite: MR4323 or similar undergraduate course in numerical weather prediction.

MR4325 - METOC for Warfighter Decision Making (3 - 2)

This course introduces decision science in the context of utilizing deterministic vs. stochastic meteorological and oceanographic forecasts to improve strategic, operational, and tactical planning. Various aspects of generating, communicating, and applying stochastic forecasts for optimal decision making under uncertainty are explored.

Prerequisite: MR3140 or similar course on statistics. MR/OC4323 and MR4324 are recommended but not

required.

MR4331 - Advanced Geophysical Fluid Dynamics I (3 - 0)

Advanced topics in the dynamics of the atmosphere and the oceans including scale analysis; geostrophic adjustment; dispersion, and barotropic and baroclinic instabilities.

Prerequisite: Consent of Instructor.

MR4332 - Advanced Geophysical Fluid Dynamics II (3 - 0)

Normal mode and baroclinic instability; frontogenesis; boundary layer analysis with application; finite amplitude baroclinic waves; symmetric instability.

Prerequisite: Consent of Instructor.

MR4413 - Air-Sea Interaction (4 - 0)

Fundamental concepts in turbulence. The atmospheric planetary boundary layer, including surface layer and bulk formula for estimating air-sea fluxes. The oceanic planetary boundary layer including the dynamics of the well-mixed surface layer. Recent papers in air-sea interaction.

Prerequisite: MR/OC3150 and OC3240 or MR4322, or consent of instructor. Cross-Listed as: Cross-listed with OC4413.

MR4414 - Advanced Air/Sea Interaction (3 - 0)

Advanced topics in the dynamics of the atmospheric and oceanic planetary boundary layers.

Prerequisite: MR/OC4413 or consent of instructor.

MR4415 - Atmospheric Turbulence (3 - 0)

Approaches for defining the structure of the turbulent atmospheric boundary layer. Review of statistical descriptions of atmospheric turbulence; averaging, moments, joint moments, spectral representation. Equations for turbulent regime in a stratified, shear flow. Scaling parameters and similarity theories for surface layer profiles, spectra; Kolmogorov hypotheses, Monin-Obukhov similarity theory. Measurement of atmospheric turbulence. Examination of observed spectra and scales of atmospheric turbulence.

Prerequisite: MR/OC3150 or consent of instructor.

MR4416 - Atmospheric Factors in Electromagnetic and Optical Propagation (3 - 0)

Principles of microwave and optical wave propagation in the atmosphere. Effects of surface and boundary layers on propagation: refraction, scattering, attenuation, ducting, etc. Addresses existing environmental effects assessment models.

Prerequisite: OC4413 or MR4415 (may be taken concurrently).

MR4520 - Topics in Satellite Remote Sensing (3 - 0)

Selected topics in the advanced application of satellite remote sensing to the measurement of atmospheric and oceanic variables.

Prerequisite: MR/OC3522.

MR4800 - Advanced Topics in Meteorology (V - 0)

(Variable credit 1-0 to 4-0.) Advanced topics in various aspects of meteorology. Topics not covered in regularly offered courses. The course may be repeated for credit as topics change.

Prerequisite: Consent of Department Chairman and Instructor.

MR4900 - Directed Study in Meteorology (V - 0)

(Variable credit 1-0 to 4-0.) Directed study of selected areas of meteorology to meet the needs of the individual student. Graded on Pass/Fail basis only.

Prerequisite: Consent of Department Chairman and Instructor.

MR5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

MR5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council. Prerequisite: Advancement to Candidacy.

R000

MRR210 - Refresher, Introduction to Meteorology/Lab (4 - 2)

(NO CREDIT) (Meets last six weeks of quarter.) An introductory course that treats the composition and structure of the atmosphere, thermodynamic processes, forces and related small- and large-scale motions, air masses fronts, tropical cyclones, solar and terrestrial radiation, general circulation and weather forecasting. Additionally, laboratory periods are included to illustrate lecture material, including surface and airways communication codes, pressure and streamline/ isotach analyses, introduction to mid-latitude and tropical analyses by the Navy Operational Global Atmospheric Prediction System (NOGAPS) over oceanic regions, plus satellite interpretation.

MS

MS2201 - Introduction to Materials Science and Engineering (3 - 2)

This is a first course in Materials Science and Engineering and emphasizes the basic principles of microstructure-

property relationships in materials of engineering and naval relevance. Topics include crystalline structure and bonding, defects, thermodynamics and kinetics of reactions in solids, deformation, strengthening mechanisms and heat treatment. Students will acquire a working vocabulary and conceptual understanding necessary for advance study and for communication with materials experts.

Prerequisite: Undergraduate courses in mathematics, physics, and chemistry.

MS3110 - Properties and Failure of Functional Materials (4 - 0)

The fundamental physical properties of materials will be presented in terms of intrinsic atomic bonding, theoretical crystalline structure, and defects that yield specific properties. Control and design of defects can yield functional properties and behavior for specific applications. Diffusion and its effect on properties and behavior, including mechanical and thermal behavior are covered. A significant portion of the course will focus on understanding the effects of intrinsic defects and properties on failure. Identifying the cause and mechanisms of failure analysis is an emphasis of the course, naturally leading to methods for failure prevention relevant to DoD and DoN assets. The electronic properties of functional materials are discussed, again with an emphasis on the understanding and exploitation of defects for acquiring desirable functional properties for specific defense and naval applications such as energy storage and delivery technologies.

Prerequisite: Students should have an understanding of concepts from undergraduate-level chemistry, physics, and calculus courses..

MS3202 - Properties, Performance & Failure of Engineering Materials (3 - 2)

The purpose of this course is to advance the students' understanding of the fundamentals of materials science, while putting that understanding in the context of the behavior of materials in engineering applications. Contemporary developments in engineering materials such as composites, ceramics and polymers are considered, as well as traditional engineering alloys such as steels and aluminum alloys. Performance and failure histories of materials in service will be studied, as well as conventional textbook subjects. Examples pertinent to Naval, Aero and Combat Systems Science are emphasized. Topics include mechanical properties, fracture, fatigue, failure analysis and corrosion.

Prerequisite: MS2201 or equivalent or consent of instructor.

MS3203 - Structural Failure, Fracture, and Fatigue (3 - 2)

Theories of yield and fracture for aircraft design limit loads and ultimate loads; stress-life and strain-life fatigue theories of crack initiation in aircraft structures subjected to realistic flight load spectra, using Neuber's

approximation and incorporating the Miner concept of cumulative damage. Fatigue crack propagation concepts and Navy methods of fleet structural fatigue tracking and monitoring.

Prerequisite: ME2601, MS3202.

MS3214 - Intermediate Materials Science and Engineering (4 - 0)

The purpose of this course is to provide a bridge between the introductory courses in materials science, MS2201 and MS3202, and the 4000-level elective courses in materials science. The emphasis is on a deepening of understanding of basic principles which govern the behavior of solid materials. Principles of physical metallurgy and the physics of materials will be considered in detail. Topics include thermodynamics of solids, electronic structure of alloys, lattice stability, phase equilibria, diffusion, dislocation theory, deformation mechanisms and an introduction to the kinetics of phase transformations. The course is intended to show how the application of basic principles leads to clearer understanding and control of the behavior and properties of contemporary materials.

Prerequisite: MS2201 and MS3202 or equivalent or consent of instructor.

MS3304 - Corrosion and Marine Environmental Deterioration (3 - 2)

The fundamentals of corrosion science and the practice of corrosion engineering are discussed. The objectives include an appreciation of the varied causes, mechanisms and effects of corrosion. Fundamental topics such as basic electrochemistry, polarization and passivity are covered. A primary goal of the course is the development of skill in the recognition and prevention of a wide variety of types of corrosion. Standard methods of corrosion control are discussed, including cathodic protection, coatings, alloy selection and inhibitors.

Prerequisite: MS2201 or equivalent or consent of instructor.

MS3606 - Introduction to Welding and Joining Metallurgy (3 - 2)

Welding and joining are presented from the point of view of metallurgy. Topics include the nature and applications of welding and joining processes; the welding thermal cycle; metallurgical effects of the welding thermal cycle; welding and joining of steels, aluminum alloys, stainless steels and heat-resistant alloys. Also, weldment inspection and quality assurance are introduced.

Prerequisite: MS2201 and MS3202 or consent of the instructor.

MS4215 - Phase Transformations (3 - 2)

The mechanisms and kinetics of structural changes in solid materials are considered in detail. A wide variety of transformation mechanisms are studied, including solidification, recrystallization, precipitation and martensitic transformation. The basic principles which

govern these reactions are developed, including principles of nucleation and growth, diffusion and lattice distortion. The relevance of various transformations to practical heat treatment, thermomechanical processing, and technological advances is discussed. Microstructural recognition and methods of monitoring phase transformations are included. Changes in properties which result from phase transformations are given limited attention.

Prerequisite: MS3214 or equivalent or consent of instructor.

MS4312 - Characterization of Advanced Materials (3 - 2)

This course is structured to provide an insight into the various tools available for advanced physical examination of engineering materials. Topics covered include thermal analysis, X-ray diffraction, and optical, scanning, transmission and scanning transmission electron microscopies as well as various spectroscopic techniques.

Prerequisite: MS3202 or consent of instructor.

MS4410 - Advanced Energy Materials (4 - 1)

As the Navy moves toward 'all electric ships' engineers will be responsible for dramatic changes in key electric systems. Officers responsible for designing and/or selecting electric systems for novel weapons to drive trains will need a thorough grounding in fundamentals in order to fully understand newly developed options and possible problems. The course provides the physics and engineering essentials of capacitors, batteries and fuel cells. For capacitors, topics include electric fields, voltage, Gauss's Law, the development of the fundamental equations for capacitors, equivalent circuits. Batteries are treated as electrical systems that convert the free energy change of reaction into electrical energy. The first fundamental topic is a review of the first and second laws of thermodynamics, leading to the concept of free energy. The students are introduced to both modern (e.g. Li ion) and classic (e.g. Pb acid) battery systems. The effect of phase change, temperature, dilution, etc. on actual energy delivered is explored. Fuel cells are introduced as devices that act primarily like batteries that is they convert chemical energy into electrical energy, but with independent fuel supplies. Energy analysis of pertinent Navy-relevant examples are developed, such as the energy and power requirements of rail guns, E-mals and laser systems.

Prerequisite: MS3202 or by consent of instructor.

MS4601 - Fabrication, Characterization and Applications of Nanomaterials (3 - 2)

This course is an interdisciplinary introduction to synthesis, processing, characterization, and applications of nanomaterials. Materials with dimensions that span from sub nanometers to few hundred nanometers ($1nm = 10^{-9}m$) will be introduced along the role that such critical size plays in the properties of Naval structures and devices. The lectures and laboratory practices will provide an

overview of the fundamental principles that apply to materials at the nanoscale: relationships between physical properties and material dimensions, strategies for their fabrication and the characterization techniques used to analyze them. Nanomaterials used for a wide range of applications including sensors, coatings, reinforcing fillers, electrodes, etc. will be presented.

Prerequisite: MS2201 Introduction to Materials Science and Engineering or consent from instructor.

MS4811 - Mechanical Behavior of Engineering Materials (4 - 0)

The response of structural materials to stress is discussed, including elastic and plastic deformation and fracture. Topics include elastic response and the modules of elasticity; plasticity; deformation mechanisms and dislocation theory; strengthening mechanisms; and fatigue and fracture. Application to materials development is also considered.

Prerequisite: MS3202, and MS3214 or consent of the instructor.

MS4822 - The Engineering and Science of Composite Materials (4 - 0)

This course focuses on the structure-property correlation in composites utilizing a multi-disciplinary approach, covering the areas of materials science and engineering and solid mechanics. Emphasis is given to the theoretical constitutive behavior at the micro- and macro-levels, as well as on how such behavior can be altered by processing and service variables. The course is divided into three broad parts: (1) Theoretical predictions of composite properties; (2) Materials issues (including processing) complicating accurate performance prediction; and (3) Thermo-mechanical behavior in actual service conditions.

Prerequisite: ME3611, MS3202 or equivalent or by consent of instructor.

MV

MV0810 - Thesis Research (0 - 8)
MOVES Thesis Research

MV0820 - Integrated Project (0 - 12)

The Naval Postgraduate School Provides many opportunities for students to participate in campus-wide interdisciplinary projects. These projects encourage students to conceptualize systems which respond to current and future operational requirements. An integral part of the project involves working with other groups to understand and resolve issues involved with system integration and to lend MOVES-specific expertise to these projects. This course is available to Modeling, Virtual Environment and Simulation Students who are participating in a campus-wide integrated project. Course is grade on a pass/ fail basis. Prerequisites: None.

MV1000 - Becoming a Master Learner (2 - 2)

This course teaches fundamental skills associated with success in higher education, with a focus on improving learning strategies and self-management skills to help students better organize, prepare, and perform effectively in an academic or work environment. The course teaches students to improve study habits, develop critical thinking skills, use time management principles, hone communication skills and develop their own individual success strategies. The course helps students understand their own cognitive processes, and what strategies work for best for them in order to improve their learning and lead them to successes academically, personally, and in their careers. Graded on Pass/Fail only PREREQUISITES: None

MV2920 - Introductory Topics in Modeling, Virtual Environments and Simulation (V - V)

Designed to support introductory subject matter of special interest, dependent upon faculty availability. Topics will typically augment those offered in the basic core courses. This course may be lecture/lab oriented or self-paced, with prerequisites determined by the instructor. Students may repeat this course for credit with a different topic. Variable hours 2-4 to 4-1.

MV2921 - Introduction to Modeling, Virtual Environments and Simulation (2 - 0)

This course is an introduction to the Modeling, Virtual Environments and Simulation discipline. Topics include Combat Modeling, Networked Visual Simulation, Web-Based Simulation, Agents and Cognitive Modeling, Training Systems, Human Factors, Physically Based Modeling, and Optimization. Graded Pass/Fail basis only. Prerequisites: None.

MV3025 - Artificial Intelligence for Simulations (4 - 1)

This course provides an introduction to artificial intelligence as it applies to the creation of entity behavior in military simulations. Search, learning, and logic are covered in lecture along with a series of additional lectures and substantial lab exercises focusing on the practical creation of behavior models for simulations.

Prerequisite: CS2072.

MV3101 - Introduction to Department of Defense Modeling and Simulation (4 - 0)

This course serves as an important overview course for all students enrolled in the MOVES curricula, in addition to other curricula at NPS. It covers the origin, evolution, breadth and importance of DoD modeling and simulation (M&S), and the utilization of M&S in DoD system acquisition life cycle. The course focuses on the functional

areas of DoD M&S, which are: Training, Analysis, Acquisition, Planning, Test, and Evaluation. Prerequisite: None.

MV3202 - Introduction to Computer Graphics (3 - 2)

This course introduces you to computer graphics -- its powerful capabilities, a history of its technologies, as well as up-to-date developments to its far-reaching potentials across the consumer, industrial, and military domains, and how to achieve these potentials. You will learn about the principles of hardware and software used to create computer-generated images, about basic rendering and raytracing, 3D graphics programming, lighting and shading, textures, and scene graph architectures. MV3202 prepares you to design and implement 3D graphics simulations and to understand the theory of modern graphics rendering. The course is intended for students who have taken a basic course in, or have recent programming experience in, a programming language such as C++ or Java.

MV3203 - Graphical Simulation (3 - 2)

Teaches the theory and techniques relevant to rapid construction of small to medium sized graphical simulations using existing simulation platforms, such as Delta3D, VBS2, Unreal, etcetera, including web browsers with plug-ins for Flash or X3D: For use as a stimulus for human performance experiments; as partial task trainers; as visualizations to support analysis; as testbeds for new hardware or software technology.

Prerequisite: MV3202.

MV3204 - Computer Graphics Modeling Using X3D/VRML (4 - 0)

An introduction to the principles of hardware and software used for computer-generated 3D graphics via the World Wide Web. The focus of the course is authoring interactive 3D scenes and a major design project. The course is intended for MOVES and Computer Science students working in visual simulation, or students in other majors interested in the basics of 3-D modeling and rendering.

Prerequisite: CS2073 or equivalent.

MV3250 - Introduction to Extensible Markup Language (XML) (4 - 0)

XML and related technologies provide platform independent representation, description, and validation of data. This is necessary for the data communication among different networks, computers, and applications that is essential for contemporary military and civilian applications. The course will present the benefits of XML and how to use software tools to construct and process XML documents using XML editors, XML parsers, XML Schema for validation, XSLT to transform documents, and DOM, SAX, and JDOM to access and manipulate XML documents within a computer program. Much of the programming code in contemporary computer applications that is used to construct data files, access databases and spreadsheets, check and validate data values, and output data can be replaced by these more general software tools. Prerequisites: None.

MV3302 - Introduction to Discrete Event Simulation Modeling (4 - 1)

This course provides an introduction to Discrete Event Simulation (DES) methodology, modeling, and analysis. Use of DES formalism, such as Event Graph methodology, for design of models. Component-based implementation of event graph models on a platform such as Simkit. Use of simulation components for building models using composition. DES modeling of movement and sensing. Random variate generation. Simple output analysis.

Prerequisite: Java programming; or permission of instructor; Basic Probability and Statistics at the level of OA3101 and OA3103.

MV3403 - Research Methods and Statistics for Healthcare Simulation (4 - 1)

This course focuses on common research and statistical methods used to assess performance in simulated healthcare environments. Research methods covered include differences between surveys, observational studies, and experiments, sampling procedures, instrumentation, reliability and validity, ethical requirements in conducting human subjects research, and the components of a grant proposal. Statistical methods include hypothesis testing, t-tests, z-tests, ANOVA, regression, and chi square methods. Labs will be conducted using appropriate statistical software that will provide students with hands-on understanding of many of the statistical methods covered in lecture. Prerequisites: None.

MV3472 - Graphical Simulation of Physical Systems in Virtual Worlds (3 - 2)

Design and construction of reusable software modules for real-time computer simulation of physical systems in graphical virtual worlds. Rigid body kinematics and dynamics, perspective transformations and wire-frame graphical models. Time domain and transform domain analysis of linearized dynamic systems. Laboratory is concerned with development and testing of software. PREREQUISITE: CS2970 or CS2971 or CS2973 or equivalent.

Prerequisite: CS2970, CS2971, CS2973.

MV3500 - Internetwork Communications and Simulation (3 - 2)

An introduction to network communications in simulation applications. Topics include an introduction to the TCP/IP protocol stack; TCP/IP socket communications, including

TCP, UDP, and multicast; and protocol design issues, with emphasis on Distributed Interactive Simulation and High Level Architecture. The emphasis will be on Windows and web-browser applications.

Prerequisite: CS2173.

MV3800 - Directed Study in Modeling, Virtual Environments and Simulation (0 - V)

Individual research and study by the student under the supervision of a member of the faculty. The course is intended primarily to permit interested students to pursue in depth subjects not fully covered in formal class work. Graded on Pass/Fail basis only. Variable hours 0-2 to 0-8.

Prerequisite: Consent of Instructor.

MV3920 - Topics in Modeling, Virtual Environments and Simulation (V - V)

Designed to support subject matter of special interest, dependent upon faculty availability. Topics will either be drawn from areas not covered by core courses, or be focused treatments of subjects of limited scope. This course may be lecture or lab oriented, with prerequisites determined by the instructor. Students may repeat this course for credit with a different topic. Variable hours 2-4 to 4-1.

Prerequisite: Consent of Instructor.

MV3922 - Introduction to Virtual Environment Technology (2 - 0)

This course is an introduction to the technology used in virtual environments and discusses applications which use Virtual Environments. It is intended to give the students an introduction to the items they are likely to use throughout the master's degree program in Modeling, Virtual Environments and Simulation (MOVES). Graded Pass/Fail basis only.

Prerequisite: MV2921.

MV3923 - Introduction to Research in Modeling, Virtual Environments & Simulation (2 - 0)

This course will examine the current and planned research of Modeling, Virtual Environments & Simulation (MOVES) faculty in multiple fields of study. The course is designed to support MOVES students in the selection of emphasis blocks and an area for thesis research. Includes readings and exercises.

Prerequisite: MV3922.

MV4000 - Hamming: Learning to Learn (3 - 2)

Richard W. Hamming's original capstone course EC4000 "Learning to Learn: Future of Science and Engineering" has been fully digitized and placed online. This course presents the distilled career insights of a preeminent thinker. In 1968 Dr. Hamming was recipient of the Turing Award, the highest honor in computer science, for his work on numerical methods, automatic coding systems, and error-detecting and error-correcting codes. This course is intended to instill a "style of thinking" that will enhance one's ability to function as a problem solver of complex technical issues. With respect, students sometimes called the course "Hamming on Hamming" because he relates many research collaborations, discoveries, inventions and achievements of his own. This collection of stories and carefully distilled insights relates how those discoveries came about. Most importantly, these presentations provide objective analysis about the thought processes and reasoning that took place as Dr. Hamming, his associates and other major thinkers, in computer science and electronics, progressed through the grand challenges of science and engineering in the twentieth century. Prerequisites: None.

MV4001 - Human Factors of Virtual Environments (4 - 1)

This course focuses on human factors issues in virtual environments (VEs). While the similarities of VEs to the real world can often make VE interfaces intuitive and easy to use, the differences between VEs and the real world can often be the cause of serious performance problems and physical inability to effectively use a system. The design of effective VE systems depends on an understanding of humans and their interaction with their environment. Only then, can a VE system hope to achieve reasonable performance levels and acceptability. This course will survey the VE literature on issues of human performance, perception, cognition, multimodal interfaces, locomotion, wayfinding, object selection and manipulation, visualization, simulator sickness, and performance differences between individuals. Prerequisites: None.

MV4002 - Simulation and Training (4 - 1)

This course focuses on training issues in virtual environments (VEs). VEs have often been considered to be general purpose trainers. However, systems are often built without an understanding of how to build a trainer that can verify that it improves subsequent performance without forming bad habits or other reverse training artifacts. This course will first investigate VE training systems from a theoretical perspective, focusing on learning, memory, and cognition. From this framework, actual training systems will be studied with the focus being on an actual study of training transfer of a real training system. Prerequisites: None.

MV4003 - Technology and Simulation in Healthcare Education (3 - 1)

This distance learning course exposes students to the full breadth of medical simulation technologies used to train healthcare-related tasks, recreate physiologic conditions and disease states, assess domain knowledge, and support review and/or archiving. An integral part of the course is participation in a hands-on simulation practicum.

The course combines structured asynchronous independent study, on-line discussion forums, post-and-assess peer-learning exercises, and weekly synchronous 'office hours' with subject matter experts (physicians, nurses, medical technology specialists) and the NPS course facilitator. Prerequisites: None.

MV4015 - Agent-Based Autonomous Behavior for Simulations (4 - 2)

Covers the concepts and skills required to apply agent-based programming to models and simulations of complex adaptive systems (CAS). Concepts covered will include: complex systems - especially their properties of path dependence, sensitivity to initial conditions, emergence of self-organized structure, adaptation to a changing environment, and criteria for evaluation model or simulation fidelity; distinctions between agent-based methods and other kinds of programming; goal-directed behavior and decision making; situational reasoning and the elements of rational behavior. The course will survey specific works and key contributors to this subject: John Holland, Complexity Science at the Santa Fe Institute, Artificial Life, Brian Arthur (the El Farol Problem and Bounded Rationality), SWARM, Sugarscape, ISAAC, Daniel Dennett (Intentionality), Richard Dawkins.   Within this conceptual and historical framework the course will emphasize design, specification, and programming skills that will equip the student to know when and how to apply agent-based methods to models and simulations. The programming skills will involve genetic algorithms, classifier systems, applications of game theory and reinforcement learning, and the treatment of collaboration and defection in groups. Finally, the course will discuss agent-based simulations in the context of distributed, virtual environments. Prerequisites: None.

MV4025 - Cognitive and Behavioral Modeling for Simulations (3 - 2)

This course focuses on the primary technologies used to model cognition and behavior in order to create agents that represent human beings in simulations.   Topics include the dominant technologies in use, the tools used to support them, and their application to the various capabilities required of an agent. The modeling technologies covered include the production-system approaches common in artificial intelligence/cognitive science/psychology, as well as the finite-state, automata-inspired approaches that are part of engineering practice in computer-generated force simulations and the computer entertainment industry. The full scope of the modeling problem will be addressed, from sensation and perception through situation awareness and action selection, to action execution. Approaches to modeling communication and behavior moderators (e.g. experience, emotion, fatigue) will also be discussed.

Prerequisite: CS3310.

MV4030 - Modeling and Simulation in Ocean Environments (3 - 2)

This course focuses on modeling and simulation (M&S) issues in ocean environments. While virtual environments (VEs) serve as M&S tools, the design of effective VE systems needs realistic physical environments. This course will cover the basic physics of ocean environments, visualization of the ocean from satellites, visualization of the ocean from Navy METOC model output, METOC information flow in M&S, the impact of the environment on human behavior, and physically-based modeling. Prerequisites: None.

MV4100 - Cognitive Engineering (4 - 1)

This course is about a cognitive approach to engineering systems. It is partly about artificial intelligence and agent-based technologies and partly about human-computer interaction. The objective is to build intelligent interactive systems where we maximize the performance and capabilities of the combined human-machine system. Prerequisites: None.

MV4205 - Advanced 3D Modeling with X3D/VRML (4 - 0)

This course teaches advanced principles and practice of web-based 3D computer graphics using X3D (formerly the Virtual Reality Modeling Language, VRML). Examples and class projects are typically oriented to problems of military or scientific interest. Topics include event scripting, optimized geometry representations, prototype extensibility, X3D Earth geospatial models, humanoid animation and IEEE Distributed Interactive Simulation (DIS) networking.

Prerequisite: MV3204 or approval of the instructor.

MV4250 - Advanced Extensible Markup Language (XML) Authoring and Design (4 - 0)

MV4250 presents advanced principles and practices for Web-based document design and authoring using XML data structures, XML applications and XML-based languages. Examples and class projects are typically oriented to problems of broad Navy, military or scientific interest. Because this new course deals with principles of all Web-based languages, and since XML authoring tools are becoming more intuitive and accessible, MV4250 will be of interest to many other Departments and curricula.

Prerequisite: MV3250 or sufficient background knowledge of XML.

MV4302 - Advanced Discrete Event Simulation Modeling (3 - 2)

This course is an in-depth study of modern methods of Discrete Event Simulation (DES) modeling. The focus will be on learning advanced methods for designing and implementing DES models using the most current

methodologies, including component based simulation modeling, listener design patterns, XML and Web-based models. Students will implement a nontrivial DES model of military relevance as a final project.

Prerequisite: OA3302 or equivalent, or consent of instructor.

MV4460 - Management of Modeling & Simulation Development (4 - 0)

The purpose of this course is to prepare MOVES students to manage large-scale modeling and simulation projects. The course traces the development lifecycle of modeling & simulation systems, including but not limited to project management, measurement, lifecycle models, requirements, implementation, testing, verification, and deployment of large-scale systems typical of DoD acquisition. Prerequisites: None.

MV4470 - Image Synthesis (3 - 2)

This course covers advanced topics in computer image generation. The focus of the course is quality and realism in computer image synthesis. Topics include illumination, shading, transparency, antialiasing, shadows, raytracing, radiosity, texture mapping, and parametric surfaces. Labs are directed towards providing students with experience working with a scene graph architecture.

Prerequisite: CS2173 and MV3202 or the consent of the instructor.

MV4471 - Computer Animation (3 - 2)

This course covers advanced topics in the state-of-the-art in animating 3D computer models. Computational techniques for real-time animation, motion control, interactive keyframe systems, kinematic methods for figure animation, dynamics for figure animation, soft object animation, procedural animation and other high-level approaches will be examined. Labs utilize state-of-the-art animation software and equipment.

Prerequisite: MV3202 or MV3204 or consent of instructor.

MV4472 - Physics for Game Developers and Virtual Environments (3 - 2)

This course enables you to produce convincing graphical virtual reality representations of the motion of vehicles and human actors or avatars. Basic linear algebra and vector-matrix calculus are explained, and the ANSI Common Lisp programming language is used, in the context of examples. This is a hands-on, project-oriented course. After studying basic topics, each student will focus on developing and presenting an individual project during the second part of the course. For more information, please visit MV4472's publicly accessible pages at http://online.nps.navy.mil/.

Prerequisite: MV3472 or equivalent.

MV4474 - Virtual Environment Network and Software Architectures (3 - 2)

This course covers the design and implementation of network and software architectures for real-time, interactive 3D virtual environments (VEs). Network architecture topics include a taxonomy for networked virtual environments, distributed interactive simulation protocols (DIS and HLA), virtual reality modeling language (VRML), agent-based network protocols (Java/Telescript), proposed solutions for large-scale networked virtual environments (area of interest mangers and object brokers), multicast backbone tools, and developments, and virtual reality transfer protocol proposals. Software architecture topics include representative software architectures for VEs (NPSNET, DIVE, MASSIVE,...), commercial toolkits for VE development (WorldToolKit, Division's dvs, Performer,...), lag in multiprocessor virtual environments, and the HCI implications on VE network and software architectures.

Prerequisite: MV3500 or the consent of instructor.

MV4501 - Simulation Application Practicum (2 - 4)

This course provides students with extensive laboratory experience applying simulations to address a defense capability gap using simulation-based system. The application domain will be selected from a representative simulation application domains (e.g. training, analysis, acquisition, experimentation). Students will analyze a specified need, develop requirements, objectives, and standards of system and human performance, select a simulation platform, develop additional infrastructure and environments needed to accomplish identified needs and objectives, test their solution, analyze its effectiveness and define recommendations for potential system re-design.

Prerequisite: MV4002.

MV4502 - Simulation Development Practicum (2 - 4)

This course provides the students the opportunity to work directly with a full scale, deployed combat simulation. This class has two main objectives. The first is to gain a deeper understanding of the inner structure of modern combat simulation systems. This goes beyond just looking at conceptual descriptions of the components to looking at the implementation intricacies that make such systems work. The second is as a practicum to provide students experience with all of the processes involved in the development of simulation software. This includes requirements definition, test and evaluation and software design and implementation. The intent is to have the students gain hands on experience in all aspects of these processes. By looking at a deployed system that is being used by the Marine Corps and Army, the students will develop an appreciation for the issues that are encountered in the real world that are often masked in purely pedagogical examples.

Prerequisite: MV4025, MV3302.

MV4503 - Simulation Interoperability Practicum (2 - 4)

This course provides students with hands-on experience with the issues around connecting live, virtual, and constructive simulations into a single federation. Students will deepen their understanding of High Level Architecture down to the Federation Object Model and Simulation Object Model level. They will encounter data and timing incompatibility issues, and learn the tools and techniques currently used to resolve them. They will develop a practical understanding of information assurance requirements on simulations and how they can be addressed.

Prerequisite: MV3500.

MV4504 - Design and Implementation of Live, Virtual, Constructive (LVC) Events (2 - 4)

For each annual offering of MV4504, the course instructor and students will address a current research topic in the design and implementation of live virtual constructive (LVC) simulations in the Navy and Marine Corps as provided by the curriculum and course resource sponsors. Students will investigate the topic through an exhaustive literature review and evaluation of the key issues limiting LVC simulation performance. Throughout the quarter, they will conduct experimentation and analysis to address the problem to ultimately provide specific recommendations to the Navy and Marine Corps sponsors in a final paper and presentation.

This course will apply system design, interoperability programming, and basic networking fundamentals learned in MV4503 to an emerging LVC research area within one quarter of the MOVES curriculum. Students will learn valuable project management, technical assessment, and solution implementation skills. Given the close working relationship with the curriculum and resource sponsor in this course, students will also be exposed to actual capability gaps within the LVC simulation domain.

Prerequisite: This course will be a follow on from MV4503 Advanced Simulation Interoperability, where students will learn about the hardware, software, systems, and service requirements for LVC simulations.   Through hands-on labs and in class exercises, students will learn about the computer hardware requirements for specific LVC events. They will also learn basic networking and the network protocols used in the delivery of data across distributed systems in an LVC environment. Throughout the course, they will be exposed to select commercial-off-the-shelf (COTS) and government-off-the shelf (GOTS) simulations presently used across the Navy and Marine Corps.. Security Clearance Required: .

MV4655 - Introduction to Joint Combat Modeling (4 - 0)

This course covers the basic tools and concepts of joint combat modeling. Both the science and the art are emphasized. Topics include: the role of combat modeling in analyses, taxonomies of models, an introduction to

some important models and organizations, measures of effectiveness, approaches to effectively using models to assist decision-making, object-oriented approaches to designing entities to simulate, firing theory, one-on-one and few-on-few engagements, introduction to aggregated force on force modeling (including the basic Lanchester model and some of its derivatives), sensing algorithms, simulation entity decision making, simulating C4ISR processes, terrain and movement algorithms, verification, validation, & accreditation (VV&A), stochastic versus deterministic representations, hierarchies of models, and variable resolution modeling. The primary course objective is for you to understand the enduring fundamentals of how combat models are built and used to support decision making. This will be done, in part, through several small projects that will require you to design, implement, and analyze models. PREREQUISITES: Probability & Statistics (through third course in the sequence), familiarity with a programming language, Calculus, concurrent instruction in computer simulation (e.g., OA3302).

Prerequisite: Remove a need for prerequisite of OA3301 (Stochastic Models) as the requisite models combat modeling are covered by the course..

MV4657 - Modeling and Simulation for Stability, Security, Transition, and Reconstruction (SSTR) Operations (3 - 2)

The purpose of this course is to explore the challenges of modeling non-traditional combat for today's war fighters. This course investigates issues, challenges, and opportunities for application of modeling and simulation (M&S) to military support for Stability, Security, Transition, and Reconstruction (SSTR) operations. The course considers application of M&S for SSTR from the perspectives of analysis, training, acquisition, and mission planning/rehearsal. Students are given hands-on experience with current and emerging SSTR M&S simulations and computational tools.

Prerequisite: MV4655.

MV4700 - Frontiers in Modeling & Simulation (3 - 0)

MV4700 serves as a seminar-like course that provides students with a perspective on how technology and techniques are evolving in the development and use of Models and Simulations (M&S). This course requires students to take the information that they have learned throughout the degree and apply it to a hypothetical future problem in a selected DoD M&S application area. The course will survey M&S developments and uses across several domains such as manufacturing, the military, healthcare, gaming industry, and corporate business. Topics may vary from year to year. Pedagogical methods will include online pre-recorded lectures, topical papers, independent research, and class discussion. The overall educational goal is for students to think creatively about how emerging M&S technologies and methodologies might be used to improve, training,

acquisition, analysis, quality, productivity, or safety within selected DoD domains.

Prerequisite: Frontiers in M&S relies on foundational material covered in MV3101 and OA3401..

MV4800 - Directed Study in Advanced Modeling, Virtual Environments and Simulation (0 - V)

Advanced group studies in modeling, virtual environments and simulation on a subject of mutual interest to students and faculty member. Intended primarily to permit students to pursue in-depth subjects not fully covered in formal class work or thesis research. May be repeated for credit with a different topic. Graded on Pass/Fail basis only. Variable hours 0-2 to 0-8.

Prerequisite: Consent of Instructor.

MV4900 - Research Seminar in Modeling, Virtual Environments & Simulation (0 - 2)

A seminar series designed to give a broad-brush introduction to MOVES. Presentations include the major areas of MOVES and are presented by subject matter experts within MOVES. Also covered are ongoing research projects within MOVES at NPS and the world. Required by all first and second quarter MOVES students. Prerequisites: None.

MV4910 - Advanced Readings in Advanced Modeling, Virtual Environments and Simulation (0 - V)

Directed readings in modeling, virtual environments and simulation on a subject of mutual interest to student and faculty member. The course allows in-depth study of advanced topics not fully covered in formal class work or thesis research. May be repeated for credit with a different topic. Variable hours 0-2 to 0-8. Can be taken Pass/Fail or graded.

Prerequisite: Consent of Instructor.

MV4920 - Advanced Topics in Advanced Modeling, Virtual Environments and Simulation (V - V)

Designed to support advanced group study of subject matter of special interest, dependent upon faculty availability. Topics will be drawn from areas not covered by other advanced courses, or be focused treatments of subjects of limited scope. This course may be lecture-or-lab oriented, with prerequisites determined by the instructor. Students may repeat this course for credit with a different topic. Variable hours 2-4 to 4-1.

MV4924 - Current Topics in Modeling, Virtual Environments & Simulation (1 - 1)

The course is designed to provide breadth in MOVES not normally provided by other classroom material, as well as focus in major areas of MOVES. Faculty and research staff attend class sessions, providing the opportunity to interact with a broad group once a week, and with a focused group of the student's choosing once a week.

Course is expected to be repeated and is required of all MOVES students every quarter starting with their fourth quarter in the curriculum. Includes student presentations and readings.

Prerequisite: MV3923.

MV4925 - Advanced Rendering Techniques for Visual Simulation (2 - 3)

Currently, the number of transistors on a certain consumer level graphics processing units exceeds the number of transistors on a Pentium IV processor. Until recently, however, programming these powerful units has been done using a limited assembly-like instruction set targeted for a specific vendor's hardware. This has made cinematic effects difficult to program, update and transport. Recent developments such as High Level Shading Language (HLSL), Nvidia's C for Graphics (CG) and the OpenGL 2.0 specification could revolutionize the process of programming GPUs. This class will provide an overview of current technology and will explore in depth its application to DoD.

Prerequisite: MV4470.

MV4930 - Advanced Topics in Advanced Modeling, Virtual Environments and Simulation (0 - 2)

A seminar series in advanced research topics in MOVES drawn from current student thesis research, funded research projects, proposed research projects, and other research directions within the MOVES Institute. Required by all MOVES students in their second quarter and beyond, as well as all CS Graphics Track students. Presentations are made by MS and Ph.D. students, as well as by MOVES faculty and researchers. This course may be repeated multiple times. Prerequisites: None.

MV5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

MV5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council. Prerequisite: Advancement to Candidacy.

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MX2001 - Introduction to Physics-Based Modeling and Simulation (4 - 0)

This course is intended for DoD non-technical acquisition

professionals who do not have engineering or science degrees so that they can obtain a general understanding of key M&S capabilities necessary for design, analysis, and maintenance of engineering systems. The course will introduce basic concepts in the modeling of engineering systems. The steps involved in the idealization of systems to produce a "computable" model will be discussed. Examples will involve structural, thermal, fluid, and electrical aspects. Fundamental physical quantities such as rates of change, (e.g. acceleration, stress) and force will be defined heuristically. The simulation of simple physical processes (e.g. falling object) will described and simple simulation algorithms will be described. No computer programming is required. Spatial discretization, finite difference and finite element methods will be introduced. This course may not be used to fulfill ME/AE degree program requirements. Prerequisites: None.

MX3001 - Basic Engineering Concepts in Modeling & Simulation I (4 - 0)

This course will provide introductory concepts of various engineering topics to DoD non-technical acquisition professionals who do not have engineering or science degrees so that they can obtain a general understanding of key M&S capabilities necessary for design, analysis, and maintenance of engineering systems. The topics covered in the course include structural mechanics, shock & vibrations, fluids, heat transfer & thermodynamics, dynamics and controls, and materials and fabrication. Upon completion, students should have basic understanding of the wide range of engineering concepts that are essential for physics-based engineering modeling and simulation. This course may not be used to fulfill ME/AE degree program requirements.

Prerequisite: MX2001.

MX3002 - Overview of Computers, Weapons Platforms and Electrical Systems (4 - 0)

This course will provide introductory concepts of various engineering topics to the DoD Modeling and Simulation workforce member supporting Defense Acquisition so that they can obtain a general understanding of key M&S capabilities necessary for design, analysis, and maintenance of computers, weapons platforms, and Electrical engineering systems. The topics covered in the course include wave propagation, modeling and simulation approaches to complex system design and assessment, fundamentals of computer software and its limitations, basic concepts in electrical engineering and electrical machinery, and the fundamental issues involved in C4ISR systems. Upon completion, students should have basic understanding of the wide range of engineering concepts that are essential for physics-based engineering M&S. This course may not be used to fulfill ME/AE degree program requirements.

Prerequisite: MX2001, MX3001.

MX4000 - Selected Topics in the Application of Engineering Modeling & Simulation (4 - 0)

This course provides the DoD acquisition professional with an overview of how typical engineering modeling and simulation applications support the acquisition process. A systematic approach will be used to demonstrate the function of physics based modeling and simulation in the design, production, operation and maintenance of complex systems. The course is broken into four general topic areas that address specific engineering features related to land vehicle systems, sea based systems, aviation systems and space-satellite systems. Investigations into the feasibility, utility, and risk of engineering modeling and simulation in each of these focus areas will be highlighting through the use of engineering case studies. Upon completion of this course, students should have a general awareness of engineering modeling and simulation applications in support of the acquisition lifecycle. This course may not be used to fulfill ME/AE degree program requirements.

Prerequisite: MX2001, MX3001, MX3002.

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NS0810 - Thesis Research (0 - 8)

Students conducting thesis research will enroll in this course.

Prerequisite: NS4080, or permission of the Academic Associate.

NS0811 - Preparation for Comprehensive Examination (0 - 8)

(NO CREDIT) Students preparing for comprehensive examinations will enroll in this course.

NS0812 - MIIS Exchange (0 - 0)

(NO CREDIT) Students participating in the exchange program with the Middlebury Institute of International Studies (MIIS) will enroll in this course.

Cross-Listed as: DA0812.

NS0856 - Cultural Immersion Experience Tour (0 - 2)

This course provides overseas cultural immersion experience for designated FAO/RAS officers. Enrollment requires prior authorization by the FAO/RAS proponent of the student's service, and permission from the cognizant Academic Associate of the student's curriculum. A trip report prepared in line with the requirements of each student's service branch is required. Course is graded Pass/Fail, and may be repeated.

NS2079 - Foreign Language Maintenance (2 - 0)

Intended for students with beginning or intermediate proficiency in a foreign language. Such students may maintain or improve their proficiency by arranging for

individualized instruction with appropriately qualified faculty at NPS or DLI. Such arrangements must be made by the student. Enrollment in NS2079 requires the approval of the cognizant Academic Associate and the Department Chairman, and is accomplished using the same procedure required for enrollment in NS3079 and NS4079.

NS3000 - War in the Modern World (4 - 0)

This course provides an introduction to war as a political and social phenomenon, and as a force in the international system. Major themes include: the development of leading ideas about war; the mutual interactions of politics, society, and warfare; the impact of military doctrine on warfighting; allocation of resources and coordination of effort among land, sea, and air forces; national strategic cultures, and their implications for strategic practice. PREREQUISITE: None.

NS3001 - War and Its Impact on Post-Conflict Reconstruction (4 - 0)

The problem of post-conflict reconstruction is hardly a new one. In the past, victors in wars frequently had to manage and rebuild societies shattered by conflict. This course will examine historical examples of post-conflict reconstruction. War creates a competitive environment exploited by groups who seek political power. This competition begins while the war is under way. Competitors seek to place themselves in a position to take advantage of the new post-war environment by choosing allies and enemies, perhaps also arming themselves. On the new post-war playing field, old antagonisms assume new guises. Groups who might have been insignificant or repressed before the conflict can often exploit the new post-war environment to seek power. The military may also be strengthened by war, posing challenges to civilian governments or occupying powers. Social disorder, economic dislocation, and the delegitimization of old political groups or ideas may invite chaos and even civil war. Prerequisites: None.

NS3003 - Nationalism and Revolution (4 - 0)

This course surveys the history of revolution in modern times, with particular emphasis on their role in the creation and development of modern nation states, and on the role of nationalism, more broadly, in the development of modern society. Prerequisites: None.

NS3005 - Great Power Conflict in Modern History (4 - 0)

This course studies the history of great power conflict in modern times, with particular attention to those periods when such conflict has given rise to war and other forms of violent upheaval. It also considers the role of the great powers in the development and evolution of the modern

nation-state, and of the international system upon which global political and economic order have come to depend.

Prerequisite: None. Corequisite: None.

NS3011 - Research and Writing for National Security Affairs (4 - 0)

This course provides students with the basic tools to understand and produce research in relevant areas of history, social science and policy analysis. The general objectives of the course are to make you a more critical reader and thinker and better writer and researcher. The course is designed to help you with your other classes at NPS, which require you to read and write research papers. The course will also introduce students to basic elements of research design and methodology. In addition, the course will provide information on the thesis process at NPS. By the end of the course, every student should be able to produce a well-designed and well-written research paper or thesis. Graded Pass/Fail. PREREQUISITE: None.

NS3014 - Research and Writing for Homeland Security (2 - 0)

Offered through the Center for Homeland Defense and Security (CHDS), NS3014, Research and Writing for Homeland Security, serves two broad purposes. First, a series of interactive workshops as well as individual assignments and one-to-one sessions with an instructor are meant to refresh and expand students' knowledge and mastery of the essentials of effective and correct research, composition, argumentation, and analysis. Second, building on these activities, as well as examples and assessments of each student's first-quarter deliverables, the coursework is meant to: a) ensure that all students are equipped to succeed in their academic writing (including the other CHDS course assignments, as well as their theses); b) familiarize students with the specific requirements and expectations of academic writing at NPS, to include appropriate quoting, paraphrasing, and citation, as well as the standards and thresholds of the academic honor code and the particulars of human-subjects research at the university; c) deepen students' competencies in such relevant productivity applications as Microsoft Word, Zotero, and iThenticate; d) advance critical thinking, research and inquiry skills; and e) propel students toward the skills and knowledge they will need to produce a strong thesis proposal (in the two-term research course sequence), and then later for the final thesis. Specifically, in this course, students, with the regular guidance of their instructor, will work toward identifying an appropriate thesis topic, drafting a workable thesis question, completing preliminary research and assessing the most relevant sources in their topic, and absolving a series of thinking, writing, revising, and practicing assignments to these ends. Prerequisites: None.

NS3021 - Defense Capability Development (4 - 0)

This course examines Service, Joint, and Multinational Concept Development and Experimentation programs for developing defense capabilities that are necessary to meet the anticipated operational challenges of the future security environment. The course explores the capabilities-based approach to defense planning that assesses how to effectively counter transnational, regional, and emergent peer competitors. The course considers what innovative capabilities are required to defeat adversaries who wage warfare across the maritime, land, air, space and cyberspace domains. The course analyzes emerging operational concepts, organizational configurations, technological advances, and people innovations, including doctrinal and training adjustments, for shifting the conduct of warfare to maintain competitive advantage in the 21st Century. Prerequisites: None.

NS3023 - Introduction to Comparative Politics (4 - 0)

This course is designed to introduce students to the major intellectual approaches to the study of comparative politics. Readings will be drawn from major theorists and leading schools of thought. Students will confront the central questions on the nature of economic, political, and cultural development. PREREQUISITE: None.

NS3024 - Introduction to International Relations (4 - 0)

This course provides an overview of the prominent theories of international relations. It surveys explanations based on decision making, organizational behavior, domestic politics, international regimes and international systems, especially in terms of the insights they offer into the conduct of international relations in the post-Cold War world. PREREQUISITE: None. CLASSIFICATION: None.

NS3025 - Introduction to Civil-Military Relations (4 - 0)

This course introduces students to the basic concepts and issues in civil-military relations. It offers a historical and comparative analysis of different patterns of military participation in politics, defense policy making and national development. The course also introduces alternative models for structuring civil-military relations, and examines the problems associated with the models adopted by the United States and other nations. PREREQUISITE: None.

NS3026 - Introduction to Post-Conflict Security Building (4 - 0)

This course introduces students to the fuller program, intended to prepare them to work together in operations that build security in post-conflict environments. As such, it provides both conceptual tools for thinking about post-conflict security building and empirical referents to ground later study. Military strategists have written much about going to war, but have given less consideration to the movement from war to peace. How can one think strategically about the post-conflict environment? This course introduces students to characteristics of post-conflict environments and the diverse actors seeking to shape it. The course draws upon real-world cases to identify patterns of conflict and their consequences for post-conflict transition. In particular, the course will focus on interventions by external actors, civilian and military, in peace implementation. What are the typical components of post-conflict security building programs? This course covers practical issues in, and normative dimensions of, post-conflict security building. PREREQUISITE: None.

NS3028 - Comparative Government for Homeland Security (4 - 0)

Offered through the Center for Homeland Defense and Security. The objectives of the NS3028 course are: (1) to understand the trans-national nature of terrorism, organized crime, pandemics and other homeland security threats, (2) to assess homeland security strategies employed by liberal democracies around the world; (3) to distill and extrapolate policy implications from these examples; and (4) to apply these lessons to the organizational and functional challenges faced by homeland security leaders in the United States. The course will focus both on a discussion of shared threats such as the global Jihadi movement, Al-Qaeda activity in Afghanistan and Pakistan, Middle Eastern groups such as Hamas and Hezbollah as well as policies and strategies employed by a range of democratic countries to cope with terrorism and other homeland security related threats. In addition to looking at specific countries, the course will also look at issue areas such as bio-threats, health system preparedness, airport security and anti-radicalization policies across countries. This course will provide students with a knowledge base and methodology with which to learn from the practices of other countries and translate those practices into policies applicable in the United States. The course will also enable students to better understand the threats that other countries face (many of which are likely to affect the United States in the near term) and how they cope with those threats. Finally, the course will enable students to be prepared to engage with their international partners at the local, state or federal levels as Homeland Security becomes an increasingly global undertaking and all levels of government in the United States move toward conducting greater international outreach. Prerequisite: None.

NS3030 - American National Security Policy (4 - 0)

An overview of U.S. national security policy formulation. Covers the processes and actors involved, both governmental and non-governmental. At instructor's

discretion, course might also address recent developments in U.S. national security strategy. Prerequisites: None.

NS3039 - Maritime Security Cooperation (4 - 0)

This course offers an introduction to the theory and practice of maritime security cooperation. It explores the main features of the maritime domain, the major challenges to maritime security, and the leading U.S. and international efforts to combat those threats by sharing information and coordinating operations. The course is grounded in the study of international relations, which provides analytical tools that help explain why cooperation succeeds or fails and how to design institutions that make success more likely, especially in the context of rising great power competition. U.S. maritime strategy regards maritime security as a key line of effort and cooperation with allies and partners as essential to securing the maritime domain.

NS3040 - The Politics of Global Economic Relations (4 - 0)

Examination of the world economy. Focuses on implications for the United States over changes in the world trading and financial systems. Topics covered include trade patterns, economic integration, trade blocs, new international economic order, and international economic organizations. PREREQUISITE: None.

NS3041 - Comparative Economic Systems (4 - 0)

An examination of the economic systems and development problems in developing countries, including post-communist states. The course focuses on the political and ideological bases of economic organizations, and the nature of basic economic problems in these regions. Special attention is given to the socio-economic strategies and tactics used in the management of the economy, and institutions and techniques of decision making. Attention is also given to problems of economic stabilization in the developing world. PREREQUISITE: None.

NS3077 - Practicum in Regional Security Studies (4 - 0)

This course supports student research conducted under the auspices of the Institute for Security Governance and the Joint Foreign Area Officer Sustainment Program. Students work overseas under NSA faculty supervision, and participate in seminars, exercises, and other programs offered in Monterey or abroad, dealing with the region that is the focus of the research. The Practicum is open to students in any NSA curriculum, but is limited to those selected for participation by the organization supervising the program. Grading is Pass/Fail.

Prerequisite: Permission of the instructor.

NS3079 - Directed Studies in National Security Affairs (V - 0)

(Credit 1–0 to 4–0)Format and content vary. Normally involves extensive assigned readings, individual discussions with the instructor, papers and/or examinations.

NS3155 - Intelligence and Democracy (4 - 0)

This course examines the methods civilian authorities in emerging democracies can use to establish strong, effective controls over their intelligence agencies. The course begins by examining the intelligence process in the United States and the United Kingdom, and the potential problems that intelligence activities can pose to democratic governance. Next, students will analyze the mechanisms used by the U.S., the U.K., France and other long-established democracies to maintain control over their intelligence organizations. These instruments of control include use of the power of the purse, structural and organizational arrangements, legislative oversight, and legal mechanisms. Employing the case study approach, students will examine the recent efforts by democracies in Latin America, Central Europe, Africa, and Asia to establish their own democratic controls over intelligence, and the challenges that such nations will face in the future. Prerequisites: None.

NS3159 - Principles of Joint Operational Intelligence (4 - 0)

This course examines the intelligence process, organizational structure and related C4I architecture within the context of intelligence support to the planning and conduct of joint and combined operations at the operational level of war. This course addresses the conduct of intelligence to include the development of requirements, collection management, threat analysis, assessments, and dissemination of intelligence to the decision maker. The course includes an overview of intelligence data systems and associated connectivity. Students are required to prepare and present intelligence briefings and staff intelligence studies, incorporating the knowledge gained in the course. Prerequisites: None.

NS3160 - Human Intelligence (4 - 0)

This course familiarizes students with the concepts, principles, and methodology of Human Intelligence collection. Additionally, students will comprehend the capabilities and limitations of various collectors and programs, learn the organizational architecture and understand the collection management process of Human Intelligence. This course is a requirement for all students in the Regional Intelligence Track of the Joint Intelligence Curriculum. Student must be a U.S. citizen holding a TOP SECRET clearance with eligibility for access to SCI.

Prerequisites: None.

Security Clearance Required: Top Secret SCI.

NS3161 - Principles of Open Source Intelligence (4 - 0)

This course examines open source intelligence (OSINT) with a focus on the following areas: definition and nature of OSINT, OSINT policy and management, history and development of OSINT, current OSINT trends, OSINT-focused organizations, challenges, reform, and future prospects. Prerequisites: None.

NS3180 - Introduction to Homeland Security (4 - 0)

Offered through the Center for Homeland Defense and Security. This course provides an overview of the essential ideas that constitute the emerging discipline of homeland security. It has two central objectives: to expand the way participants think, analyze and communicate about homeland security; and to assess knowledge in critical homeland security knowledge domains. Prerequisites: None.

NS3181 - Introduction to Homeland Defense and Security (4 - 0)

This course surveys the distinctive features and challenges of homeland defense and security, with emphasis on the interagency process by which the contributions of the armed forces and defense agencies are integrated with those of civilian federal agencies and state and local governments. Prerequisites: None.

NS3200 - Cyberspace Operations Fundamentals (4 - 2)

This course explores the fundamentals of cyberspace operations. The broad goals of the course are to cover the three main domains of cyber – science and technology, computation and data analytics, and strategy, policy and ethics. Conceptually cyberspace operations are the employment of cyber capabilities to achieve objectives in or through cyberspace. Nation state militaries, agencies or proxies use these operations as a component of conflict or warfare for political utility or competitive advantage.This course analyzes the offensive and defensive dimensions of cyberspace operations based on actual campaigns and incidents. It examines network architectures, technical methods, and emerging innovations for the conduct of cyberspace operations. The course debates policy and legal precedents to counter malicious actors operating in the domain. The hands-on lab exercises provide students with opportunities to employ cyber tools and techniques used by actors and to engage in war game decisions. The course concludes by proposing novel strategies to mitigate risk and prevail in cyber enabled military affairs.

Cross-Listed as: Cross-listed with CY3200.

NS3210 - The Unconventional Threat to HLS (4 - 0)

Offered through the Center for Homeland Defense and Security. The purpose of this course is to provide an introduction to the operational and organizational dynamics of terrorism. It considers those who act as individuals, in small groups or in large organizations. By the end of the course, students should be able to design effective measures for countering and responding to terrorism based on an understanding of its organizational and operational dynamics. Prerequisites: None.

NS3225 - Civil-Military Relations and Defense Budgeting (4 - 0)

Accelerated course, offered through the Defense Resource Management Institute. This course provides a detailed analysis of the budget process used by the United States and other democracies to allocate defense resources. Students will become familiar with the planning, programming and budgeting system (PPBS) and other budgeting models and techniques. Students will also examine the sources of civil-military conflict in defense budgeting, and analyze different structures to resolve those conflicts. Prerequisites: None.

NS3230 - Innovation and Adaptation in the Military (4 - 0)

This course provides an introduction to and critical examination of the role the military plays in U.S. strategic planning and national security policy formulation. The focus will be on the institutions and actors involved in strategic planning, the planning process itself, and the outputs of that process. Theory and process meet through case study and analysis of the evolution of U.S. military planning practices, including the changing roles of the Joint Staff, combatant commands and service components, joint task forces, and service staffs following passage of the Goldwater-Nichols Act and post-Cold War international security developments. Prerequisites: None.

NS3235 - Civil Wars (4 - 0)

Since 1945, civil wars have occurred five times more frequently than interstate wars. These civil conflicts produce major humanitarian crises, give rise to violent extremists, and serve as arenas for strategic competition. This course explores three phases of civil wars: *conflict onset*, *conflict dynamics*, and *conflict termination*. This exploration will involve reading the scholarly literature on civil wars and simulating key dynamics to truly understand the complexities of civil conflicts across multiple regions of the world.

Prerequisite: None.

NS3280 - Nuclear Weapons and National Strategies (4 - 0)

This course surveys the history of nuclear weapons policies both in the United States and internationally, focusing in particular on comparative national strategies. It considers requirements for deterrence, incentives for arms control and nonproliferation policies, and new challenges posed by nuclear proliferation. PREREQUISITE: None.

NS3285 - Nuclear, Biological, and Chemical Weapons: Proliferation and Nonproliferation (4 - 0)

This course examines the proliferation of nuclear, biological, and chemical (NBC) weapons. It is an introductory survey course that covers the history and causes of NBC proliferation, the impact of proliferation on U.S. and international security, and the range and effectiveness of past efforts to restrain and/or mitigate proliferation. The class focuses on the changing nature of NBC proliferation problems, evaluating contemporary challenges and assessing potential future policy responses. It assumes no specialized prior knowledge of the subject matter. For this reason, it reviews the basic technologies of NBC weapons and current perspectives on proliferation problems and debates on means to overcome them. Prerequisites: None.

NS3300 - Islam (4 - 0)

Islam is one of the great monotheistic faiths of the modern world. This survey course examines the history and tenets of Islam and the breadth of Muslim cultures and civilizations. PREREQUISITE: None.

NS3301 - African History and Cultures (4 - 0)

This course provides a broad overview of African history, with an emphasis on understanding the historical foundations of important contemporary issues. In addition, it examines the process of cultural change in Africa over the course of the twentieth century, through an in-depth study of the fiction of Chinua Achebe. PREREQUISITE: None.

NS3311 - Government and Politics in Sub-Saharan Africa (4 - 0)

This course is designed for graduate students with little or no background in the study of African government and politics. It introduces students to the main structures and processes of contemporary African politics, and to important theoretical debates in the field of African studies. The emphasis is less on formal institutions of government and more on the informal practices that compromise the primary arena of African government and politics. Prerequisites: None.

NS3315 - Modern Arab History (4 - 0)

This course studies the history of the Arab Middle East from the end of the First World War to the present. It will examine Western engagement in the region and the eventual creation of the current nation-states. The political and social evolution of the region and its relations with the West will be broadly surveyed. Prerequisites: None.

NS3320 - US Foreign Policy in the Middle East (4 - 0)

The course reviews the historical background and current status of American interests and policies in the Middle East. The course focuses on how different U.S. administrations in the post-World War II era defined American interests in the Middle East, and on the major policies enacted to pursue those interests. PREREQUISITE: None.

NS3321 - U.S. Foreign Policy towards Africa (4 - 0)

This course examines U.S. foreign policy in Sub-Saharan Africa since 1960, with emphasis on the post-Cold War period. PREREQUISITE: None.

NS3325 - War in the Middle East (4 - 0)

This course studies the international history of the Middle East and North Africa since the fall of the Ottoman Empire, with a particular focus on the origin, conduct, and consequences of the region's major wars. Prerequisites: None.

NS3330 - Comparative Politics of the Middle East (4 - 0)

Focuses on the Middle East region's role in world events in the post-World War I era, including the impact of great power rivalries in the region, transnational movements, and envirostrategic considerations. PREREQUISITE: None.

NS3345 - International Relations of the Middle East (4 - 0)

The Middle East is one of the most conflict-prone regions of the world. Great powers now, as in the past, view the Middle East as an arena for local alliances and competition by proxy actors. In this general survey course, we will study the international politics of the Middle East from WWI to the present. We will explore how the great powers have shaped the region's borders, identities, and conflicts. It will also make sense of the foreign policies of pivotal regional states such as Egypt, Iran, Iraq, Israel, Saudi Arabia, Syria, and Turkey.

Prerequisite: No prerequisites required.

NS3361 - Politics and Security in Levant (4 - 0)

A survey course on the politics and security of the Levant in the post-World War I era. The geographic focus is on the countries of Syria, Jordan, Lebanon, Israel and Palestine. PREREQUISITE: None.

NS3365 - Politics and Security in the Persian Gulf (4 - 0)

A survey course on the politics and security of the Persian Gulf in the post-World War I era. The geographic focus is on the countries of Iraq, Saudi Arabia, Kuwait, Bahrain, Qatar, Oman and the UAE. PREREQUISITE: None.

NS3366 - Modern Turkish History (4 - 0)

This course covers the History of Modern Turkey and its transition as a society and political entity from the late Ottoman Empire to the Republic of Turkey today. While the course will be organized around political events there will also be discussions about culture, religion, nationalism and everyday life. The primary focus is historical - focusing on how Turkish society evolved and responded to a number of domestic, regional, and international processes and challenges. Prerequisites: None.

NS3400 - History of Russia and Eurasia (4 - 0)

An examination of the history of Russia, Eastern Europe, and Central Asian nations. The emphasis is on historical influences, political institutions, ethnic and social problems, and the economy. PREREQUISITE: None.

NS3401 - Contemporary Politics of Russia (4 - 0)

This course introduces students to the contemporary politics of Russia, focusing on the post-Soviet era. PREREQUISITE: None.

NS3412 - Government and Security in the Central Asian Republics (4 - 0)

With China and Russia taking an ever increasing greater interest in central Asia, U.S. policy makers face the challenge of maintaining an influential presence in the region. Over a decade since the breakup of the Soviet Union, the five Central Asian Republics have emerged as a critical security issue as WMDs, terrorists and hard-line regimes have come to dominate the landscape. In a land where Islam is more cultural than religious, communism more trusted than capitalism, and ethnic divisions a Soviet invention, how can stable democracies emerge? This course will represent a comprehensive assessment of the newly formed states of central Asia that were formerly parts of the Soviet Union. Through examination of the complex historical, ethnic, religious, and linguistic factors that unite and divide the Central Asian Region, we will better understand the challenges of political

modernization, economic reform, and integration into the international community. The course topics will include; the history of the region; the relationship between Islam and Central Asia; environmental issues; economic development and emerging energy markets in the region; the contemporary political scene; and the role of the region in world affairs. Special emphasis will be placed on the contemporary crises in the region. Prerequisites: None.

NS3450 - The Russian Military, Past and Present (4 - 0)

This course examines Russia's military from the past to the present. It is organized chronologically and is divided into three parts. The introductory section begins with Muscovy and the foundations of Russia's military to the First World War. The second section explores the rise of the Soviet military-industrial complex and the emergence and decline of the Soviet Union as a military superpower. The final section considers the current state of the Russian military. This course weaves politics, history, and foreign policy into one historical and analytical narrative by focusing on interpretations of Russia's past wars and analysis of the Russian military today. Throughout the course we will explore such questions as: What has been the role of war in the creation of the Russian Empire, the Soviet Union, and the Russian Federation? What ideas have motivated people to fight? What is the relationship between technological innovation and war? And how do we write about war and the military?

NS3460 - Government and Security in Eastern Europe (4 - 0)

This course examines the countries of east central Europe that fell in the Soviet sphere of influence after World War II. It is concerned in particular with the complex relationship of Marxism and nationalism, the nature of communist revolution from abroad, revolutions against communist states including Hungary in 1956 and Poland in 1980, and the present situation of the Central European states in the transition from communism to democracy. PREREQUISITE: None.

NS3501 - History and Cultures of Latin America (4 - 0)

This introductory course examines the heritage of Latin America from pre-Columbian Indian traditions and Iberian colonial patterns, through the independence movements of the early nineteenth century, and the global economic relationships that re-oriented the region toward Northwestern Europe and the United States. PREREQUISITE: None.

NS3510 - Government and Politics in Latin America (4 - 0)

This introductory course is designed to familiarize

students with the politics of contemporary Latin America. The course will cover such topics as the various types of political systems found in Latin America, the political economy of development and the issue of regime transition. PREREQUISITE: None.

NS3520 - Latin American International Relations (4 - 0)

This course surveys the international relations of Latin American nations. It analyzes the relations of Latin America with the United States and other nations, both within and outside of the region. Attention is given to political, economic, and cultural issues. PREREQUISITE: None.

NS3578 - Society, Politics, and Security in Contemporary Brazil (4 - 0)

Brazil is the largest county in South America, a major regional power that is rapidly emerging as an important global actor. This course will provide students with the historical and social background required to better understand contemporary Brazil. It will survey its recent history and current condition as a consolidating democracy, and focus on security issues both as perceived by the Brazilian elite, and as projected upon Brazil by the United States and Brazil's neighbors in South America. Prerequisites: None.

NS3580 - Comparative Border Security (4 - 0)

This course offers a thorough introduction to the border as a geopolitical construct that materializes in territories of linear configuration the balance of power among nations or regions (both internal and supranational). We will study and compare the elements that make borders a singular geographic space with unique management challenges and institutions, its relation with conflict, security and war. Prerequisites: None.

NS3600 - History of Modern East Asia (4 - 0)

This course surveys the interaction between the traditional civilizations of east Asia and the Western great powers since the early 19th century. It emphasizes the evolution of the modern international system in the region, beginning with the imposition of the treaty port system on China, Japan, and Korea, and follows the separate responses of those countries to Western influences though the era of the world wars and down to the present. PREREQUISITE: None.

NS3601 - History and Cultures of Southeast Asia (4 - 0)

This course addresses the historical development of the peoples of mainland and island Southeast Asia from their origins to the end of the nineteenth century. It focuses on the political, military, social and economic development of

these societies and on their belief systems, including Hinduism, Buddhism, and Islam. PREREQUISITE: None.

NS3620 - Survey of Asian Politics (4 - 0)

This course surveys the major themes of Asian politics. The goals of the course are to introduce students to major debates and various modes of political interaction and patterns of political development in Asia. Half of the course is devoted to Northeast Asia and the other half to Southeast Asia. Prerequisites: None.

NS3621 - International Relations of South East Asia (4 - 0)

This course focuses on the contemporary international relations of South East Asia, to include Thailand, Malaysia, Singapore, Indonesia, and Oceania. Prerequisites: None.

NS3645 - Political Economy of Asia (4 - 0)

This course explores the reasons for the different timing and paths of economic development in Japan, China, Taiwan and South Korea. It examines the reasons for the lateness of development of East Asia relative to the West, and especially the lateness of development of China compared to Japan. Emphasis will be on the evolution of institutions in the course of state building, and the international geopolitical context of Asian development. Prerequisites: None.

NS3661 - Politics in China (4 - 0)

An examination of the rise of the Chinese Communist Party and the establishment of the Communist state; its domestic achievements and problems; and the special issues posed by Taiwan, Hong Kong, and Xinjiang.

NS3662 - Government and Security in Japan (4 - 0)

An examination of Japan in the contemporary world, focusing on Japan's political dynamics, economic evolution, social transformation, the National Self Defense Forces and alternatives for ensuring national security. Includes an examination of U.S. relations with Japan. PREREQUISITE: None.

NS3663 - Government and Security in Korea (4 - 0)

An examination of the division of the Korean nation into two states; the aftermath of the Korean war; domestic political, economic and social problems of North Korea and South Korea; the prospects for reunification; the military balance and the changing strategic environment; and the relations of Pyongyang and Seoul with their key allies. Includes an examination of U.S. relations with Korea. PREREQUISITE: None.

NS3664 - Government & Security in Southeast Asia (4 - 0)

This course examines the development of South East Asian politics from decolonization to the present day. Prerequisites: None.

NS3667 - Chinese Foreign Policy (4 - 0)

This course provides a systematic examination of contemporary Chinese foreign policy. It reviews the evolution of Beijing's international goals and policies since 1949, but focuses of Beijing's contemporary foreign policy goals, its policy-making process, and the foreign relations instruments at its disposal including military force.

Prerequisite: NS3661 or consent of the instructor.

NS3668 - Politics and Security in South Asia (4 - 0)

This course traces the history and evolution of South Asian politics leading up to the partition of the Subcontinent. It familiarizes students with the key debates and future trajectories in contemporary South Asia. This course creates a sound base for advance seminars on NS 4668, which should be a logical follow-up and other regional security seminars. Prerequisites: None.

NS3700 - History of Modern Europe (4 - 0)

Review and analysis of the political and military history of Europe, including Russia, from the Congress of Vienna to the present. PREREQUISITE: None.

NS3710 - Government and Security in Western Europe (4 - 0)

Survey and analysis of government and security issues in contemporary Western Europe. The course emphasizes the post-1945 history, government, political system, and security policies of Britain, France, Italy, and Germany. Major topics include relations with the United States and policies concerning the future of NATO and the European Union. Prerequisites: None.

NS3720 - European Security Institutions (4 - 0)

Survey and analysis of the main international institutions dealing with European security: the North Atlantic Treaty Organization (NATO), the Organization for Security and Cooperation in Europe (OSCE), the European Union (EU), and the United Nations (UN). The survey includes selected challenges facing each organization, particularly NATO, and their relation to specific European countries and to U.S. foreign and defense policy. Prerequisites: None.

NS3730 - The Balkans: History & Politics (4 - 0)

A survey of the historical background of and contemporary developments in the Balkans region, with a special focus on the collapse of the former Yugoslavia, the various conflicts that followed, including that in Kosovo, the role of other regional actors in these events, and the prospects for future stability and progress in the region. Prerequisites: None.

NS3801 - Introduction to Terrorism (4 - 0)

This course provides an in-depth examination of the origins, nature, and political/military roles of contemporary international terrorism. It briefly examines the early history of terrorism, the contending theories that purport to explain the sources of terrorist behavior, the different types of terrorism and terrorist actions, and the challenge international terrorism poses for American interests and foreign policy. Functional topics, such as the special problems posed by state-sponsored terrorism, the relationship between terrorism and the media, and the range of possible military responses to terrorism are also examined. The course will conclude by comparing and contrasting different national responses to the problem of international terrorism, and examining the difficulties faced by the United States in its efforts to find an effective policy response.

Prerequisite: NS3023 or permission of the instructor.

NS3802 - Counter-terrorism Policy in Comparative Perspective (4 - 0)

This course studies counterterrorist policy in a variety of countries, including the United States. It considers the means by which policies are formulated, and their effectiveness evaluated, as well as the implementation of counterterrorist policies as they affect human rights, civil liberties, and the population at large. We also look at issues such as oversight of institutions charged with internal security, executive power, and the impact of international law on domestic politics. Prerequisites: None.

NS3900 - International Law and Organizations (4 - 0)

An introduction to the principles of international law including origins, sources, sovereignty, states, territory, jurisdiction, persons, treaties, settlement of disputes and the Law of the Sea. The course also traces the evolution of international organizations from the Concert of Europe, through the League of Nations, United Nations, European Economic Community, NATO, and various forms of multi-national and transnational organizations. PREREQUISITE: None.

NS3903 - Ethical Theory for Military Officers (4 - 0)

This course is a philosophical survey of major ethical theories that individuals or societies use to form their moral worldview. One presupposition of the course is that, as moral agents by virtue of being in various

relationships with others, everybody has a philosophy--a way of thinking about and engaging others-that is, our social behavior. Thus, the course will also seek to move the student, as a military officer and a moral agent, beyond an external understanding of the major ethical theories and ask them to articulate their moral worldview and the ethical framework (theory) that forms the skeleton of that worldview. Such introspection is also vital for engaging other cultures when deployed as operators, analysts, or staff officers. In short, this course is designed to enable military officers to gain that inner knowledge and engage others from positions of ethical strength rather than of weakness. Prerequisites: None.

NS4000 - Great Power Competition: Current Policy and Strategy (0 - 2)

This course provides critical and timely information on the political and strategic challenges posed for the United States by the emergence of great power competition (GPC) with China and its re-emergence with Russia. The course will begin with a brief overview of the core dynamics of GPC historically, then examine the political, economic, and military drivers behind current Chinese and Russian policies, next discuss Chinese and Russian efforts to extend their influence into critical regions and functional domains, and conclude with a discussion of possible U.S. (and allied) responses.

Prerequisite: None.

NS4021 - Europe and the United States (4 - 0)

A historical-political advanced seminar on the evolution of U.S. policy towards Europe from the end of the 19th century until the present; the character of anti-European ideas in U.S. political and strategic culture; the role of leading personalities in the formulation of U.S. policy towards Europe in the critical periods of the twentieth century; the character of anti-U.S. sentiment in continental Europe; U.S. alliance cohesion and cultural diplomacy in continental Europe. The seminar analyzes readings in common and requires a larger independent research project. Prerequisites: None.

NS4022 - Soldiers and Politics in the Euro-Atlantic Region (4 - 0)

A comparison in an advanced seminar format via historical case studies of the evolution of the soldier and the state in the Anglo-Saxon countries and their continental European counterparts. the evolution of civil-military relations from the dynastic, absolutist Europe to the era of total war in the twentieth century, with special attention to the German, British and U.S. cases of the evolution of state, national, military institutions, alliance cohesion, and wars of ideology. Further attention is also paid to the proliferation of warfare, ideology, and mass politics and the professional soldier in modern history. An analysis of common readings as well as an independent research

paper round out the seminar. Prerequisites: None.

NS4023 - State, Nation, and Nationalism in Europe, 1500-1945 (4 - 0)

An advanced seminar on the evolution of the state, nation, and nation-state in western, central and eastern Europe from the seventeenth century until the middle of the twentieth. Special emphasis falls on the rise of national ideas in the eighteenth century, case studies of nation building and the propagation of nationalism in the nineteenth and twentieth centuries, as well as the transformation of nationalism into a force of total war and genocide in the twentieth century. An analysis of the common readings as well as an independent research project is required. Prerequisites: None.

NS4024 - Political Economy of China (4 - 0)

This course explores how state, society, and politics impinge on the Chinese economy in its transition from planned to market economy; and examines what political and economic adjustments China has to make as the country becomes increasingly integrated with the world economy. Prerequisites: None.

NS4025 - Special Topics: East Asia (4 - 0)

We use a paired comparative method in order to assess some of the leading theories on market transformation, and examine the geopolitical context, the strategies, process of institutional adjustment, and the coalition of interests formed to support or resist change as Japan, North and South Korea, China, and Russia undertake market reform. Prerequisites: None.

NS4032 - Special Topics: International Relations (4 - 0)

This course will focus on current topics in the broader international system. The list of issues to be analyzed for the seminar is announced at least one quarter prior to the offering of the seminar. Advanced study and research is conducted on topics not covered in other seminars. A major, graded research paper is required.

Prerequisite: Permission of the instructor.

NS4035 - Special Topics: Intelligence (4 - 0)

This seminar will focus on contemporary topics involving joint intelligence and related areas. The list of issues to be analyzed for the seminar is announced one quarter prior to the offering of the seminar. Advanced study and research is conducted on topics not covered in other seminars. Requires U.S. citizen holding a TOP SECRET clearance with eligibility for access to SCI.

Prerequisite: Permission of the instructor. Security Clearance Required: Top Secret SCI.

NS4037 - NATO (4 - 0)

This advanced seminar is a colloquium on the past and present policy and strategy of NATO via an examination of its leading crises from 1949 until 2003 in an effort to understand the nature of alliances in the Euro-Atlantic world, their strategies and issues of cohesion amid crisis. The class examines such themes as: a.) the evolution of ideas in the formulation of alliance statecraft and strategy; b.) the dimension of burden sharing in alliance statecraft and bi-lateral relations; c.) the problems of defense and military transformation in the past, especially connected with alliance politics and political biography; d.) the past instances of severe discord in national strategy and alliance statecraft with enduring importance for the essence of NATO; the modalities of NATO enlargement in the era 1989-1999 and beyond; the post-1990 shift from forward defense in central Europe to the rise of peace enforcement operations in S.E. Europe. Finally, attention is also given to the issues of the present connected with the role of NATO in ongoing security operations on a wide front. This class is taught in a colloquium format; further, it requires an additional book report and the preparation of large synthetic essay on the sum of the readings. Prerequisites: None

NS4051 - Special Topics: Comparative Politics (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles. Prerequisite: NS3023.

NS4052 - Special Topics: International and Military History (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles. Prerequisite: NS3000.

NS4053 - Special Topics: Political Economy (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles.

NS4054 - Special Topics: Strategic Studies (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles.

Prerequisite: NS3000, NS3023.

NS4055 - Special Topics: Africa (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles.

Prerequisite: Prior completion of at least one 3000-level course on Africa, or permission of the instructor.

NS4056 - Special Topics: South Asia (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles.

Prerequisite: Prior completion of at least one 3000-level course on South Asia, or permission of the instructor.

NS4057 - Special Topics: Southeast Asia (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles.

Prerequisite: Prior completion of at least one 3000-level course on Southeast Asia, or permission of the instructor.

NS4058 - Special Topics: Eurasia (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles.

Prerequisite: Prior completion of at least one 3000-level course on Eurasia, or permission of the instructor.

NS4059 - Special Topics: Latin America (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of

each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles.

Prerequisite: Prior completion of at least one 3000-level course on Latin America, or permission of the instructor.

NS4060 - Special Topics: Stabilization and Reconstruction (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles.

Prerequisite: NS3026.

NS4061 - Special Topics: Homeland Security and Defense (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles.

Prerequisite: NS3181.

NS4062 - Special Topics: Terrorism (4 - 0)

This course introduces students to specialized subjects or problems within its particular field of study. The topic of each segment will be specified via a subtitle in departmental course scheduling documents. Detailed information should be sought from the professor offering the course. Special Topics courses with the same number may be repeated with different subtitles.

Prerequisite: NS3801 or NS3802, or permission of the instructor..

NS4079 - Advanced Directed Studies in National Security Affairs (V - 0)

(Variable credit, from 1-0 to 4-0.) Format and content vary. Normally involves extensive individual research under direction of the instructor and submission of a substantial paper of graduate seminar quality and scope.

Prerequisite: Permission of the instructor.

NS4080 - Thesis Proposal (0 - 8)

This course is intended to assist students in the preparation of their master's thesis proposals. A completed proposal, endorsed by the thesis advisors, the cognizant Academic Associate, and the department chair, is required to pass this course. Grading: Pass/fail. Prerequisites: None.

NS4081 - Research Colloquium (2 - 0)

Offered through the Center for Homeland Defense and Security (CHDS) NS4081, as the second part of the research and writing sequence, is designed to advance students' critical thinking, research and inquiry, and all other competencies required to produce a strong thesis proposal (in this course sequence), and then later for the final thesis. As its main thrust, this course sequence identifies and practices, with the sustained individual guidance of the instructor and CHDS and university writing support, the main steps and modalities of good research: the construction of research questions; literature review; hypothesis testing; proper handling of arguments, claims, and evidence; problem statements; research design and planning; research methods. In addition, targeted workshops in both the in-residence and distance-learning phases of the course serve to keep students researching, writing, drafting, and thinking at an advanced level. Prerequisites: NS3014.

Prerequisite: NS2013.

NS4133 - Psychology of Fear Management and Terrorism (0 - 4)

Offered through the Center for Homeland Defense and Security. This course serves as an introduction for homeland security professionals to terrorism as a psychological phenomenon. Government agencies involved in homeland security need to understand the psychological consequences of mass-casualty terrorist attacks and other disasters. This course provides a broad overview of psychological effects of terrorism.

Prerequisite: NS3180.

NS4156 - Intelligence for Homeland Security: Organizational and Policy Challenges (4 - 0)

Offered through the Center for Homeland Defense and Security. This course examines key questions and issues facing the U.S. intelligence community and its role in homeland security and homeland defense. Students will have the opportunity to fully address policy, organizational and substantive issues regarding homeland intelligence support. Prerequisites: None.

NS4157 - Intelligence for Homeland Defense and Security (4 - 0)

This course will provide students with a fundamental knowledge of U.S. operational intelligence capabilities to detect and deter terrorist and other unconventional threats to the United States. Topics will include the structure and function of U.S. intelligence organizations, systems, architecture, and capabilities. Issues in intelligence oversight, joint and inter-agency intelligence sharing, intelligence community administration, and intelligence support to national decision-making will be discussed.

Prerequisite: NS3181 or consent of the instructor.

NS4159 - Seminar on Joint intelligence support to Crisis Operations (4 - 0)

Advanced seminar on intelligence support to military commanders and national-level policy makers. Using case studies, the course examines concepts of individual and organizational factors affecting the analytic process. Students will identify near-to mid-term regional events with force employment implications, develop associated intelligence support requirements, and create collection plans in support of indications and warnings, crisis shaping and identified operational mission areas. Open to intelligence specialists. Requires U.S. citizen holding a TOP SECRET clearance with eligibility for access to SCI.

Prerequisite: NS3159 or permission of instructor required.. Security Clearance Required: Top Secret SCI.

NS4160 - Foreign Intelligence Services (4 - 0)

This course examines selected foreign intelligence services. It emphasizes their organization, missions, and functions. This course is intended for students in the Joint Intelligence Curriculum and others upon permission of the instructor. U.S. citizen holding a TOP SECRET clearance with eligibility for access to SCI.

Prerequisite: NS3160 or permission of the instructor. Security Clearance Required: Top Secret SCI.

NS4225 - Civil-Military Relations and Transitions to Democracy (4 - 0)

A seminar which reviews selected cases of transitions from authoritarian rule in the post-1945 period. The course compares the various roles played by the military and other actors in these transitions, examines the participation of the military in the consolidation of democracy and the problem of democratic consolidation. Students will also examine different theories and concepts of democratic transition and consolidation.

Prerequisite: NS3025 or permission of instructor.

NS4231 - Seminar on Terrorism Financing and State Responses (4 - 0)

This course examines exactly how far we have come in understanding how terrorists raise, store, and transfer funds. It also evaluates challenges facing the U.S. government and international community in responding to this problem. In each module, we use a mix of official reports, academic papers, and other works to explore the subject and identify problems with the received wisdom about terrorist financing. Prerequisites: None.

NS4232 - Knowledge into Practice: A Homeland Security Capstone Course (3 - 0)

Offered through the Center for Homeland Defense and Security. This course is intended to provide participants the opportunity to review and integrate the knowledge and technical learning acquired in the courses leading up to the capstone. This course will reinforce the motivation

and skills needed to perform their professional roles in ways that will initiate and sustain change within the homeland security enterprise.

Prerequisite: NS4156, CS3660.

NS4237 - Building Agency Capability in the Homeland Security Enterprise (4 - 0)

The Building Agency Capability course explores organizational resilience at the corporate, team, and individual level. Students learn resilience frameworks and challenges as they consider and apply "force multiplier" concepts to Homeland Security Enterprise (HSE) challenges and contexts. Students examine existing agency capabilities with a critical comparative analytical eye. Students learn human capital issues in the HSE: i.e., how agencies develop resilience to ensure successful leadership at every level of the organization, or how networks that draw together diverse constituencies form and support HSE efforts through collective impact. The underpinnings of this course include comparative examples, including historic case studies that have direct applicability to the US model of homeland security (HS).

Prerequisite: Students are required to complete NS3180 before enrolling..

NS4238 - Policy and Leadership Issues in Homeland Security (4 - 0)

Offered through the Center for Homeland Defense and Security. The course focuses on helping students gain a better understanding of policy design and development, policy implementation, and the application of strategic leadership concepts and principles to the operationalization of policy in the homeland security context.

Prerequisite: Successful completion of NS3180 -- Introduction to Homeland Security -- is required before enrolling. Enrollment is limited to CHDS master's degree program students..

NS4239 - Special Topics in American Government for Homeland Security (4 - 0)

Offered through the Center for Homeland Defense and Security. The purpose of this course is to provide participants with an insight into the structural, conceptual and intellectual underpinnings and implications of the homeland security project. Looking at a wide range of topics and problems, the course seeks to stimulate a comprehensive discussion of how homeland security professionals and the general public think about homeland security; whether/why there may be significant differences in professional and public perceptions of homeland security; and how those differences constrain/leverage various elements of the homeland security effort. By incorporating a selection of key texts in Western political and social thought alongside current topical writings, the course seeks to equip participants with a deeper understanding of the prevailing discourse and its impact on the homeland security project.

Prerequisite: NS3180.

NS4253 - Seminar on Technology and Strategic Planning (4 - 0)

This course is intended to develop an understanding of the relationship between strategic planning and disruptive/emergent technologies. Issues include technological risk, symmetric and asymmetric technology applications, institutional impediments to innovation, and implementing a technology-based strategy in the context of great power competition.

NS4256 - Maritime Strategy (4 - 0)

This course studies maritime strategy from the Age of Sail to the present. Topics include the history and theory of war on and from the sea; sanctions regimes and coercive diplomacy; neutral rights and the law of the sea; maritime security and sea-borne trade; imperialism and globalization.

Prerequisite: Any two NSA disciplinary core courses, or consent of the instructor.

NS4257 - Security Sector Assistance in an Era of Strategic Competition (4 - 0)

NS4257, Security Sector Assistance in an Era of Strategic Competition, will give students the background and practical understanding needed to answer the question; how can policymakers and strategic leaders best use Security Sector Assistance (SSA) to meet evolving security threats? The course looks at themes in international relations and military theory and explores how SSA tools align with foundational theoretical approaches to national security policy. The course also examines the historical development of these tools to understand how the U.S. approach has evolved. From there, the course will clarify SSA's role as a national security tool, including the programmatic and organizational guidelines that provide authority, funding, and direction to the interagency SSA enterprise; how SSA has, and can, address U.S. and Partner security objectives in each Combatant Command's Area of Responsibility; and how current national security threats impact the United States' use of SSA.

Prerequisite: None..

NS4259 - Science and Technology in Geostrategic Competition (4 - 0)

This course surveys the role of science and technology (S/T) in international security and economic competition and in peaceful and violent changes in the global order. It analyzes the role that S/T have played in both generating and moderating competition and war among major powers from the First Technological Revolution of the nineteenth century to the current Fourth Technological Revolution. It examines the way S/T has constituted contemporary geostrategic competition *and* cooperation, while altering the relations among states and between governments and their societies.

The course considers the role of S/T in the rise of the Western powers in the 19th century and the competition between the United States and the Soviet Union. The course looks at the contemporary efforts of China and Russia to generate indigenous innovation programs on par with the leading Western countries. It delves last into the profound changes the Anthropocene Age—climate change and the Fourth Technological Revolution— are having on competition and cooperation among the major powers. The course weaves the connections between S/T, security and economic competition and global governance into a contemporary survey of the geostrategic impacts of technological change and the potential for a great transformation of the global order.

NS4260 - Hybrid Warfare (4 - 0)

This course explores the background, applicability, and relevance of US, NATO, and EU concepts of hybrid warfare. Conceptually hybrid warfare simultaneously blends modes of warfare, including use of conventional weapons, irregular tactics, terrorist acts, and criminal disorder. These multivariant activities are operationally directed within the battlespace to target vulnerabilities and achieve synergistic effects. Hybrid warfare has recently evolved to undermine an opponent through a variety of coercive and subversive acts to include by disinformation, proxy groups and economic or cyber means. This course analyzes in case studies the progression of hybrid warfare and the distinction from other forms such as compound warfare, fourth generation warfare and asymmetric warfare. It examines and debates the characteristics and capabilities of adversaries conducting hybrid warfare, then proposes novel strategies and change frameworks for the DoD/DoN, working with Allies and partners, to confront them.

Prerequisite: NS3021.

NS4280 - Nuclear, Biological and Chemical Weapons: Proliferation and Non-Proliferation (4 - 0)

This advanced research seminar examines the origins of nuclear, biological, and chemical (NBC) weapons proliferation, and its impact on U.S. and international security. The course investigates the causes and consequences of proliferation; studies central debates and key case-studies on the subject; and evaluates policy responses designed to impede, discourage, and cope with the spread of NBC weapons. This course is unclassified. The seminar presumes familiarity with U.S. national security approaches to proliferation, and prefers, though not require-prior participation in NS3280. The seminar refers to and draws upon topics that are covered in NS3280: nuclear strategy, deterrence theory, and strategic arms control.

Prerequisite: NS3280.

NS4285 - Counterproliferation (4 - 0)

This course will prepare students to counter nuclear,

biological, and chemical (NBC) weapons threats in future operational or staff assignments by improving their understanding of the causes and consequences of NBC weapons proliferation and use and the strategies and capabilities available to counter these threats. Prerequisites: None.

Cross-Listed as: Cross-listed with DA4285.

NS4300 - Special Topics: Middle East (4 - 0)

A research seminar on politics in contemporary Middle East. Students conduct and present original research on selected issues concerning Middle Eastern politics. Since the topic of the seminar will vary, the registrar will be provided with the full title each quarter the course is taught. Sample subject areas include the Arab-Israeli conflict, the politics of oil, and the revolution in the Middle East. This course may be repeated as long as the subject material and title of the class is different.

Prerequisite: Two 3000-level Middle East courses or permission of the instructor.

NS4301 - African Political Economy (4 - 0)

This course examines economic development issues in Sub-Saharan Africa from a very broad perspective. We will consider how political and social as well as economic structures impact economic growth and development, assess policy and performance in the postcolonial period, and discuss the challenges for the twenty-first century. PREREQUISITE: None.

NS4310 - Seminar on Middle Eastern Security Issues (4 - 0)

A research seminar on security issues in the contemporary Middle East. Students conduct and present original research on selected issues concerning Middle Eastern security. Since the topic of the seminar will vary, the registrar will be provided with the full title each quarter the course is taught. Sample subject areas include the domestic security implications of Middle East peace, environmental security in the Middle East, and terrorism in the Middle East. This course may be repeated as long as the subject material and title of the class is different.

Prerequisite: Two 3000-level Middle East courses or permission of the instructor.

NS4311 - Resources, Politics and Conflict in Sub-Saharan Africa (4 - 0)

Many countries in sub-Saharan Africa have abundant natural resources, which have deeply affected the development of states, and the nature of politics, economics, and conflict in these countries. Understanding how natural resources have affected these countries is key to gaining insight into their contemporary political dynamics. In this class, students will learn about the impact of natural resource abundance on state formation, politics, and economics; the relationships between natural resources and conflict; and assess attempts to manage the effects of resources on both politics and conflict in countries with abundant natural resources. This is an advanced topics class and will require deep analysis of the dynamic relationships in these processes. As foreign policy professionals, understanding the challenges faced by countries is as important as thinking about how to respond to them.

Prerequisites: Suggested to take the introduction to politics in Sub-Saharan Africa course before this one.

NS4313 - Government and Security in West Africa (4 - 0)

This course introduces students to government and politics in West Africa, with an emphasis on political, economic, and social change since the end of the Cold War. Why are some countries in the subregion making peaceful progress toward democratic consolidation while others are dissolving into violent conflict? How does the coexistence of zones of conflict and peace affect regional security? Prerequisites: None.

NS4315 - Security and Politics in Iran (4 - 0)

Iran has been one of the most important countries in the Middle East region. It is located strategically, connecting the Caucasus and Central Asia to the Persian Gulf on the one side, and South Asia to the Arab Middle East on the other. Iran is home to one of the principal languages and cultures of the region. It is also one of the most populous countries in the Middle East with one of the largest economies. Iran has been a politically and strategically significant country for most of the past century. It was a front-line state during the Cold War. It was the scene of a major revolution that changed the face of the Muslim world and the relations between the United States and regional powers. Since 1979, Iran has been an avowedly Islamic state that has been engaged in a protracted war with the West. However, Iran has also witnessed profound political, social, and cultural changes that can be consequential for the future of the region. This course provides an overview of Iranian politics, and how those developments in turn change our views on political change in the Muslim world and beyond. Prerequisite: None.

NS4320 - Islamic Fundamentalism (4 - 0)

A research seminar on the ideology and practice of Islamist radicals and violent extremists in the Muslim World. Students read primary source translations of major Islamist ideologues, such as Hassan Al-Bannah, Ayatollah Khomeini, Sayyid Qutb, and Usama bin Laden, in addition to focusing on the strategies and histories of specific Islamist groups such as Hamas, Hezbollah, Al-Qaeda, and Islamic State. Students will conduct and present original research on this topic.

Prerequisite: NS3000 or consent of the instructor.

NS4326 - Social Mobilization and Conflict in the Middle East and Africa (4 - 0)

This course analyzes the organization, incentives, and goals of non-state actors. Subjects include protest and mobilization of civil society and their relations with violent actions, how available alternatives shape the form that opposition action takes, and the effects of repression and political inclusion.

Prerequisite: Prior completion of at least one 3000-level Middle East Course, or permission of the instructor.

NS4327 - Southern African Politics (4 - 0)

The countries of the Southern African region are closely linked by economics, social demographics, and history. This course will examine the dynamics of Southern Africa, combining detailed studies of individual countries with themes that cross the region, such as migration, trade, regional security, economic development, and post-conflict reconstruction. Some of the topics we will cover include attempts by Southern African countries to strengthen regional integration; the role of South Africa as local hegemon; how recent events in Zimbabwe have impacted on regional dynamics; democratization and demobilization in South Africa, Namibia and Mozambique, and the peace process in Angola. Designed as an upper-level seminar, the course will focus on discussion and debate of weekly reading assignments. Prior coursework in African Politics is desired, but not required. Prerequisites: None.

NS4328 - Government and Security in the Horn of Africa (4 - 0)

Addresses government and security issues in the Horn of Africa. Its main focus is on how conflicts in the region -- persistent civil war in Sudan, state collapse in Somalia, contentious ethnic politics and secessionist movements in Ethiopia and Djibouti, state formation processes in (internationally recognized) Eritrea and (internationally unrecognized) Somaliland -- interact to produce a particularly challenging regional security environment. We conclude with a consideration of what this regional security environment means for the War on Terrorism, as well as how the War on Terrorism is impacting the regional security environment. Prerequisites: None.

NS4332 - Ethnicity and Ethnic Conflict in the Developing World (4 - 0)

The goal of this course is to examine issues of ethnicity and ethnic identity as they relate to conflict and democracy in the non-Western world. This course will be offered as an elective that will fit in with the regional studies curricula for students in the Africa, Latin America, Middle East, and Asian curricula in the NS department. The course will provide students with the theoretical tools and approaches to the study of ethnicity and ethnic conflict in multiple-country contexts. The course is divided into three main subject areas: (1) the nature of ethnicity, (2) the nature of and explanations for ethnic conflict, and (3) solutions to ethnic conflict. Weekly course readings present a mix of theoretical approaches and case studies, and will cover all the major areas of the world: Africa, the Middle East, Latin America, Asia, and Eastern Europe. Prerequisites: None.

NS4335 - REFUGEES AND FORCED MIGRATION: DYNAMICS AND POSSIBILITIES (4 - 0)

We examine the political, social, and economic implications, including traditional and non-traditional security, of the movement of displaced persons worldwide. We will learn about the humanitarian issues and concerns of refugees and the displaced, what the international community is doing to help them and whether it works or not. Students will learn the international laws governing refugees, the differences between refugees and other displaced or stateless persons, and the laws governing off-shoring of refugees and rescues at sea. We discuss potential solutions and repercussions for host countries.

NS4362 - The Arab-Israeli Conflict (4 - 0)

This course studies the evolution and current state of the Arab-Israeli conflict from the end of the 19th century to the present, including a consideration of its historical development, the principal individual and institutional actors involved, and an assessment of current prospects for conflict resolution.

Prerequisite: Prior completion of at least one NSA course on the Middle East.

NS4410 - Seminar on Security Issues in Russia, Eastern Europe and Central Asia (4 - 0)

This advanced seminar addresses the security problems of the successor states to the former Soviet Union, focusing on the military, the security environment, political culture, Russian and non-Russian nationalism, and the relationship between domestic and foreign policies.

Prerequisite: NS3400 or NS3450 or permission of the instructor.

NS4415 - Seminar on Security Issues in Central Asia (4 - 0)

For the purpose of this course, Central Asia refers to Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. The seminar will consist of three parts. In the first part, the students will gain a general background in history of Central Asia. In the second part, the students will survey the current situation in Central Asia. The seminar sessions in the third part of the course will be dedicated to presentations of students' research. Prerequisites: None.

NS4420 - Seminar on History & Politics of Central Europe (4 - 0)

Central Europe constitutes a coherent and identifiable historical, cultural, and political entity. Its component states--conventionally including Germany, Austria, Poland, Hungary, the Czech Republic, and Slovakia--have been competitors and even enemies, as well as allies and neighbors. The region is distinct from Western or Eastern Europe because of its unique historical and political development. This seminar examines this region in detail, including the history, politics, and interstate relations within the region in the past and present. Prerequisites: None

NS4425 - Russian Foreign Policy (4 - 0)

This advanced seminar introduces theoretical approaches to the study of foreign policy and focuses on the content of post-soviet Russia's foreign policy. Students will learn what Russia's foreign policy consists of and who or what makes it. The course aims to give students a greater ability to analyze the critical determinants of foreign policy and an in-depth understanding of the various aspects of contemporary Russia's foreign policy interests. Prerequisites: None.

NS4501 - Politics, Film and Fiction in Latin America (4 - 0)

This course explores how Latin American film and fiction has portrayed politics. Specific novels, short stories and films (all with a political context) will be compared with social scientific readings analyzing the same topics. All movies will be in Spanish with English subtitles. All readings will be available in Spanish and English versions.

Prerequisite: NS3501.

NS4502 - Russian Film and Fiction (4 - 0)

Examination of Russian culture through that country's film and fiction. Prerequisites: None.

NS4550 - Government and Politics in Mexico (4 - 0)

The purpose of this course is to explore the complexities of the Mexican political environment, its power structure, its profound contradictions and the multi stakeholder conflicts that shape Mexican decision making today. While a certain historical perspective is always necessary and unavoidable, this class is about Mexico's current political environment, its security ecosystem and how those two elements affect the homeland security enterprise and North American security in general.

Prerequisite: NS3510 or NS3181 or permission of the instructor.

NS4560 - Seminar on Latin American Security Issues (4 - 0)

A research seminar on security issues in contemporary Latin America. Students conduct and present original research on selected issues concerning Latin American security.

Prerequisite: NS3510, NS3520, NS3024 or permission of the instructor.

NS4580 - U.S. Security Cooperation in Latin America and Africa (4 - 0)

NS4580 analyzes historical and contemporary problems in US military engagements in the developing world, from basing to multilateral exercises to arms sales. It focuses on extracting usable lessons for enhancing security cooperation effectiveness both for the United States and for partner nations in Africa and Latin America, and on preparing Foreign Area Officers for successful defense diplomacy.

NS4620 - Seminar on the Chinese People's Liberation Army (4 - 0)

This course is a reading seminar on the evolution of the PRC's military and its domestic and foreign policy roles. It reviews the evolution of Maoist and post-Mao security strategies, military decision making, professionalism versus politicization of the army, the calculus of deterrence and the use of force in PRC foreign policy, and party-army and civil military relations. Prerequisites: None.

NS4630 - Seminar on Northeast Asian Security (4 - 0)

Advanced research on national, regional, and global security dynamics among the states of Northeast Asia. The course explores policy options facing North Korea, South Korea, Russia, Japan, and China, their regional interactions, and the likely implications for the United States. Non-traditional security topics such as energy and space will be covered along with questions of military modernization, weapons proliferation, alliance behavior, and deterrence.

Prerequisite: NS3024 AND one course in Asian politics/security (such as NS3620, NS3661, NS3662 or NS3663); or consent of the instructor.

NS4640 - War in Asia (4 - 0)

This course studies the history of war and international relations in East and Southeast Asia since the end of the eighteenth century.

Prerequisite: Consent of instructor..

NS4641 - Political and Ethnic Violence in South East Asia (4 - 0)

This course will examine the sources of political and ethnic violence in the South East Asia region.

Prerequisite: NS3620.

NS4642 - Chinese Foreign Policy (4 - 0)

This seminar examines and analyzes the major developments in Chinese foreign policy since 1949. It introduces historical legacies and traces the major developments during the Cold War, such as Chinese intervention in the Korean War, the rise and fall of the Sino-Soviet alliance, and improvement in Sino-American relations. The course focuses on understanding and analyzing Chinese foreign policy in the post-Cold War world and China's rise, including topics such as China's grand strategy, China's relations with the U.S., Taiwan, and Asia, and PLA modernization. This seminar also provides an opportunity for students to conduct original analysis and research on Chinese foreign policy.

Prerequisite: At least one NS Asia/China course (two preferred) or consent of the instructor.

NS4643 - Science, Technology, and Society in China (4 - 0)

This course surveys the relationship between science, technology, and society in China. The course begins by examining science and technology in ancient and early modern China followed by a discussion of how Western imperialism led to state-led efforts to expand modern China's technological and scientific capabilities. The remainder of the course focuses on major scientific and technological issues in contemporary China. Overall, this course investigates how science, the state, and society have interacted over the course of Chinese history and the causes and consequences of scientific and technological achievements and failures.

The course is relevant to the DoD and DoN emphasis on Great Power Competition.

Prerequisite: N/A. Corequisite: N/A. Cross-Listed as: N/A.

NS4660 - Seminar on Asia in World Affairs (4 - 0)

Advanced study of Asia's contemporary economic, security, diplomatic, and cultural roles in world affairs, with special emphasis upon the policy interaction of China, Japan, India and other key states with the United States, Russia, Europe and the developing world.

Prerequisite: A NS3000-level course on Asia, or permission of the instructor.

NS4663 - Politics and Security in Pakistan and Afghanistan (4 - 0)

This course focuses on the political and security dynamics of Pakistan and Afghanistan. In recent history the region has been a hotbed of instability and s focal point of terrorism. The course will explore the complex interplay of history, geography and ethno-religious politics of the two contagious countries, analyze its impact on regional stability, and examine the implications for global security.

Prerequisite: NS3668.

NS4667 - Political Economy and Security in South Asia (4 - 0)

This seminar examines different dimensions of South Asian political economy, with an emphasis on understanding the relationship between economy and security in the region. What are the economic structures in the countries of the region? How did these structures shape politics in the initial years after independence and, as a consequence, security across the region? What is the contemporary context in which these globalizing political economies operate? How has economic liberalization since the 1980s impacted their politics, defense, and foreign relations? What are the economic causes and consequences of insurgencies and government responses? Overall, this course will expand students' understanding of legacies across these countries and the crucial impact of their unique structures. Students will also be exposed to political economy theory in the process of studying these issues.

Prerequisites: None.

NS4668 - Security in South Asia (4 - 0)

The seminar places particular emphasis on the conditions affecting the occurrence, conduct, and aftermath of war in the region. Topics covered in the seminar include the independence of India and Pakistan in 1947 and the creation of political, ethnic, religious, and territorial disputes between the two countries; ethnic and religious sources of instability in the region; civil-military relations; South Asia during the Cold War; South Asia and the global war against terrorism; the foreign relations of India and Pakistan with the United States, Russia, China, and neighboring countries; the origins and military conduct of the three India-Pakistan wars; and the acquisition of nuclear weapons by India and Pakistan and their impact on regional security and international stability. Depending on student interest, the course also will cover security dynamics of smaller South Asian states (Afghanistan, Bangladesh, Nepal, Sri Lanka, and Bhutan). Prerequisites: None.

NS4677 - Space and International Security (4 - 0)

This course examines the political history of the space age from the perspective of U.S. national security. After reviewing Cold War developments and the U.S.-Soviet space race, the course turns to current great power competition in space. It seeks to familiarize students with the international dimensions of space activity, current strategies of the major spacefaring countries, and challenges facing the U.S. Space Force. The course covers the major space treaties and policy debates, as well as different approaches to space security, including alliances. It also considers the impact of commercial and civil space developments on space security.

Prerequisite: NS3011 and NS3024 or permission of

instructor..

NS4710 - Eur-Asia in the Global Economic Order (4 - 0)

This course surveys the integrative and disintegrative processes at work in northern Eurasia, emphasizing the European Union, the Russian Federation and China. The overarching frame for the discussion of Eur-Asian dynamics is the transformation underway in the post-Cold-War global economic and political order. Re-centering attention on the Eurasian landmass allows us a different lens through which to understand changes in the economic power and interdependence of the EU, Russia and China, on the one hand, and the emerging contours of the post-Covid, post-Ukraine global order.

Prerequisite: NS3710 or permission of the instructor.

NS4720 - Seminar on European Security Issues (4 - 0)

A research seminar on security issues in contemporary Europe. Students conduct and present original research on selected issues concerning European security.

Prerequisite: NS3720 or permission of the instructor.

NS4721 - Critical Infrastructure Analysis and Defense (4 - 0)

The premise of this course is straightforward: our dependence on critical infrastructures makes us vulnerable to both deliberate and non-deliberate events that can disrupt our physical, economic, and social welfare. This course develops the literacy and competencies necessary to understand potential problems and realistic solutions for critical military and civilian infrastructure in the United States. Students gain experience in the use of "red teaming" analysis for evaluating infrastructure vulnerability through case studies on civilian and DoD/DoN systems, and through a course project.

Prerequisite: NS3180 or OA4202 or consent of instructor. Cross-Listed as: Cross-listed with OS4621.

NS4722 - Special Topics: Europe (4 - 0)

Current issues in Europe Security. Prerequisites: None.

NS4755 - Strategic Planning and Budgeting for Homeland Security (4 - 0)

Offered through the Center for Homeland Defense and Security. Employing a social entrepreneurship approach to the strategic process, this course will provide students with the necessary methodological tools and content to think differently about strategy, manage complex challenges, and facilitate a planning process that fosters innovation and positive change in the homeland security enterprise. Prerequisites: None.

NS4757 - Media and Communications for Homeland Security Professionals (4 - 0)

Offered through the Center for Homeland Defense and Security, this course offers a detailed overview and assessment of media and communications – both theory and practice - for homeland security professionals. The course is grounded in media studies theory and seeks to bridge the gap between abstract framing concepts and the practical application of assessment and engagement techniques. Central themes include the relationships between and among the free press, public engagement, and homeland security; the utility of the internet for homeland security agencies as a tool to address challenges and threats; the impact of social media on the public sector, especially when deployed by adversaries to create confusion and undermine public confidence in government; the applicability of strategic communications, risk communications, and crisis communications techniques in different operating environments and when dealing with different audiences; and understanding and countering media elements of terrorism, information operations, and disinformation.

Prerequisite: NS3180, CS3660. Students are expected to have completed the core Introduction to Homeland Security core course (NS3180) and Critical Infrastructure Protection (CS3660) before enrolling in this course. The Media course builds upon core knowledge of homeland security law and practice, as well as foundational concepts of adversarial modeling and risk analysis introduced in Critical Infrastructure Protection (CS3660).

NS4801 - Seminar on Terrorism (4 - 0)

This course attempts to provide a broad sweep of the field of terrorism. We explore general issues - the structure of terrorist groups, the motivation of those who join, the patterns of authority and decision-making within groups, the impact of different types of operations on governments and the public. In the second portion of the course, we discuss in greater depth the campaigns of a few selected terrorist organizations. We will also look at what some scholars call the "new" terrorism. Prerequisites: None.

NS4880 - Seminar on Legal and Military Responses to Political Violence (4 - 0)

The course will first review the variety of legal and military policy options open to any state that confronts political violence, with particular attention to short versus long-term consequences of different policy options. It then analyzes a few individual cases (the British in Ulster, violence in Spain) in depth, in order to assess how different policy options combine or cancel each other.

Prerequisite: Consent of Instructor.

NS4881 - Multi-Discipline Approaches to Homeland Security (4 - 0)

Offered through the Center for Homeland Defense and Security. Homeland security efforts in the United States constitute a project framed by the rule of law and boundaries of discourse. Constitutional concerns, civil

rights issues, ethical questions, and the roles of the various disciplines engaged in the effort are driven and impacted by the various local, state, and federal systems of law, and also by public, media, and political narratives. This course allows students to explore the homeland security project in relation to the laws, narratives, and ideas that support and constrain it. Prerequisites: None.

NS4910 - Internet, Society, and Cyberconflict (4 - 0)

Offered through the Center for Homeland Defense and Security. This course examines the internet in its broader social and policy context with a particular focus on threats in, of, and to the internet. The course considers the relevant questions of identity, agency, legitimacy, regulation, and innovation in the cyber realm from all angles, including public policy, national security, U.S. law, and international norms. It also will study the views, practices, and ethos of such other stakeholders as developers, hacktivists, tech entrepreneurs, and the public. This course introduces students to exponential thinking and advances their practice of strategic foresight as regards the ways that internet technologies currently under development may affect homeland security in the future. Prerequisites: None.

NS4920 - Special Topics: Civil-Military Relations (4 - 0)

Selected special issues in Civil-Military Relations. Prerequisites: None.

NS4930 - Media and War (4 - 0)

This seminar will analyze the interaction between the media, both in the United States and abroad, and society during wartime. Prerequisites: None.

NS4941 - National Security Law for Homeland Security and Defense (4 - 0)

The course studies the legal framework within which defense strategy is formulated and executed, with emphasis on the identification and resolution of jurisdictional conflicts, the interaction of municipal and international law governing the use of force, and the organization challenges presented by the coordination of military activities with those of civilian law enforcement agencies and the judiciary.

Prerequisite: NS3000, NS3023, or NS3024 or consent of the instructor.

NS4951 - Environmental Security (4 - 0)

This course addresses broad themes and debates in environmental security at an advanced level. Particular emphasis is given to the intersections between environmental stress and U.S. national security. The course also examines regional environmental insecurities and their implications for the United States.

Prerequisite: None.

NS4960 - Energy Security and Geopolitics (4 - 0)

This course addresses broad themes and debates in energy security at an advanced level. Particular emphasis is on the history, economics and politics of energy and their implications for the energy security policy options the U.S. faces today. While the course looks at energy issues from a U.S. national security perspective, regional energy security issues around the world are examined to provide prospective on the policy differences the U.S. is encountering at the international level and will face in the future. Prerequisites: None.

NS4967 - Energy Security and Geopolitics (DL) (4 - 0)

This course addresses broad themes and debates in energy security at an advanced level. Particular emphasis is on the history, economics and politics of energy and their implications for the energy security policy options the U.S. faces today. While the course looks at energy issues from a U.S. national security perspective, regional energy security issues around the world are examined to provide prospective on the policy differences the U.S. is encountering at the international level and will face in the future. This course is offered DL. Prerequisites: None.

NS4990 - Seminar in Strategic Studies (4 - 0)

This course studies the theory and practice of national defense strategy, approached by means of selected theoretical texts and historical case studies in military and political decision-making. Topics include combined-arms land warfare, maritime strategy, strike warfare, nuclear strategy, and revolutionary insurgency. A significant independent research paper is required.

Prerequisite: Prior completion of NS3000, plus at least one other 4000-level seminar in National Security Affairs.

NS4991 - Seminar in United States Foreign Policy (4 - 0)

This course studies the conduct of foreign policy by the United States from the founding of the American Republic through the end of the Cold War. A significant independent research paper is required.

Prerequisite: At least one 4000-level seminar in National Security Affairs; or permission of the instructor.

NS4992 - History of Insurgency and Counterinsurgency (4 - 0)

The purpose of the course is to familiarize students with the history, theory and practice of counterinsurgency and insurgency. Insurgency has been around for a long time and is considered one of the oldest forms of conflict, where an internal group within a country (possibly with assistance from outside the nation) is attempting to use violence to change the existing political and economic order. Given the ongoing challenges in Afghanistan, Syria, and Iraq, it is likely that the U.S. will be involved in

combating insurgencies for many years to come. This course reviews how insurgencies evolve and how they have been countered in the past. The policy implications of U.S. involvement in insurgencies will be examined. Best practices for future counterinsurgency operations will be identified and discussed.

Prerequisite: NS3000 or NS3003.

NS5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

NS5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council. Prerequisite: Advancement to Candidacy.

NU

NU3009 - Electrical Power Engineering and Machinery Theory (4 - 1)

Topics are shipboard power-systems architectures, current shipboard power lineups and operation, including paralleling, breakers, and operation in split plant. (This course is taught at Naval Nuclear Power School and not at Naval Postgraduate School. The course contents and credits are periodically reviewed and approved by NPS faculty with expertise in this subject area.) Graded pass/fail only.

NU3159 - Heat Transfer (4 - 0)

Conduction, convection, and combined mode heat transfer. Steady state and transient conduction using field equations. Single- and two-phase heat transfers are presented, along with applications to steam generators and condensers. Detailed analysis of heat exchangers and cooling systems with film and drop-wise condensation, along with the description of critical heat flux and the modes of equipment failure. (This course is taught at Naval Nuclear Power School and not at Naval Postgraduate School. The course contents and credits are periodically reviewed and approved by NPS faculty with expertise in this subject area.) Graded pass/fail only.

NU3209 - Deformation, Fracture and Failure Analysis (4 - 0)

Elastic and plastic deformation, fracture theory, impact transition behavior and fracture toughness concepts, ductile and brittle failure, creep, stress relaxation, fatigue, corrosion and combined failure modes. Introduction to concepts of failure analysis. (This course is taught at Naval Nuclear Power School and not at Naval Postgraduate School. The course contents and credits are periodically reviewed and approve by NPS faculty with expertise in this subject area.) Graded pass/fail only.

NU3249 - Power Plant Systems (4 - 0)

Machinery and operation of the propulsion and electrical power generation plants, along with the auxiliary machinery such as gears, bearings, seals, hydraulic valves, refrigerators (vapor compression and absorption.) Operation of ejectors, pumps, and valves. Physical description of turbo-machinery, including degree of reaction and blading types. One-dimensional flow in simple and complex piping systems including frictional and minor losses and matching of parallel and series pumps with piping systems. (This course is taught at Naval Nuclear Power School and not at Naval Postgraduate School. The course contents and credits are periodically reviewed and approved by NPS faculty with expertise in this subject area.) Graded pass/fail only.

NU3819 - Radiological Fundamentals (4 - 0)

Interaction of radiation with matter, including the biological effects of radiation. Detailed calculations of high-energy radiation from point, line, and plane sources and methods for estimating the radiation emitted from power plant components. Calculation of radioactivity buildup and decay for a variety of production and removal mechanisms in both liquid and gas systems. Detectors for radiation and radioactivity with emphasis on the underlying physics of detection as well as the electronics associated with accurate measurement. Radiation shielding design, including calculations to optimize both permanent and temporary shields. (This course number and title represent course content taught at Naval Nuclear Power School and not at Naval Postgraduate School. Credit will be granted for students enrolled in a NPS graduate studies program.) Graded pass/fail only.

NU4809 - Reactor Dynamics (4 - 0)

Fission reactions. The neutron lifecycle model in a reactor core using both the 4 and 6 factor approach. Neutron diffusion theory and the differential equations for the neutron flux in rectangular, cylindrical and spherical reactors. The design of the reactor fuel distribution (including neutron poisons) to optimize the neutron flux along with strategies to prolong the lifetime of the fuel over the expected life of the core. The startup, shutdown and control of the reactor core by using neutron-absorbing materials in control rods and the concept of reactivity. The effect of temperature, pressure, and concentration of fission product poisons on reactivity.

Detailed calculations for determining the position of control rods for maintaining a critical reaction. Steady state and transient behavior of critical reactors. Emphasis is placed on criticality control by delayed neutrons in the six-group model. (This course number and title represent course content taught at Naval Nuclear Power School and not at Naval Postgraduate School. Credit will be granted for students enrolled in a NPS graduate studies program.) Graded pass/fail only.

NU4819 - Reactor Operations (4 - 0)

A capstone course in integrated reactor plant operations drawing on many areas of physics to develop a fundamental understanding of the underlying principles governing the procedures for safe operation of a nuclear power plant. Emphasis is placed on pressurized water reactors. Special attention is devoted to plausible reactor plant casualty analysis from the point of view of safe system design and proper operator response. (This course number and title represent course content taught at Naval Nuclear Power School and not at Naval Postgraduate School. Credit will be granted for students enrolled in a NPS graduate studies program.)Graded pass/fail only.

NW

NW3230 - Strategy & War (4 - 2)

The S&W course is designed to prepare the military officer for mid-level to advanced stages of a professional career in which he or she may be intimately involved in the interplay between military power and the political process – that is, between strategy, policy, and major operations. The course uses NWC themes, military theorists, and historical examples to develop critical thinking and demonstrate the military officer's urgent need for a joint and combined warfare perspective on the military profession.

NW3231 - Strategy and Policy Group Seminar (taken with NW3230) (0 - 0)

This is a group seminar that must be taken at the same time by all students taking NW3230 in order to ensure they have no conflicts in taking one of the large group lectures that combine all the lecture segments of students taking NW3230.

NW3240 - Strategy and Policy: Directed Study - Part I (2 - 0)

*Admission by special permission only. This two course series (NW3240 and NW3241) represents a directed study version of the SP course, which will be available only to students with special circumstances that preclude them from taking NW3230. First of a sequence of two Strategy and Policy courses, must be followed by NW3241 to earn four graduate credit hours. PREREQUISITE: None

NW3241 - Strategy and Policy: Directed Study - Part II (2 - 0)

* Admission by special permission only. (See NW3240 for info).

Prerequisite: NW3240.

NW3275 - Joint Maritime Operations - part 1 (4 - 0)

The Joint Maritime Operations curriculum develops the ability to translate contemporary national and regional military strategies into naval, joint and multinational operations, with particular emphasis on the operational art and employment of the Sea Services. NW-3275 is the first of a sequence of two classes required to complete the JMO curriculum; it must be followed by NW-3276 to earn credit for the course. Prerequisites: None.

NW3276 - Joint Maritime Operations - part 2 (2 - 2)

This class is the second in a sequence of two classes required to complete the JMO curriculum. (See NW-3275 for info.)

Prerequisite: NW3275.

NW3285 - Theater Security Decision Making (4 - 0)

The Theater Security Decision Making (TSDM) course offers a broad security studies curriculum that encompasses the strategic and theater-strategic levels with particular emphasis given to understanding decision making challenges and processes at the theater-strategic level of the combatant commands. Prerequisites: None.

OA

OA0001 - Seminar for Operations Analysis Students (0 - 2)

(NO CREDIT) Guest lecturers. Review of experience tours. Thesis and research presentations.

OA0810 - Thesis Research for Operations Analysis Students (0 - 8)

Every student conducting thesis research will enroll in this course.

OA0820 - Integrated Project (0 - 12)

The Naval Postgraduate School provides many opportunities for students to participate in campus-wide interdisciplinary projects. These projects encourage students to conceptualize systems which respond to current and future operational requirements. An integral part of the project involves working with other groups to

understand and resolve issues involved with system integration and to lend OR-specific expertise to these projects. This course is available to Operations Research students who are participating in a campus-wide integrated project. Course is graded on a pass/fail basis.

OA1600 - Introduction of Operations Analysis I (2 - 2)

(NO CREDIT) A first course in Operations Analysis, covering its origins in World War II to current practice. Introduces concepts, tools and methods of analysis, with tactical examples. Emphasis is on measuring combat effectiveness and developing better tactics. PREREQUISITE: None.

OA2801 - Computational Methods for Operations Research (4 - 1)

An introductory course in computation and procedural programming with an emphasis on the analysis and implementation of algorithms relevant to Operations Research. The course is taught using a general purpose programming language. The laboratory has weekly programming assignments. Prerequisite: None.

OA2900 - Workshop in Operations Research/Systems Analysis (V - 0)

This course may be repeated for credit if course content changes. Graded on Pass/Fail basis only.

Prerequisite: Department approval and a background in Operations Research.

OA2910 - Selected Topics in Operations Analysis (V - 0)

(Variable hours 2-0 to 5-0.) Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes.

Prerequisite: A background in operations research.

OA3040 - Research Methods, Planning and Execution (4 - 0)

This course covers the complete research process from start to finish and will include: ethical use of human subjects; institutional approval of the use of human subjects; the issue of research validity and reliability; formulation of the research question; research design; database management considerations; analytical approaches; and writing the research paper. Prerequisites: None.

OA3101 - Probability (4 - 1)

Probability axioms, counting techniques, conditional probability. Discrete and continuous probability distributions: binomial, hypergeometric, negative binomial, Poisson, normal, exponential, gamma, and others. Joint probability distributions, conditional distributions and conditional expectation, linear functions. Random samples, probability plots. CO-REQUISITES:

MA1118 and MA3042.

Corequisite: MA1118, MA3042.

OA3102 - Statistics (4 - 2)

Introduction to data entry, manipulation, descriptive statistics and graphing using statistical software.   Point estimation, method of moments, maximum likelihood, least squares. Confidence intervals, tests of hypotheses for one- and two-sample problems. Goodness of fit and contingency tables, sign tests, Wilcoxon-Mann-Whitney test.

Prerequisite: PREREQUISITE: OA3101.

OA3103 - Data Analysis (4 - 1)

Techniques for analyzing, summarizing and comparing sets of real data with several variables focusing on linear models. Computations are done using statistical software. Model building and verification, graphical methods of exploration. Analysis of variance including multiple comparisons, with coverage of interaction and simple design cases. Least squares and robust regression, diagnostics, selection of transformations, and variable selection techniques. PREREQUISITE: OA3102.

Prerequisite: OA3102.

OA3105 - Nonparametric Statistics (4 - 0)

Tests based on the binomial distribution; confidence intervals for percentiles, tolerance intervals and goodness-of-fit tests; contingency tables; one sample-tests, two-sample tests and tests for independence based on ranks and scores; nonparametric analysis of variance and regression. Applications will illustrate the techniques.

Prerequisite: A course in statistical inference.

OA3201 - Linear Programming (4 - 0)

(Same as MA3301.) Theory of optimization of linear functions subject to linear constraints. The simplex algorithm, duality, sensitivity analyses, parametric linear programming. Applications to resource allocation, manpower planning, transportation and communications, network models, ship scheduling, etc. Introduction to computer-based linear programming systems.

Prerequisite: MA3042.

OA3301 - Stochastic Models I (4 - 0)

Course objectives are to provide an introduction to stochastic modeling. Topics include the homogeneous Poisson process and its generalizations and discrete and continuous time Markov chains and their applications in modeling random phenomena in civilian and military problems.

Prerequisite: OA3101 or consent of instructor.

OA3302 - Simulation-Modeling (4 - 0)

Discrete event digital simulation methodology. Monte Carlo techniques, use of simulation languages. Variance reduction techniques, design of simulation experiments and analysis of results.

Prerequisite: OA3103 and OA3301.

OA3304 - Decision Theory (4 - 0)

This course provides an introduction to modern theory and methods for decision making in both single and multiple person decision making situations. Bayesian methods are emphasized in the single-person case, including decision trees, Bayesian networks, influence diagrams, and multi-criterion decision making. Multi-person situations covered include two-person-zero-sum games, voting, Nash bargaining, and the Shapley value. Applications mainly to military problems. Prerequisites: None.

OA3401 - Human Factors in System Design (3 - 1)

This course will provide an introduction to the field of Human Factors with an emphasis on military systems. Humans are the most important element of any military system. Consequently, the design of effective systems must take into account human strengths and limitations as well as considerations of human variability. The course surveys human factors and human-centered design and system effectiveness and safety. Topics include human cognition and performance as they are influenced physiological, anthropometric and environmental considerations.

Cross-Listed as: OS3401.

OA3402 - Research Methods for Performance Assessment (3 - 1)

Well-constructed research is invaluable, informing and enabling decision makers to make better choices. This course covers the research process from beginning to end and explores the types of research conducted in a variety of laboratory and field settings. Topics include institutional approval and ethical use of human subjects; research reliability and validity; formulation of the research question; research designs ranging from experimentation to systematic observational techniques and subjective surveys; database management considerations; analytical approaches; and writing and presenting the research paper. Prerequisites: None.

OA3411 - Introduction to Human Systems Integration (3 - 0)

This course serves as the framework for examining Human Systems Integration in the context of Department of Defense Systems Acquisition as mandated by DoD Instruction 5000.2, Enclosure 7. This course provides an overview of the HSI domains: Human Factors Engineering, Personnel, Habitability, Manpower, Training, Environment Safety and Occupational Health, and Survivability. Principles of individual physiological and psychological capabilities and limitations and team attributes are also introduced. Prerequisites: None.

OA3412 - Human Systems Integration in the DoD Acquisition Lifecycle (3 - 0)

This course further expands on the role of Human Systems Integration within the context of the Department of Defense Systems Engineering Process in the DoD Acquisition Lifecycle. Students examine select acquisition activities (e.g., Joint Capabilities Integration Development System, or JCIDS) and the manner in which HSI practitioners influence these activities. This course also focuses on leveraging the unique activities of HSI practitioners to assist/support program managers and lead systems engineers in developing human-centered systems that optimize total system performance while minimizing cost and risk.

Prerequisite: OA3411.

OA3413 - Human Systems Integration Tools, Tradeoffs, and Processes (3 - 1)

This course provides a description and evaluation of tools and techniques available to facilitate the acquisition of human-centered military systems. It also provides an overview of techniques employed by practitioners within the sub-disciplines of HSI. The focus of this course is on tool inputs and outputs and their utility. This course also examines the manner in which HSI trade space analysis is performed - one of the most important roles of the HSI practitioner in the acquisition process.

Prerequisite: OA3412.

OA3501 - Inventory I (4 - 0)

A study of deterministic and approximate stochastic inventory models. Deterministic economic lot size models with infinite production rate, constraints, quantity discounts. An approximate lot size-reorder point model with stochastic demand. An approximate stochastic periodic review model. Single period stochastic models. Applications to Navy supply systems.

Prerequisite: OA3101 or consent of instructor.

OA3601 - Combat Models and Games (4 - 0)

This course provides a discussion of measures of effectiveness and a quantitative introduction to dynamic programming, target coverage models, Kalman filters, Lanchester Systems, and two-person zero-sum games.

Prerequisite: MA3110, OA3102.

OA3602 - Search Theory and Detection (4 - 0)

Search and detection as stochastic processes. Characterization of detection devices, use and interpretation of sweep widths and lateral range curves, true range curves. Measures of effectiveness of search-detection systems. Allocation of search efforts, sequential search. Introduction to the statistical theory of signal detection. Models of surveillance fields, barriers, tracking and trailing.

Prerequisite: OS2103 or OA3101.

OA3611 - Principles of Operational Logistics (4 - 0)

Introduction to principles of Operational Logistics (OPLOG) as a discipline that encompasses the resources needed to deploy and sustain military forces at the operational level of warfare. The course includes technical (mathematical and quantitative) facets of OPLOG, as well as historical perspective, plus qualitative aspects of OPLOG that are not readily quantifiable. Topics include logistics attributes, quantitative analytical tools, OPLOG planning principles, information requirements and information flow, warfare sustainment demand forecasting, and network analysis. Prerequisites: None.

OA3650 - Improvised Explosive Devices (IED) Seminar (4 - 0)

The seminar studies the improvised explosive device (IED) problem, with special emphasis on its use by insurgents in Iraq and Afghanistan. The seminar will discuss IEDs as one tactic in an insurgency and the goals and strategies with respect to the use of IEDs. The focus of the seminar will be the use of models, analysis, and systems technology to defeat the IED system. Topics include: short history of Iraq including demographics, religion, politics, and economics; access to SIPRNET data on IED incidents and analysis of attacks; geographic information systems (GIS) for display of incidents; a short overview of counterinsurgency methods that have been used in Iraq and elsewhere; systems engineering approaches to countering the use of IEDs; and operations research models of IED issues. There will be guest speakers with current knowledge of the IED threat. The seminar is open to all NPS students with U.S. citizenship.

Prerequisite: OS2103 or equivalent. Security Clearance Required: Secret.

OA3801 - Computational Methods for Operations Research II (3 - 1)

An advanced course in computation, with emphasis on data structures and algorithms particularly appropriate for military Operations Research. The course is taught using a general-purpose programming language. The laboratory has weekly programming assignments.

Prerequisite: OA2801.

OA3802 - Computational Methods for Data Analytics (4 - 0)

(Same as CS3802.) This course introduces several tools for analysts to acquire, store, access, clean, and merge relevant data, so as to produce a dataset that can be analyzed with necessary tools. The topics include binary data, popular text formats, bash command interpreter, relational and NoSQL databases, web scraping methods, parallel processing, and geographic data. Students will be introduced to high-performance computation facility, such as NPS Hamming and Grace clusters.

Prerequisite: OA2801 or consent of instructor.

OA3900 - Workshop in Operations Research/Systems Analysis (V - 0)

(Variable hours 2-0 to 5-0.) This course may be repeated for credit if course content changes. Graded on Pass/Fail basis only.

Prerequisite: Departmental approval.

OA3910 - Selected Topics in Operations Research/Systems Analysis (V - 0)

(Variable hours 2-0 to 5-0.) Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes.

Prerequisite: A background of advanced work in operations research. Consent of instructor..

OA4101 - Design of Experiments (3 - 1)

(Same as MA4302.) Theory and application of the general linear hypothesis model. Analysis of variance and analysis of covariance. Planning experiments, traditional and hybrid experimental designs. Use of standard computer packages for analysis of experimental data.

Prerequisite: OA3103 or equivalent.

OA4102 - Regression Analysis (4 - 0)

(Same as MA4303.) Construction, analysis and testing of regression models. An in-depth study of regression and its application in operations research, economics and the social sciences.

Prerequisite: OA3102, OA3103.

OA4103 - Advanced Probability (3 - 0)

Probability spaces, random variables as measurable functions, expectation using the Lebesque-Stieltjes integral and abstract integration. Modes of convergence, characteristic functions, the continuity theorem, central limit theorems, the zero-one law. Conditional expectation.

Prerequisite: Departmental approval.

OA4104 - Advanced Statistics (3 - 0)

Foundations of statistics from a decision-theoretic viewpoint. Robust estimation techniques, biased estimation. Fisher and Kullback information, asymptotic methods, sufficiency, completeness, the Cramer-Rao inequality. Sequential tests, empirical Bayes tests. Statistical computation methods.

Prerequisite: OA3103 and consent of instructor.

OA4105 - Nonparametric Statistics (4 - 0)

Inference based on the binomial distribution, including hypothesis tests, confidence intervals for percentiles, and tolerance intervals. Kaplan-Meier estimation with censored failure data. Analysis of contingency tables, including tests for goodness-of-fit and independence. Permutation tests and tests based on ranks and scores in a variety of applications. Goodness-of-fit testing for continuous distributions and families. Application of techniques to data using computing software will be

emphasized.

Prerequisite: OA3103 or consent of the instructor.

OA4106 - Advanced Data Analysis (3 - 1)

The course features the blending of sophisticated statistical software and data from recent DoD applications. The manipulation of multivariate data and statistical graphics are emphasized. Methodologies presented can include survival analysis, classification and discrimination, categorical data analysis, and sample survey methods.

Prerequisite: OA3103.

OA4107 - Categorical Data Analysis (3 - 1)

Contingency tables in two, three and higher dimensions. Exact procedures for small tables. The course will feature case studies and treat log-linear models, expanded logistic analysis, ordinal variables, multinomial response methods. Poisson regression and the problems of sparse data sets. Applications and DoD case studies appear in the laboratory exercises.

Prerequisite: OA3103.

OA4108 - Introduction to Statistical and Machine Learning (2 - 2)

The art and science of finding real patterns in (usually very large) data sets as seen from a statistical perspective. Introduction to some of the techniques used in machine learning and discussion of their implementation, their strengths and weaknesses, and some common and specific pitfalls. Supervised algorithms for classification and regression include trees and neural networks, as well as ensembles. Some unsupervised techniques for clustering, dimension reduction, and visualization are presented. Data acquisition including web scraping, SQL and regular expression for handling of disparate data types needed as inputs for machine learning algorithms will also be covered. Most computation will be done using the R software package, but other software will be introduced as needed.

Prerequisite: OA3103, OA4106.

OA4109 - Survey Research Methods (4 - 2)

The course will cover the basic principles of survey research methods. It will provide students with a practical grounding in all aspects of survey methodology, from survey instrument design, to sample design, to modes of data collection, to methods for survey data analysis. Students will be able to immediately apply coursework to their theses and other real-world applications, including a class capstone project in which students will design, field, and analyze a survey on behalf of a DoD organization.

Prerequisite: OA3103, OS3101, or equivalent, or permission of the instructor.

OA4118 - Statistical and Machine Learning (4 - 0)

This course introduces the art and science of statistical and machine learning to find patterns in large and "Big" data. The focus is on the strengths and weaknesses of learning techniques and their implementation. We cover the fundamental ideas common to learning methods and introduce supervised/unsupervised techniques including: re-sampling methods, advanced clustering and visualization, tree-based ensembles, stochastic gradient boosting, deep neural networks, auto-encoding and other dimension reduction techniques, and applications to natural language processing. The software package Rand high-performance parallel or distributed computing will be used to demonstrate these methods. May not be taken for credit with OA4108.

Prerequisite: OA4106 or consent of instructor.

OA4201 - Nonlinear Programming. (4 - 0)

(Same as MA4301.) Convex sets, convex functions, and conditions for local and global optimality. Elements and convergence of algorithms for solving constrained and unconstrained optimization problems. Introduction to algebraic modeling languages. Many applications of integer and nonlinear programming to military and civilian problems, such as weapons assignments, force structuring, parameter estimation for nonlinear or constrained regression, personnel assignment and resource allocation.

Prerequisite: OA3201.

OA4202 - Network Flows and Graphs (4 - 0)

Introduction to formulation and solution of problems involving networks, such as maximum flow, shortest route, minimum cost flows, and PERT/CPM. Elements of graph theory, data structure, algorithms, and computational complexity. Applications to production and inventory, routing, scheduling, network interdiction, and personnel management.

Prerequisite: OA3201.

OA4203 - Mathematical Programming (4 - 0)

Advanced topics in linear programming, large scale systems, the decomposition principle, additional algorithms, bounded variable techniques, linear fractional programming, formulation and solution procedures for problems in integer variables. Applications to capital budgeting, large scale distribution systems, weapon systems allocation and others.

Prerequisite: OA3201.

OA4204 - Games of Strategy (4 - 0)

Mathematical models of conflict situations, emphasizing the theory of decision making against a completely opposed enemy. Topics include matrix games, Blotto games, stochastic games, and the Shapley value. Applications to combat, resource allocation, cost sharing, etc.

Prerequisite: OA3101, OA3201.

OA4205 - Advanced Nonlinear Programming (4 - 0)

Continuation of OA4201. Advanced topics in non-linear

programming including duality theory, further consideration of necessary and sufficient conditions for optimality, additional computational methods examination of recent literature in non-linear programming.

Prerequisite: OA4201.

OA4301 - Stochastic Models II (4 - 0)

Course objectives are to discuss methods of stochastic modeling beyond those taught in OA3301 and give students an opportunity to apply the methods. Topics include conditioning; renewal processes; renewal reward processes; length biased sampling; semi-Markov models, and novel queuing, reliability and maintenance models. The Topics are illustrated by DoD applications. Same as MA4305.

Prerequisite: OA3301.

OA4302 - Reliability and Weapons System Effectiveness Measurement (4 - 0)

Component and system reliability functions and other reliability descriptors of system effectiveness. Relationships between system and component reliability. Point and interval estimates of reliability parameters under various life testing plans.

Prerequisite: OA3301.

OA4303 - Sample Inspection and Quality Assurance (4 - 0)

Attribute and variables sampling plans. Military Standard sampling plans with modifications. Multilevel continuous sampling plans and sequential sampling plans. Structure and implementation of quality assurance programs and analysis of selected quality assurance problems.

Prerequisite: OA3101 or consent of instructor.

OA4305 - Stochastic Models III (4 - 0)

Lecture topics include, non-stationary behavior of Markov processes, point process models, regenerative processes, Markovian queuing network models, and non-Markovian systems. Applications to include reliability, computer system modeling, combat modeling and manpower systems. Students are given exercises entailing data analysis, formulation of probability models, and application of models to answer specific questions concerning particular phenomenon.

Prerequisite: OA3103, OA3301, OA4301 and consent of the instructor.

OA4308 - Time Series Analysis (4 - 0)

(Same as MA4304.) Second order stationary processes. Harmonic analysis of correlation functions. Filters and spectral windows. Ergodic properties. Problems of inference in time series analysis. Box-Jenkins techniques. Introduction to the analysis of multivariate processes.

Prerequisite: OA3103, OA3301.

OA4321 - Decision Support Systems (3 - 1)

An introduction to the topic; includes an overview of organizational decision making, discussion of OR techniques integral to DDS, relationships to artificial intelligence and expert systems, specialized computer languages, and non-traditional techniques for handling uncertainty. Current operational systems, both military and civilian, will be used as examples.

Prerequisite: OA3101.

OA4333 - Simulation Analysis (4 - 0)

Advanced techniques of model development and simulation experimentation. Discussion of current research. Actual topics selected will depend on interests of students and Instructor.

Prerequisite: OA3302.

OA4401 - Individual Performance & Personnel Considerations (3 - 1)

This course provides students with a working knowledge of current theories regarding individual human performance and the methods used to measure individual states and traits that affect that performance. In addition, the course includes familiarization with tests and procedures used by the DoD and industry for personnel selection and job/task assessment procedures. The course builds on information covered in OA-3401, Human Factors in Systems Design.

Prerequisite: OA3401, specifically, knowledge and basic understanding of human information processing, sensation, perception, attention, vigilance, and memory OR permission of instructor.

OA4402 - Training and Simulation (3 - 1)

The theoretical foundations of skilled performance will be covered including the principles of skill acquisition, the specificity or transferability of skills, individual differences and the prediction of skilled operator performance. The second half of the course will be devoted to advances in training systems and instructional design for promoting the efficient acquisition of military-related skills, knowledge and abilities. Same as MV4002.

Prerequisite: OA3401.

OA4403 - Special Topics in Human Factors (3 - 0)

This course will cover current topics and advances in human factors research and application. The course will have a different topic each time it is offered depending on the interests of the faculty, needs of the students, or availability of visiting professors.

Prerequisite: OA3401.

OA4405 - Anthopometry and Human Biometrics (V - V)

This course will cover current topics and advances in human factors research and application. The course will have a different topic each time it is offered depending on the interests of the faculty, needs of the students, or

availability of visiting professors. Prerequisites: None.

OA4406 - Survivability, Habitability, Environmental Safety and Occupational Health (4 - 0)

This course will provide an overview of personnel survivability methodology, safety, health hazards, and occupational health concepts. The evaluation of new and modified military systems and equipment for safety and potential health hazards will be addressed through reviewing models, methods and processes available to help identify and mitigate the potential harm from accidents and hostile environments. Occupational health concerns will be addressed and methods of alleviating or minimizing workplace hazards will be analyzed. Risk analysis and mitigation models also will be examined for their contribution to increased safety and operational effectiveness. Prerequisites: None.

OA4407 - Human Anthropometry-and Biomechanics (3 - 1)

This course will cover current techniques for combining anthropometric and biomechanical data to model the relationships among people, tasks, equipment, and the workplace. The historical development of anthropometric databases and human engineering models will be reviewed and current techniques and multivariate models will be introduced. Both military and commercial guidelines for ergonomic design will be covered and emphasis will be given to software tools for 3-D modeling, visualization and workstation design. Prerequisites: None.

OA4408 - Macroergonomics and Organizational Behavior in Human Systems Integration (3 - 1)

This course systematically examines the application of macroergonomic concepts and organizational processes in orchestrating human systems Change Description integration (HSI) efforts in acquisition programs. The key concepts, principles, and theories of macroergonomics are defined and then applied to analyze organizational structures, policies, and processes that impact effective HSI efforts. Specific attention will be paid to leadership, organizational, group, and team behaviors as they impact HSI strategy, planning, program execution, and risk assessment. The material covered will then be applied to manning, training, and safety challenges in current acquisition programs. Prerequisites: None.

OA4414 - Human Systems Integration Case Studies and Applications (4 - 0)

This is the capstone course in the Human Systems Integration (HSI) Certificate Program. This course provides students the opportunity to integrate and apply the materials from previous courses through the examination of actual military acquisition programs. One of the course objectives is to provide an historical analysis of both small and large military acquisition programs. The lessons learned from these historical case studies will reinforce best practices for HSI practitioners.

Prerequisite: OA3413.

OA4415 - HSI Case Studies and Applications (Capstone II) (4 - 0)

This is the final course in the Naval Postgraduate School's distributed learning Master of Human Systems Integration (MHSI) Program. Students will engage in a capstone project that builds on the activities in the OA44I4 HSI Case Studies and Applications(Capstone I) and all other previous courses, A typical capstone project would require a student to create a detailed HSI process document for his or her organization. This document would describe the HSI processes and activities that should be employed by that organization to design, develop, produce, deploy, operate, and support a system with an appropriate focus on the operators, maintainers, supporters, and trainers.

Prerequisite: OA4414.

OA4501 - Seminar in Supply Systems (3 - 0)

A survey of the supply system for the U.S. Navy. Topics include inventory models at all levels for consumables and repairables, budget formulation and execution, provisioning and allowance lists, planned program requirements, transaction item reporting and current topics of research such as stock migration, and material distribution studies.

Prerequisite: OA3501.

OA4600 - Information in Warfare (4 - 0)

Quantitative approaches to measuring and assessing the value of information in warfare, with emphasis on tradeoffs between information and firepower. Major components are on information as precision (Bayesian filtering, data association and fusion), and information as a guide to decision making (decision theory, Markow policies, optimization).

Prerequisite: OA3102, OA3201, OA3301.

OA4601 - Models for Decision Making (4 - 0)

The objective is to be able to formulate and analyze operational and executive decision problems, where a lack of clear problem definition and data, sequential timing of decisions, uncertainty, and conflicting objectives, are all normal features of such problems. Understanding and applying influence diagrams and decision trees form the core part of the course. Emphasis is on building models and determining data requirements. Specific areas include the use of policy space analysis in sensitivity.

Prerequisite: OA3304.

OA4602 - Joint Campaign Analysis (4 - 0)

This course studies the development, use, and recent applications of campaign analysis in actual procurement, force structure and operations planning. Emphasis is on

formulating the problem, choosing assumptions, structuring the analysis, and measuring effectiveness. Interpreting and communicating results in speech and writing is an important part of the course. In the last three weeks students conduct a broad gauge, quick reaction campaign analysis as team members.

Prerequisite: A course in basic probability and statistic theory and operational experience in military environments.

OA4603 - Test and Evaluation (4 - 0)

This course is designed to cover Developmental and Operational Test and Evaluation and Military Experimentation, including statistical concepts and methods frequently used in weapon system testing and experimentation environments. The course is taught from the perspective of the Program Manager, Test Project Officer, Test Engineer, Test Analyst, and Statistician. A number of actual military cases are used for examples. Topics include the Role of Test and Evaluation in Systems Engineering and Acquisition Management, Test Planning and Design, Development of Measures of Effectiveness and Measures of Performance, Conduct of Tests, Data Analysis, and Reporting of Test Results. A detailed group test planning project and design exercise are included. Upon successful completion of this course, students receive DAWIA Level II and Level III Intermediated and Advanced Test and Evaluation certification.

Prerequisite: A Previous course in probability and statistics or instructor's permission.

OA4604 - Wargaming Applications (3 - 2)

Wargaming has been an essential tool for military planning and decision making for centuries. A properly designed wargame provides a structured environment that allows military professionals to gain insight into complex military problems. The first half of the Wargaming Applications course teaches the fundamentals of wargaming using a mix of lectures and practical exercises. The second half of the course focuses on applying wargaming fundamentals to answer a DoD sponsor's real-life requirement. Student groups will design, develop, conduct, and analyze a wargame to address sponsor's needs.

Prerequisite: OA4655 or consent of instructor.

OA4605 - Operations Research Problems in Naval Warfare (3 - 0)

Analysis of fleet exercises. Changes in tactics and force disposition arising from the introduction of nuclear weapons and missiles. Relationship of air defense to strike capability and USW. Current radar, sonar, communications and ECM problems.

Prerequisite: OA4604, OA4655.

OA4607 - Tactical Decision Making (4 - 0)

This course deals with computer-aided decision making. Topics include the human-computer interface, the construction of effective graphics, verification/validation, and theoretical frameworks for competitive and non-competitive decision making. Kalman filters are introduced as an important fusion and tracking tool. The primary classroom application areas are information fusion, search/track and mine warfare. A project is required.

Prerequisite: OS2103 or equivalent, and a working knowledge of a programming language such as R, MATLAB, or Python..

OA4608 - Foreign Military Operations Research (4 - 0)

This course considers military operations research (OR) of foreign countries that are of current concern to DoD. Because many of these have been military clients of the former Soviet Union, the course will take Soviet military O/R as a point of departure for study. Asymmetries between Soviet and American military O/R are emphasized. Exploitation of such information is discussed. Course content will change as concerns change. Topics have included: Soviet military O/R textbooks, use of combat models in automated systems of troop control (Soviet C3), Soviet combat models, network models for planning and control of combat operations, target-engagement models, models for reconnaissance/intelligence processes, modeling of deception, automated artillery fire planning, strategic models. English translations of major Soviet works on military O/R will be supplied. SECRET clearance and U.S. citizenship.

Prerequisite: OA4655. Security Clearance Required: Secret.

OA4610 - Mobilization (4 - 0)

Introduction to the military and civilian systems for mobilization, linear programming and simulation formulations of strategic mobility and munitions scheduling. Planning and controls of the logistics systems, including planning factors and joint operations planning. Integration of mobilization with Navy operational logistics. Prerequisites: None.

OA4613 - Energy Logistics in Warfare Operations (4 - 0)

Case studies and quantitative analysis of energy sources, distribution, and consumption focused on the sustainment of warfare operations. Energy sources to include petroleum-based fuels, and synthetic liquid fuels and other alternative energy sources. Distribution analysis to include requirements and vulnerability of operational logistics lines of supply by ship, rail, pipeline, trucks and air. Consumption analysis to include modeling of energy consumption logistics planning factors for ship, aircraft, and ground force operations.

Prerequisite: OA3201 or OS3007 or OA3611 or permission of instructor.

OA4614 - Advanced Wargaming Applications (3 - 2)

Student groups will create a military modeling application for an external defense wargaming sponsor and/or an NPS faculty advisor, and examine approved issues in depth. Starting with a well-defined wargame with a functioning framework, student groups will learn, apply, and integrate relevant problem-structuring methods, combat models, and decision analysis tools. The end product will be a functioning military modeling application that produces relevant qualitative and/or quantitative insights in a final course project.

Prerequisite: OA4604, OA4655.

OA4655 - Introduction to Joint Combat Modeling (4 - 0)

(Same as MV4655.) This course covers the basic tools and concepts of joint combat modeling. Both the science and the art are emphasized. Topics include: the role of combat modeling in analyses, taxonomies of models, an introduction to some important models and organizations, measures of effectiveness, approaches to effectively using models to assist decision making, object-oriented approaches to designing entities to simulate, firing theory, one-on-one and few-on-few engagements, introduction to aggregated force-on-force modeling (including the basic Lanchester model and some of its derivatives), sensing algorithms, simulation entity decision making, simulating C4ISR processes, terrain and movement algorithms, verification, validation, and accreditation (VV&A), stochastic versus deterministic representations, hierarchies of models, and variable resolution modeling. The primary course objective is for you to understand the enduring fundamentals of how combat models are built and used to support decision making. This will be done, in part, through several small projects that will require students to design, implement, and analyze models. Prerequisites: Probability and Statistics (through third course in the sequence), familiarity with a programming language, Calculus, and concurrent instruction in computer simulation (e.g., OA3302).

OA4656 - Advanced Combat Modeling (4 - 1)

The objective of this course is to educate and train model-builders (as opposed to model-users). The phenomena and situations that are modeled in this course range from fundamental shooting processes to force-on-force engagements and from minefields to air-defense systems. Special attention is given to contemporary issues such as the effect of information in the presence of precision guided weapons and UAVs, and the war against terror. The focus of the course is on analytic models that are based on probability and optimization techniques.

Prerequisite: OA4655, OA3301 (or OS3311).

OA4657 - Survey of Joint Modeling and Simulation Combat Models (2 - 0)

This course introduces the student to a wide variety of M&S-based combat models from throughout the DoD. A broad cross section of joint combat models various M&S domains are examined. A case study on the development of joint combat models is presented for discussion. Several simulations are selected by students for detailed study from among a list of more than thirty models. The set of available joint combat models for study includes COMBAT XXI, ITEM, IWARS, JACATS, JTLS, OneSAF, STORM and many others. The examination of these models is the basis for instruction and discussions on M&S related concepts and issues. Students explore DoD M&S repositories, evaluate recent M&S research, interact with users and developers of joint combat models, and gain insight into current joint M&S issues. Prerequisites: None.

OA4658 - Survey of Joint Combat Models (1 - 0)

The purpose of the course is to introduce the student to a wide variety of models that are being used throughout DoD. A broad cross section of models are envisioned to be taught – characteristics of the models will include both large and small; analytical models as well as those for experimentation and/or training; theater level as well as strategic/tactical level models; ground as well as air models. Prerequisites: None.

OA4659 - Survey of Joint Combat Models (1 - 0)

The purpose of the course is to introduce the student to a wide variety of models that are being used throughout DoD. A broad cross section of models are envisioned to be taught – characteristics of the models will include both large and small; analytical models as well as those for experimentation and/or training; theater level as well as strategic/tactical level models; ground as well as air models. Prerequisites: None.

OA4701 - Econometrics (4 - 0)

Construction and testing of econometric models, analysis of economic time series, and the use of multivariate statistical analysis in the study of economic behavior.

Prerequisite: OA3103.

OA4702 - Cost Estimation (4 - 0)

This course provides a broad-based understanding of the cost analysis activities involved in the acquisition and support of DoD weapon systems. In addition, it introduces Operations Research techniques fundamental to the field of cost estimation. The course covers the Defense Systems Acquisition Process, Time Value of Money, and Economic Analysis; it develops, uses and analyzes estimating techniques commonly encountered in both the DoD and industry, including statistical and non-statistical cost estimating relationships, inflation indices, cost improvement curves, time phasing and uncertainty analysis. Prerequisites: None.

OA4703 - Defense Expenditure and Policy Analysis (4 - 0)

A presentation of the major components of defense budgeting and policy formulation from the standpoint of the three major institutions involved, the agency, executive and congress. The use of quantitative models of institutional behavior is emphasized when examining both individual institutions and the interaction between them.

Prerequisite: OA3103.

OA4704 - O/R Techniques in Manpower Modeling (4 - 0)

The objective of this course is to introduce the student to the major types of manpower and personnel models for estimating the effects of policy changes on the personnel system. Topics include longitudinal and cross-section models, optimization models, data requirements and validation. Application in the form of current military models are included.

Prerequisite: OA3103 or permission of the instructor.

OA4801 - Spreadsheet Modeling for Military Operations Research (3 - 2)

Implementation of a wide variety of military Operations Research topics on software accessible in any typical Department of Defense (Fleet) environment. This course highlights military spreadsheet applications of Operations Research methods (e.g. discrete event simulation, optimization, queuing, Markov chains), discusses limitations, and demonstrates methods to supplement and customize spreadsheet analytical functions.

Prerequisite: OA3103, OA3301, OA3302.

OA4820 - Case Studies in Applied Defense Analytics (3 - 1)

This course introduces established graduate students of operations research to analysis of real military problems. After a structured introduction on analytical project management, these novice operations researchers organize into small teams to conduct the analytic process on a single unresolved military problem. These problems retain real-world complexity and ambiguity requiring scoping, data management, model development, analytic methodology, and communication plan. Throughout the course period, these teams are mentored by experienced operations researchers and supported with access to modern analytical computation systems. Student teams present their findings to real military sponsors at periodic check points and receive feedback on their work. The objective of the course is to provide the experience of developing science-based insight on complex problems for the purpose of informing military decisions.

Prerequisite: OA3802 and OA4118, or Instructor permission.

OA4910 - Selected Topics in Operations Analysis (V - 0)

(Variable hours 2-0 to 5-0.) Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes.

Prerequisite: A background of advanced work in operations research and departmental approval.

OA4930 - Readings in Operations Analysis (V - 0)

(Variable hours 2-0 to 5-0.) This course may be repeated for credit if course content changes. Graded on Pass/Fail basis only.

Prerequisite: Departmental approval.

OA5805 - Dissertation Proposal Prep (0 - 8)

Dissertation preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

OA5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council. Prerequisite: Advancement to Candidacy.

R000

OAR100 - Introduction to Computational Methods for Operations Research (2 - 2)

(NO CREDIT) (Meets first 6 weeks of quarter.) Introduction to the Naval Postgraduate School computer laboratories and software. Windows operating system, files, internet, editing, word processing, spreadsheets, data analysis and presentation graphics.

OAR160 - Introduction of Operations Analysis II (2 - 2)

(NO CREDIT) This course is the second half of OA1600.

OAR200 - Introduction to Visual Basic for Operations Research (2 - 2)

(NO CREDIT) (Meets last 6 weeks of quarter.) A first course in computer programming using Visual Basic as a high level programming language. Primary emphasis will be on the planning, structuring, and debugging of computer programs for solving Operations Research problems.

OC

OC0001 - METOC Colloquium (0 - 1)

(No credit.) Departmental lecture series covering topics of current interest by NPS and outside guest speakers. Graded pass/fail. Prerequisites: none.

OC0002 - METOC Colloquium (0 - 1)

(No credit) Departmental lecture series covering topics of current interest by NPS and outside guest speakers. Graded pass/fail. Prerequisites: none.

OC0810 - Oceanography Thesis Research (0 - 8)

Every student conducting research in oceanography will enroll in this course.

OC0999 - Thesis Seminars (2 - 0)

(NO CREDIT) Students in the various oceanography curricula present their thesis research. PREREQUISITE: Preparation of a thesis.

OC2020 - Computer Computations in Air-Ocean Sciences (2 - 2)

Introduction to the programming languages, operating systems, and computing facilities which METOC students use in MR and OC courses. Laboratory assignments are elementary problems in oceanography and meteorology.

Prerequisite: Calculus and college physics.

OC2902 - Fundamentals of Geospatial Information and Services (3 - 0)

This course will give the student an appreciation for the important facts about precision location today, from the true physical shape of the earth to the fusion of geographically labeled data in modern electronic databases. Today's military officer needs to know the fundamentals of precision location systems to operate in the battlespace of the twenty-first century. We have come from precise position being 60 nautical miles in the 1700s to a few meters in the 2000s. We have gone from dead reckoning on paper charts to GPS positions fed to fully automated navigation and weapons systems. The entire process of producing modern geospatially tagged items will be reviewed. This will include the scientific background of the processes and the advantages and limitations of the steps.

Prerequisite: Students will need to have a basic understanding of algebra, geometry and trigonometry. A basic course in physics or equivalent that covers vector, conservation of energy and forces is needed. The student needs to be familiar with basic computer skills including the storage of data in arrays (spreadsheets work is sufficient for example)..

OC2930 - Oceanography for Undersea Warfare (3 - 0)

An introduction to ocean processes and phenomena with applications to Undersea Warfare.

OC3030 - Oceanographic Computing and Data Display (2 - 2)

Course emphasizes the use of the computer as a tool in oceanography problem-solving. Use of various software packages for graphics, scientific visualization, statistics and numerical computation. Graded: Pass/Fail. Prerequisites: None.

OC3120 - Biogeochemical Processes in the Ocean (4 - 3)

Basic biological, geological, and chemical processes in the ocean. Bioacoustics, deep scattering layers, and bio-deterioration. Geomorphic features of the ocean floor; kinds and distribution of ocean bottom features. Chemical composition of the ocean. Prerequisites: None.

OC3140 - Probability and Statistics for Air-Ocean Science (3 - 2)

Basic probability and statistics, in the air-ocean science context. Techniques of statistical data analysis. Structure of a probability model, density distribution function, expectation, and variance. Binomial, Poisson and Gaussian distributions. Conditional probability and independence. Joint distributions, covariance and central limit theorem. Transformations of random variables. Histograms and empirical distributions and associated characteristics such as moments and percentiles. Standard tests of hypotheses and confidence intervals for both one-and two-parameter situations. Regression analysis as related to least squares estimation.

Prerequisite: Calculus.

OC3150 - Analysis of Air Ocean Time Series (3 - 2)

Analysis methods for atmospheric and oceanic time series. Fourier transforms applied to linear systems and discrete data. Correlation functions, power density spectra and cross-spectrum. Optimal design of air-ocean data network. Laboratory work involves analysis of actual atmospheric and ocean time series using principles developed in class.

Prerequisite: A probability and statistics course.

OC3210 - Polar Oceanography (3 - 0)

Covers the ice characteristics and physical oceanography of polar seas. Sea ice: types, physical and mechanical properties, heat flux, temporal and spatial distribution, melting and freezing processes, forecasting models, and remote sensing of ice/snow covered surfaces. Physical oceanography of currents and water masses, deep and bottom water formation, fronts and eddies, polynya processes, and underwater acoustics. Discuss naval and research operations in polar warfare.

Prerequisite: OC3240.

OC3212 - Polar Meteorology/Oceanography (4 - 0)

Operational aspects of Arctic and Antarctic meteorology,

including polar lows, boundary layer and marginal ice zone influences. Polar oceanography. Sea ice amount, seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions. Physical oceanography of currents and water masses, deep and bottom water formation, fronts and eddies, polynya processes.

Prerequisite: MR3222 and OC3240, or consent of instructor.

OC3230 - Descriptive Physical Oceanography (3 - 1)

Physical properties of seawater. Processes influencing the distribution of heat, salt and density in the ocean. Static stability in the ocean. Circulation and water masses in the ocean. Laboratory work involves collection and analysis of actual data using principles developed in class.
Prerequisites: None.

OC3231 - Descriptive Regional Oceanography (4 - 0)

Overview of basic concepts. Water masses and regional circulation including littoral regions and marginal seas. Recent developments dealing with ocean circulation, sea level, climate, El Nino, ocean resources and pollution, and modern observational techniques.

Prerequisite: OC3230 or equivalent.

OC3240 - Ocean Circulation Analysis (4 - 0)

Application of dynamic concepts of ocean circulation, including conservation of mass, momentum and energy. Oceanic currents without friction: inertial and geostrophic flows. Frictional currents: Reynolds equations, Ekman and wind-driven flows. Vorticity balance: Sverdrup transport, potential vorticity, topographic steering, western intensification and Rossby waves. Thermohaline effects and thermocline theory.

Prerequisite: OC3230, OC3321.

OC3260 - Fundamentals of Ocean Acoustics (4 - 1)

The fundamentals of ocean acoustics, including the acoustic wave equation, ray theory, acoustic arrays and filters, ambient noise, scattering, absorption, an introduction to normal mode theory, and sonar equations. Laboratory emphasizes acoustic signal processing techniques.

Prerequisite: OC3230, partial differential equations or equivalent.

OC3266 - Operational Acoustic Forecasting (3 - 2)

Course emphasizes tactical use of the environment as a force multiplier in acoustic USW. Tactical guides involving ducts, fronts, eddies and bottom structure are examined in ange-dependent propagation loss models. Emerging tactics using LFA, VLF and Fixed Distributed systems and non-acoustic methods are reviewed.

Prerequisite: OC3260.

OC3300 - Ocean Policy (3 - 1)

Students will study ocean policy issues as they relate to the use and restriction of use of waters, both international and national, by the U.S. Navy and joint forces. The course will include an introduction to the institutions and players involved in the policy formulation; the policy making process; implementation, enforcement, and compliance; and consequences and effectiveness. Several questions relevant to Navy operations will be addressed: What are the consequences of the current policy structure (protected areas, impeded exercises, etc.)? How do we operate under these policies? What alternatives exist? How do we influence the policies? Students will become familiar with current issues for the Navy Environmental Readiness staff (OPNAV N45), current policy issues for the Oceanographer of the Navy staff (OPNAV N84), with current Navy guidance on environmental programs and protections, and with the reports and recommendations of the several national-level commissions on the ocean.
Prerequisites: None.

OC3321 - Air-Ocean Fluid Dynamics (4 - 0)

A foundation course for studies of atmospheric and oceanographic motions. The governing dynamical equations for rotating stratified fluid are derived from fundamental physical laws. Topics include the continuum hypothesis, real and apparent forces, derivations and applications of the governing equations, coordinate systems, scale analysis, simple balanced flows, boundary conditions, thermal wind, barotropic and baroclinic conditions, circulation, vorticity, and divergence.

Prerequisite: Multi-variable calculus, vectors, and ordinary differential equations (may be taken concurrently).

OC3325 - Marine Geophysics (3 - 0)

Theory and methods of marine geophysics surveys, and emphasis on gravity, magnetism, seismic and acoustic wave propagation; geophysical anomalies associated with major sea floor features; marine geodesy.

Prerequisite: OC3120 (may be taken concurrently).

OC3445 - Oceanic and Atmospheric Observational Systems (2 - 2)

Principles of measurement; sensors, data acquisition systems, calibration, etc. Methods of measurement for thermodynamic and dynamic variables in the ocean and atmosphere, including acoustics and optics.

Prerequisite: MR3420, OC3150, OC3230.

OC3520 - Remote Sensing of the Atmosphere and Ocean (4 - 0)

Principles of radiative transfer and satellite sensors and systems; visual, infrared and microwave radiometry, and radar systems; application of satellite remotely-sensed data in the measurement of atmospheric and oceanic variability.

Prerequisite: Undergraduate physics and differential/integral calculus; ordinary differential equations and MR3480 or consent of instructor.

OC3522 - Remote Sensing of the Atmosphere and Ocean/Laboratory (4 - 2)

Same as OC3520 plus laboratory sessions on the concepts considered in the lecture series. PREREQUISITES: Same as OC3520.

Prerequisite: OC3520.

OC3570 - Operational Oceanography and Meteorology (2 - 4)

Experience at sea acquiring and analyzing oceanographic and atmospheric data using state-of-the-art instrumentation. Integration of satellite remote sensing and other operational products with in-situ data. Includes survey of instrumentation, pre-cruise planning, operations at sea, and post-cruise analysis.

Prerequisite: MR3220, OC3240.

OC3571 - Instruments and Observations (2 - 0)

Introduction to the core oceanographic and atmospheric instruments used in support of environmental monitoring and modeling. Principles of instrument design and sampling protocols will be covered. Emphasis will be placed on the capabilities and limitation of autonomous platforms, on aircraft- and shore-based remote sensing, and on the major systems in place to organize and distribute environmental data. A brief introduction to data assimilation will be included to illustrate the critical link between observations and oceanic and atmospheric circulation models.

Prerequisite: OC3230 or consent of instructor.

OC3572 - Operational Oceanography and Meteorology Laboratory (0 - 4)

This course is intended to insure a flexible hands-on experience deploying equipment in a realistic environment. Students will be required to design their individual field programs working with the instructor and the curriculum's program officer. Approved programs include: 1) design and implementation of coastal ocean or atmosphere sampling protocols using unmanned vehicles, 2) design and implementation of monitoring plans for the surf zone or estuarine environments (in this case OC4210 may be taken as an alternative), 3) design and implementation of sampling protocols for the atmosphere using fixed-location or aircraft-based sensors, 4) design of and participation in upper-ocean or lower-atmosphere sampling protocols at polar ice camps, and 5) design of and participation in deep-water surveys onboard ocean-going research vessels using NPS vessel time or faculty-mentored cruises of opportunity.

Prerequisite: OC3571 (may be taken concurrently) or consent of instructor.

OC3750 - Naval Astronomy and Precise Time (2 - 0)

Positional astronomy. Coordinate systems. Solar system dynamics. Astrometry (measurements of positions and motion of stars). Time, earth rotation and atomic clocks. Naval applications of astronomy. Overview of astrophysics and cosmology.

Prerequisite: College physics and calculus.

OC3902 - Fundamentals of Mapping, Charting and Geodesy (3 - 2)

Basics of map/chart generation and scientific basis for their accuracy and precision. Ellipsoids, latitudes, longitudes, datums, datum transformations, map projections, geoid and heights. Map/chart generation process including satellite surveying. Use of map/charts with modern navigation systems, including GPS. Digital map characteristics.

Prerequisite: Vector analysis, probability and statistics or consent of instructor.

OC4210 - Littoral Field Studies (2 - 4)

Employs the scientific method for studying nearshore and wave processes using field observations in littoral battlespace environments. Monterey Bay, CA will be used as a natural laboratory for studying a plethora of littoral related topics. Students will design a small nearshore field experiment or set of experiments, deploy state-of-the-art instrumentation, and analyze data to test relevant nearshore hypotheses. Students will write a mini-proposal with budget focused on their scientific hypothesis, experiment, and analysis, and write a scientific final report. Introductions and limitations of instrumentation will be discussed and integrated into the field design, which will include deployment schemes and subsequent analyses. Data quality control and analysis techniques will be described and implemented. In particular, tidal harmonic analysis will be introduced and performed. The course is divided into 1) in-class discussions (instrumentation, deployment schemes, and data analysis techniques), and 2) field exercises that require student participation in performing the proposed small experiments. There is a high probability that students will get wet, but it is not a requirement.

Prerequisite: OC3140; OC3150; Matlab familiarity; or consent of instructor.

OC4211 - Ocean Dynamics II (4 - 0)

Linear theory of surface, internal, inertial-internal and Rossby waves, barotropic and baroclinic instabilities. Coastal and equatorial trapped waves.

Prerequisite: Partial differential equations and OC3240.

OC4212 - Tides (4 - 0)

Development of the theory of tides including the tide-producing forces, equilibrium tides, and the dynamic theory of tides; harmonic analysis and prediction of tides; tidal datum planes and their relationship with geodetic

datum planes, short-term and secular changes in sea level.

Prerequisite: OC4211.

OC4213 - Nearshore and Wave Processes (3 - 1)

Shoal-water wave processes, breakers and surf; nearshore water circulation; beach characteristics; littoral drift; coastal hydraulics; storm surge.

Prerequisite: OC4211 or consent of instructor.

OC4220 - Coastal Circulation (4 - 1)

Coastal ocean physical processes. Dynamics and models of coastal ocean circulations driven by wind, thermohaline, tidal, boundary currents, and ocean eddy forces. Recent papers on coastal ocean circulation. Laboratory sessions on computing properties of tides, coastal trapped waves and wind-driven motions over the shelf and slope.

Prerequisite: OC4211 (may be taken concurrently).

OC4262 - Theories & Models in Underwater Acoustics (3 - 0)

Development of the underlying theories and algorithms of ray, normal mode, and parabolic equation acoustic models for both range independent and dependent environments. Examination of the strengths and weaknesses of and similarities between the various models.

Prerequisite: OC3260.

OC4267 - Ocean Acoustic Variability and Uncertainty (4 - 0)

Examines sound speed profiles (time and space variability), ambient noise, absorption, and reflection and scattering from the sea surface and bottom as they affect sound propagation in the ocean. Synoptic prediction techniques for ambient noise and transmission loss are reviewed. Environmental data input and computational approximations for acoustic models are evaluated against observed signal fluctuations and transmission loss. The course is designed for the Air-Ocean Science, Operational Oceanography, and USW Curricula.

Prerequisite: OC3230 and OC3260 or equivalent.

OC4270 - Tactical Oceanography (3 - 4)

Course emphasizes the tactical use of the environment and battlespace characterization as a force multiplier in naval operations including acoustic undersea warfare, special operations, amphibious warfare, and mine warfare. Using tailored lectures, students will examine oceanographic conditions and the ability for naval forces to exploit them in nearshore, coastal and deep ocean settings. Current acoustic prediction models, remote sensing, tactical decision aids and Geographic Information Systems (GIS) will be utilized by students as they explore a broad spectrum of environmental conditions and methods for exploitation by naval forces. Students will also utilize the R/V PT SUR to perform experiments and analyze data relating to acoustic propagation and the ocean. SECRET Clearance and US Citizenship is required. Lecture series is

UNCLASSIFIED.

Prerequisite: OC3260 or permission of the instructor. Corequisite: For METOC Students: OC4267. For USW Students: EC4450. Security Clearance Required: Secret.

OC4271 - Topics in Tactical Oceanography (3 - 0)

Course emphasizes the tactical use of the environment and battlespace characterization as a force multiplier in naval operations, including acoustic undersea warfare, special operations, amphibious warfare, and mine warfare. Using tailored lectures, students will examine oceanographic conditions and the ability for naval forces to exploit them in nearshore, coastal and deep ocean settings.

Prerequisite: OC3260 or permission of the instructor.. Corequisite: For International METOC Students: OC4267. For International USW Students: EC4450..

OC4323 - Air and Ocean Numerical Prediction Systems (4 - 2)

Numerical models of atmospheric and oceanic phenomena. Major components and sources of error for operational primitive equation prediction systems. Data assimilation concepts, techniques, and limitations. Finite difference, spectral, and finite element methods, computational instability, and approximation error. Horizontal grid variants, vertical coordinate systems, and factors affecting resolution. Overview of subgridscale processes and boundary conditions: physical parameterizations of moisture and convection; land surface models; air-ocean coupling; ocean surface forcing; topography and bathymetry; hydrostatic and nonhydrostatic ocean models. Verification methods and model output. Introduction to uncertainty, chaos, and ensembles.

Prerequisite: MR4322, OC4211, partial differential equation, MA3232 desirable..

OC4324 - Advanced Numerical Ocean Modeling (3 - 0)

Advanced techniques for simulating and predicting ocean circulation, including recent modeling results. Topics to include multi-layer guasi-geotrophic models, multi-level primitive equation models, treatment of irregular geometry and open boundary conditions, satellite data assimilation and computer technology considerations.

Prerequisite: OC4323 or MR4323.

OC4325 - METOC for Warfighter Decision Making (3 - 2)

This course introduces decision science in the context of utilizing deterministic vs. stochastic meteorological and oceanographic forecasts to improve strategic, operational, and tactical planning. Various aspects of generating, communicating, and applying stochastic forecasts for optimal decision making under uncertainty are explored.

Prerequisite: MR/OC3140 or similar course on statistics. MR/OC4323 and MR4324 are recommended but not required..

OC4331 - Ocean Variability (4 - 0)

Contemporary knowledge of ocean mesoscale eddies, fronts, meandering currents; baroclinic and barotropic instabilities; kinematics, dynamics and energetics for observations, theories and models.

Prerequisite: OC4211 or equivalent.

OC4335 - Naval Ocean Analysis and Prediction (3 - 2)

Advanced knowledge of the U.S. Navy ocean analysis and prediction systems, including the Naval Ocean Modeling Program (NOMP), naval ocean data systems, atmospheric forcing systems, data assimilation systems, Optimal Thermal Interpolation System (OTIS), Thermal Ocean Prediction Systems (TOPS), the global ocean circulation prediction system, Shallow Water Analysis and Forecast System (SWAFS), Polar Ice Prediction System (PIPS), and global wave prediction system (WAM).

Prerequisite: OC4211 and MR/OC4323 (may be taken concurrently).

OC4413 - Air/Sea Interaction (4 - 0)

Fundamental concepts in turbulence. The atmospheric planetary boundary layer, including surface layer, and bulk formulae for estimating air-sea fluxes. The oceanic planetary boundary layer including the dynamics of the well-mixed surface layer. Recent papers on large-scale air-sea interaction.

Prerequisite: MR/OC3150, and OC3240 or MR3240 or consent of instructor. Cross-Listed as: Cross-listed with MR4413.

OC4414 - Advanced Air/Sea Interaction (3 - 0)

Advanced topics in the dynamics of the atmospheric and oceanic planetary boundary layers.

Prerequisite: MR/OC4413 or consent of instructor.

OC4415 - Ocean Turbulence (3 - 0)

Advanced topics in the dynamics of ocean turbulence, wakes and microstructure.

Prerequisite: MR/OC4413 or consent of instructor.

OC4490 - Ocean Acoustic Tomography (3 - 0)

(Same as EC4490.) An introduction to Ocean Tomography, an underwater acoustic inverse technique for mapping ocean sound speed and current fields. Covers the major aspects of Ocean Acoustic Tomography, including the underlying concepts, the design and transmission of tomographic signals, and linear inverse methods for the reconstruction of ocean fields.

Prerequisite: OC3260 or EC3450 or PH4453 or equivalent; linear algebra, partial differential equations or equivalent.

OC4520 - Topics in Satellite Remote Sensing (3 - 0)

Selected topics in the advanced application of satellite remote sensing to the measurement of atmospheric and oceanic variables.

Prerequisite: MR/OC3522.

OC4610 - Wave and Surf Forecasting (2 - 2)

Theory and prediction of wind-generated ocean waves. Spectral transformation of waves from deep to shallow water. Prediction of surf and wave related influences on operations.

Prerequisite: OC3150, OC4211.

OC4800 - Advanced Courses in Oceanography (V - 0)

(Variable hours 1-0 to 4-0.) Advanced courses in various aspects of oceanography. Typically, these are advanced topics not covered in regularly offered courses. The course may be repeated for credit as topics change.

Prerequisite: Consent of the Department Chairman and Instructor.

OC4900 - Directed Study in Oceanography (V - 0)

Independent study of advanced topics in oceanography. Graded on Pass/Fail basis only.

Prerequisite: Consent of the Department Chairman and Instructor.

OC5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

OC5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council.

Prerequisite: Advancement to Candidacy.

OS

OS2080 - Probability and Statistics I (3 - 0)

Fundamentals of probability and statistics useful in military modeling. Topics include probability laws and calculation methods, conditional probability, Bayes' Theorem, discrete and continuous random variables, the binomial, geometric, Poisson, exponential, and normal distributions, expectation, variance, and covariance, confidence intervals, hypothesis testing, and simple linear regression. Emphasis is on understanding uncertainty and developing computational skills for military systems analysis.

Prerequisite: Single variable calculus.

OS2101 - Analysis of Experimental Data (4 - 0)

Introduction to statistical analysis of measurements and experimental data. Frequency distributions, graphical representation. Populations and sampling. Principle of least squares, estimation of mean and standard deviation. Curve fitting and regression, propagation of errors.

Confidence intervals, tests and contingency tables. Elementary ANOVA. Relevant probabilistic concepts introduced as needed. Prerequisites: None.

OS2103 - Applied Probability for Systems Technology (4 - 1)

A first course in probability for students in operational curricula. Topics include probability laws and calculation methods, discrete and continuous random variables, expectation, variance, covariance, correlation, computing probabilities and expectations using conditioning, common probability distributions, introduction to probability modeling, and an introduction to statistics. Emphasis is on understanding uncertainty and developing computational skills in probability.

Prerequisite: Single variable differentiation and integration at the MA1113 level and multiple integration at the MA1115 level..

OS3000 - Introduction to Management Science (3 - 0)

A survey of techniques for making decisions quantitatively. Utility theory, linear programming, decision trees, networks and graphs, games, simulation, and waiting lines.

Prerequisite: OS2103.

OS3002 - Operations Research for Naval Intelligence (4 - 0)

This course provides an introduction to the approach and methods of operations research, with special emphasis on military applications of interest to intelligence. It focuses on the mathematical modeling of combat operations and considers intelligence aspects. Students develop basic skills in such modeling. Topics include: operational definitions, measurement of combat effectiveness, model validation/verification, and models versus modeling. Also included are modeling of processes of target acquisition, fire assessment (kill probabilities and target coverage), tactical decision making, and games. Prerequisites: None.

OS3003 - Operations Research for Information Operations (4 - 0)

This course is a survey of operations research techniques. Spreadsheet analysis using Excel is applied to problem solving using methods in optimization, network flow, simulation, queuing, forecasting and decision analysis. Students will practice defining a problem, formulating a model, attaining a solution and evaluating the results using operations research techniques. The relationship between operations research and information operations is explored. Students will develop and understanding of operations research techniques and their application in the information operations domain.

Prerequisite: OS2103.

OS3004 - Operations Research for Computer Systems Managers (4 - 1)

A one-quarter survey of operations research techniques of particular interest to students in computer systems management. Topics covered include optimization, network flow models, simulation, queuing, forecasting techniques, Markov chains, decision analysis, reliability, and project management techniques. Spreadsheet models and analysis tools are an integral part of the course.

Prerequisite: MA2300, OS3101.

OS3006 - Operations Research for Cost Analysts (3 - 0)

This course is a survey of operations research techniques. Spreadsheet analysis using Excel is applied to problem solving using methods in decision theory, linear programming, network flow, simulation, queuing, forecasting, and project management techniques. Students will practice defining a problem, formulating a model, attaining a solution and evaluating the results using operations research techniques. Subject Matter Experts in cost estimation will provide an overview and background in cost estimation. Cost estimation examples are provided as part of homework exercises. Prerequisites: None.

OS3007 - Operations Research for Energy Systems Analysts (4 - 0)

A survey of operations research techniques with emphasis on techniques relevant to energy applications. Topics covered include optimization, stochastic modeling, simulation, and statistical methods including forecasting and system test and evaluation. Excel-based spreadsheet models are used to analyze energy systems and energy consumption logistics during wartime operations and during peacetime. Prerequisites: None.

OS3008 - Analytical Planning Methodology (4 - 0)

A one-quarter survey of operations research techniques of particular interest to students in the C4I curriculum, with emphasis on model formation. Topics include linear and nonlinear programming, integer programming, networks, shop flow and project scheduling, decision analysis, queuing and simulation.

Prerequisite: MA2300.

OS3080 - Data Analysis and Probability Models (3 - 0)

OS3081 - Systems Analysis Cases I (3 - 0)

This is the first course in a three-course sequence in systems analysis practice. This course focuses on learning from real defense systems analysis case histories through readings, discussion, and writing point papers. Emphasis is on understanding the pitfalls of analysis, highlighting critical assumptions, and recognition of the strengths and weaknesses of applied analytical methodologies. Case

histories include actual defense studies conducted with large-scale warfare simulations, seminar wargaming, and other methodologies common in DoD studies and analysis. PREREQUISITES: Graduate standing in Systems Analysis, Operations Research, or Systems Engineering; completion of courses in probability, statistics, simulation, uncertainty modeling, cost-benefit, decision analysis, and optimization.

Prerequisite: The three-course sequence requires satisfactory graduate standing in Systems Analysis, Operations Research, or Systems Engineering; completion of courses in probability, statistics, simulation, uncertainty modeling, cost-benefit, decision analysis, and optimization..

OS3082 - Systems Analysis Cases II (3 - 0)

This is the second course in a three-course sequence in systems analysis practice. This course focuses on learning from participating in class discussion of decision & analysis problem cases and writing concise systems analysis proposals. Cases are drawn from scenarios in defense planning, programming, and budgeting of weapons systems and forces. Emphasis is on systems analysis problem formulation, identification of objectives, measures of effectiveness, articulation of critical assumptions, and outlining of appropriate analytical methodologies. Special emphasis is placed on Cases that are typical of quick-turn-around, limited-resources Pentagon programming analysis and budget drills.

Prerequisite: OS3081.

OS3101 - Statistical Analysis for Management (4 - 1)

A specialized course covering the basic methods of probability and statistics with emphasis on managerial applications. The course includes applications of probability models, statistical inference and regression analysis. Computation for these applications are carried out on a computer, using commercial software packages. Topics in probability include the binomial, geometric, Poisson and normal distributions, risk and expected value. Parametric statistical techniques include significance testing and confidence intervals, together with point estimation of model parameters. Regression analysis includes simple linear regression and multiple regression, with estimation of parameters and tests of hypothesis and confidence intervals for regression coefficients and the variance of the error term.

Prerequisite: College Algebra.

OS3104 - Statistics for Science and Engineering (4 - 0)

Acquaint the engineering student with the techniques of statistical data analysis with examples from quality control, life testing, reliability and sampling inspection. Histograms and empirical distributions and random variables are introduced along with their probability distributions and associated characteristics such as moments and percentiles. Following a brief introduction to decision making, standard tests of hypotheses and

confidence intervals for both one and two parameter situations are treated. Regression analysis is related to least squares estimation and associated tests of hypotheses and confidence intervals are treated.

Prerequisite: Calculus.

OS3105 - Statistics for Technical Management (4 - 1)

The course emphasizes management applications of probability models, statistical inference, and regression analysis. Those aspects of probability germane to distributions such as the binomial and normal are covered. Statistical inference for one and two variables is introduced in the settings of both hypothesis testing and confidence interval estimation. Students develop problem solving and numerical computation skills during laboratory periods using commercial software packages. Prerequisites: None.

OS3111 - Probability and Statistics for HSI and MOVES (4 - 0)

Non-calculus based introduction to basic probability theory and statistics for the non-statistician. Descriptive statistics and graphical techniques. Probability rules including Bayes Rule and independence. Discrete and continuous distributions (Boolean, geometric, binomial, exponential, normal). Expected values, quantiles, variance, covariance, correlation. Expected values and variance of linear combinations of random variables, notably the sample mean. Central Limit Theorem. Student's t-distribution and test, normalization (z-scores), confidence intervals, and introduction to hypothesis testing for the one sample data set, including categorical data. Additional topics may include paired designs, contingency tables and chi-squared test. Prerequisites: None.

OS3112 - Statistics and Design of Experiments (4 - 2)

This course covers fundamentals of experimental design, analysis of categorical data, the general linear model, and regression. Students will learn how to set and analyze experiments using basic experimental design starting with two-sample methods and advancing to designs such as factorials, fractional factorials, and randomized block designs. Designs appropriate for human research (such as repeated measure designs) and /or large scale simulation experiments (such as Latin hypercube designs) are included. Parametric and nonparametric approaches are compared and contrasted. Datasets and motivational examples are drawn from recent research relevant to HSI and/or MOVES.

Prerequisite: College Algebra and OS3111.

OS3113 - Data Analysis for HSI and MOVES (4 - 1)

Introduction to common types of data collection (sampling methods, surveys, observational studies, and experiments) and the link between data collection

methods and data analytic procedures. Non-calculus based introduction to conducting statistical inference for estimation of population parameters and hypothesis testing with common parametric methods (confidence intervals, z-tests, t-tests, ANOVA, regression, chi-square). Data sets and motivational examples are drawn from recent research relevant to HSI and/or MOVES. Prerequisites: None.

OS3180 - Probability and Statistics for Systems Engineering (4 - 1)

This course introduces the systems engineering and analysis student to probability, descriptive statistics, inferential statistics, and regression.   The modeling and analysis of the stochastic behavior of systems provides the context for the course.   Topical coverage includes the normal, binomial, Poisson, exponential, and lognormal distributions; probabilistic measures of system performance; graphical and numerical data summaries; confidence intervals and hypothesis tests based on one or two samples; regression with one or more predictors; and single factor analysis of variance. The lab portion of the class uses spreadsheets to support the modeling and analyses. The course is delivered in block format.

Prerequisite: SE1001 or equivalent.

OS3211 - Systems Optimization (4 - 0)

This course is an application-oriented introduction to optimization. It introduces models (linear, integer and nonlinear programs), modeling tools (sensitivity and post-optimality analysis), and optimization software and solution techniques (including heuristics). It presents many military and private sector optimization applications in production planning and scheduling, inventory planning, personnel scheduling, project scheduling, distribution systems planning, facility sizing and capacity expansion, communication systems design, and product development. Prerequisites: None.

OS3301 - Simulation Modeling and Analysis (3 - 1)

OS3301 is a simulation and analytical course that provides students with a foundation in simulation theory and process modeling, random number generation concepts, basic queuing theory in process modeling, applied data analysis, an introduction into experimental design, hypothesis testing, and hands-on system simulation using a simulation modeling package. Students will use these concepts in class projects to simulate systems, evaluate system performance, and compare alternative systems.

Prerequisite: OS2080, or OS2103 and OS3604, or equivalent.

OS3302 - Quality Assurance and Reliability (4 - 0)

This course is a technical treatment of a contractor's quality assurance program with attention to Sampling Inspection, Statistical Process Control and Reliability.

Topics include attribute and variables sampling plans, MILSTD/ANSI/ASQC and sequential sampling plans, quality control chart development and utilization, and manufacturing process capability estimation. Process management analytical tools are introduced using Minitab Quality Control software applications. Structure and implementation of quality assurance programs and quality improvement measures are discussed. Fundamentals of reliability modeling, life testing, reliability growth, estimation and assessment are presented. Time and failure censored life-testing methods for Exponential and Weibull reliability models and Bayesian reliability estimation techniques are introduced. Best Management Practices and Program Managers Workstation are reviewed.

Prerequisite: A previous course in probability and statistics.

OS3303 - Computer Simulation (4 - 1)

Design, implementation and use of digital simulation models will be covered with special emphasis on features common to USW problems. War gaming will be discussed and a game using the digital computer will be played and critiqued by the class. Exercise planning and analysis will be treated. Basic topics are explained including computer generation of random variates, statistical design and monitoring of model progress, machine representation of dynamic data structures, model verification and validation on special purpose simulation and gaming languages.

Prerequisite: OS2103 and OS3604 or equivalent.

OS3307 - Modeling Practices for Computing (4 - 1)

An applied course in modeling and understanding systems where randomness plays a significant role. Topics include basic probability and statistics, queuing models, Monte Carlo and discrete-event simulation, least squares curve fitting, and elements of statistical design of experiments. The focus will be on applications of these techniques in a computer science context.

Prerequisite: Discrete Math, Intro Programming.

OS3311 - Probability Models for Military Applications (4 - 0)

An intermediate course in probability modeling focused at military systems and combat situations. Following a review of random variables, probability distributions, expected values and variance, we will present a selection of probability models that range from elementary models that describe static and simple dynamic military (mostly combat) related situations, to Markov models that represent more complex combat situations (e.g., tactical battle) and processes (e.g., surveillance and employment of UAVs). Prerequisites: None.

OS3380 - Combat Systems Simulation (3 - 1)

This course provides an introduction to discrete and continuous time modeling of systems, especially combat

systems. Students learn the fundamentals of simulation modeling and analysis, and construct increasingly sophisticated models of combat behavior. Students are introduced to Lanchester equations and other abstract models, as well as JANUS and other high resolution commercial combat simulation programs. Students reinforce and extend statistical skills by learning the principles for design and analysis of simulation experiments for estimation and comparison. The primary course objective is for the student to understand the enduring fundamentals of how combat models are built and used to support decision-making.

Prerequisite: OS2080 or OS3180.

OS3401 - Human Factors in System Design (3 - 1)

This course will provide an introduction to the field of Human Factors for Systems Engineering students with an emphasis on military systems. Humans are the most important element of any military system. Consequently, the design of effective systems must take into account human strengths and limitations as well as considerations of human variability. The course surveys human factors, human-centered design, and system effectiveness and safety. Topics include system design in light of human cognition and performance as they are influenced by physiological, anthropometric and environmental considerations. Emphasis is given to the responsibility of Systems Engineers to assure human performance and system effectiveness. Prerequisite: None

OS3403 - Human Factors in Information Warfare (3 - 1)

This course will provide the student with the ability to evaluate and predict human performance in specified operational environments. The effects of stress factors such as noise, temperature, motion, work load, etc., on various aspects of human performance will be studied. Students will identify the control and display requirements or an EW system and design a workspace to accommodate an EW data reduction/analysis system.

Prerequisite: OS3604.

OS3404 - Human Machine Interaction (3 - 2)

An introduction to the man-machine interface problems in C3. Information, display and human communication requirements for effective C3. Applied orientation involving message handling systems, query languages, computer to computer communications, command and control applications programs, file transfer between host computers, etc.

Prerequisite: Enrollment in the Joint C4I curriculum.

OS3603 - Simulation and War Gaming (3 - 1)

This course introduces students to systemic and interactive wargame simulation models. The students will understand and play two interactive wargames and will run an existing systemic combat model to conduct output and sensitivity analyses on the results. Basic topics include

measures of effectiveness, Monte Carlo processes for generating simulation events, decision and utility models, high resolution versus aggregated combat models, scenario development and analysis objectives.

Prerequisite: Basic probability, statistics and Data Analysis - OS2103, OS3604 or equivalent, and a working knowledge of a computer programming language.

OS3604 - Statistics and Data Analysis (4 - 1)

An introduction to statistics and data analysis for students in the operational curricula. Topics include point and interval estimation, hypotheses testing, analysis of variance, multiple regression techniques, and categorical data analysis. Emphasis is placed on decision rules and in the analysis of data sets from operational environments. Computations are done in a statistical analysis package.

Prerequisite: A course in probability (OS2103 or EC2010 or equivalent).

OS3605 - Introduction to Data Analytics for Cost Estimators (3 - 0)

This course provides a comprehensive introduction to data analytics, focusing on key concepts and practical skills related to machine learning, artificial intelligence, programming languages such as R and Python, and state-of-the-art DOD data platforms for automating and visualizing data-related tasks. Students will gain a better understanding of the various aspects of data analytics, including data curation, web scraping, data preparation, cleaning, merging, and predictive modeling and how these techniques can be applied in the cost estimating field. The course will also show students how to use data to provide better decision advantage when briefing senior leadership on their cost analysis.

Prerequisite: OS2080, OS3080, and OS3006 or with the consent of the instructor.

OS3613 - Introduction to Energy Logistics in Warfare Operations (3 - 0)

Studies in energy sources, distribution, and consumption focused on the sustainment of warfare operations. Energy sources to include petroleum-based fuels, and synthetic liquid fuels and other alternative energy sources. Introductory distribution analysis to include requirements and vulnerability of operational logistics lines of supply by ship, rail, pipeline, trucks and air. Introductory consumption analysis to include modeling of energy consumption logistics planning factors for ship, aircraft, and ground force operations. This course is designed for Distance Learning Energy Certificate students.

Prerequisite: None. Corequisite: None.

OS3640 - Framework for Countering Improvised Explosive Devices (2 - 0)

The course describes the use of improvised explosive devices in contemporary warfare with emphasis on how to organize to counter an IED campaign. The course begins

with descriptions of IED devices, why and how they are used, methods and technology to counter IEDs, the IED organization, how to organize to counter an IED campaign, and how to target organizations that control IED violence. A framework is developed to understand and address the many interlocking aspects of countering an IED campaign including: insurgency and civil war; recruiting, training, and financing of IED makers; data collection; geospatial analysis; crime forensics; intelligence; detainee interrogations; reconstruction; political and economic development; society and culture; information operations; training local police, security forces, and military personnel; reconciliation; and negotiations. The class will be taught in the accelerated mode with four hours per week for the first six weeks of the quarter. There will be extensive reading, weekly homework, and a short paper. Graded on a Pass/Fail basis. Prerequisite: None.

OS3661 - Introduction to Modeling and Simulation in Test and Evaluation (4 - 0)

This course introduces the use of modeling and simulation as a complement to physical testing in support of systems evaluation. The general relationships among modeling, simulation, test, and evaluation are introduced in context of systems acquisition life-cycle management. Forms of Live, Virtual and Constructive simulation in support of test planning, test execution, and systems analysis will be described, characterized, and illustrated with real-world examples. VV&A issues and opportunities relevant to the integrated use of simulation and testing in Systems Engineering and Acquisition will be identified. Strategies to optimize the use of scarce resources in executing test and evaluation programs will be provided. Methodologies for identifying and developing test MOEs, MOPs, and test scenarios will be introduced. Appropriate statistical concepts for evaluating Performance Guarantees and Specifications will be presented. Students in groups will develop a detailed T&E and Simulation Plan for a weapons system or future systems of systems concept. Prerequisites: None.

OS3680 - Naval Tactical Analysis (4 - 0)

This course surveys and applies various tools of operational and decision analysis to naval tactical problems. Topics include basic operational and tactical problem formulation, tactical decision analysis, and the application of uncertainty models for tactical problems in search and detection and weapons effectiveness.

Prerequisite: A course in calculus-based probability and statistics (OS2080, OS3104, OS3180 or equivalent) or permission of the instructor.

OS3701 - Cost Estimation I: Methods and Techniques (3 - 0)

This course provides a broad-based understanding of the cost analysis activities involved in the acquisition and support of DoD systems. It introduces operations research techniques fundamental to the field of cost estimation. The course covers the collection and sources, and economic analysis; it develops, uses, and analyzes cost estimating techniques commonly encountered in both the DoD and industry, including statistical and nonstatistical cost estimating relationships, inflation indices, cost improvement curves, time phasing, wrap rates, and uncertainty analysis.

Prerequisite: OS3080.

OS3703 - Systems Assessment (4 - 0)

This course provides an understanding of Cost Analysis (CA) and Test and Evaluation (T&E) applied to the acquisition and support of DoD weapon systems. It introduces operations research techniques fundamental to the evaluation of concepts, processes and systems. Topics include cost estimation, effectiveness estimation through the T&E process, techniques for conducting design trades, and managing the risk involved. Development of communication skills is accomplished through oral presentations and written reports.

Prerequisite: A graduate course in probability and statistics or permission of the instructor.

OS4001 - Introduction to Probabilistic Modeling for HSI (4 - 0)

This course will introduce the student to desktop modeling of humans, particularly emphasizing models that are relevant to military systems. The course will demonstrate current software tools designed around models of human stature, movement, and behavior. We will focus on the utilization of existing modeling techniques which are useful for system design or evaluation, e.g., JACK, MicroSAINT, and SAFTE/FAST. Prerequisites: None.

OS4010 - Engineering Risk Benefit Analysis (3 - 2)

This course emphasizes three methodologies, Decision Analysis (DA), Reliability and Probabilistic Risk Assessment (RPRA) and Cost-Benefit Analysis (CBA). The course is designed to give students an understanding of how these diverse topics can be applied to decision making process of product design that must take into consideration significant risk. The course will present and interprets a framework for balancing risks and benefits to applicable situations. Typically, these involve human safety, potential environmental effects, and large financial and technological uncertainties. Concepts from CBA and RPRA are applied for real world problems resulting in decision models that provide insight and understanding and consequently leading to improved decisions. Prerequisites: None.

OS4011 - Risk Benefit Analysis (3 - 2)

This course emphasizes decision analysis, probabilistic risk assessment, and cost-benefit analysis in systems analysis and systems acquisition contexts. The course is designed to give students an understanding of how these diverse topics can be applied to a decision-making process that must take into consideration significant technological and financial risk. The course will present and interpret a framework for balancing risks and benefits to applicable situations. Typically, these involve large financial and technological uncertainties. Concepts are applied to real-world problems resulting in decision models that provide insight, understanding and improvement of acquisition decisions.

Prerequisite: OS3080, or an equivalent graduate level course in probability modeling.

OS4012 - Cost Estimation III: Risk and Uncertainty Analysis (3 - 0)

Risk and Uncertainty Analysis provides the foundation for an understanding of risk management as it relates to cost estimation. It addresses program risks that help ensure program costs, schedule, and performance objectives are met. Students are given an overview of how to model the cost/risk associated with a defense acquisition program. Topics covered include basic probability concepts, correlation, Cost drivers, subjective probability assessment, goodness-of-fit testing, and simulation concepts using spreadsheet-based simulation packages. Monte Carlo simulation based cost risk case reinforce the techniques taught.

Prerequisite: OS3080, OS3701.

OS4013 - Cost Estimation VI: Decision Analysis for Cost Estimators (3 - 0)

This course presents an introduction to the techniques of Decision analysis. Decision analysis techniques can be used to help decision makers solve complex decision problems involving sequential decisions, major uncertainties, imperfect information, varying degrees of risk, and often multiple competing or conflicting objectives. The course includes structuring decision with influence diagrams and decision trees, modeling uncertainty with subjective probabilities, sensitivity analysis, the value of information, and modeling risk attitudes using utility theory. A fundamental understanding probability and calculus is expected.

Prerequisite: OS3080, OS3006, OS4702.

OS4080 - Cost Estimation V: Cost Estimating and Analysis Cases (3 - 0)

This course focuses on learning from real cost estimation case histories through readings, discussion, and writing point papers. Emphasis is on understanding the capabilities and limitations of cost estimation and analysis, highlighting critical assumptions, and recognition of the strengths and weaknesses of applied analytical methods.

Case histories include actual department of defense cost studies conducted that have been considered successes and those that have been considered failures. These cases provide the lessons learned for future cost estimation and analysis studies.

Prerequisite: OS4703.

OS4081 - Cost Estimating and Analysis Capstone I (3 - 4)

This course focuses on learning from participating in a cost estimation team project. Small-teams (4-6 students) will be given an actual cost estimating analysis project drawn from actual cost problems compiled by the major systems commands and Service Cost Agencies from the departments of the Army, Navy, and Air Force. Emphasis is on cost problem formulation, identification of objectives, measures of effectiveness, articulation of critical assumptions, and outlining of appropriate analytical methods. Class time during the quarter is used for team progress briefings and critical class discussion.

Prerequisite: OS4080.

OS4082 - Cost Estimating and Analysis Capstone II (3 - 4)

This course continues the on hands-on experience of OS4081, completing the cost estimation project. Student teams will develop the cost model and analyze alternative cost estimations of the problems presented in the previous course; they will develop and test the estimate, and then document and defend their estimate. Students provide concise written reports, which include the analytical results, and a presentation to decision makers. Class time during the quarter is used for team progress briefings and critical class discussion.

Prerequisite: OS4081.

OS4083 - Systems Analysis Cases III (3 - 4)

This is the third course in a three-course sequence in systems analysis practice. This course focuses on hands-on experience conducting rapid quantitative systems analysis. Emphasis is on small-team (2-3 student) systems analysis projects and presentations. Typical projects are based on analysis proposals developed in the preceding course. Class time during the quarter is used for team progress briefings and critical class discussion. The projects culminate with a concise written report, including analytical results, and a presentation to decision-makers.

Prerequisite: OS3082.

OS4106 - Advanced Data Analysis (3 - 0)

This course moves beyond the ordinary linear model to other types of statistical models that will be appropriate in different circumstances. Students are first introduced to supervised models, including logistic regression and "generalized linear models" (GLM). The importance of complexity control and a training-set/test-set division is emphasized. Non-parametric models are introduced through classification and regression trees. Classification performance assessment is discussed. Unsupervised models, to include clustering and principal components

are presented. Throughout the course, examples are drawn from practical experience with conducting research and solving problems for Navy and DoD customers.

Prerequisite: OA3103 or equivalent, such as an intermediate course on linear models; or the instructor's consent.

OS4118 - Statistical and Machine Learning (3 - 0)

This course introduces students to the art and science of statistical and machine learning to find patterns in large and "Big" data. The focus is on the strengths and weaknesses of learning techniques and their implementation. Fundamental ideas common to learning methods are covered, and supervised/unsupervised techniques are introduced. These techniques include: re-sampling methods, advanced clustering and visualization, tree-based ensembles, stochastic gradient boosting, deep neural networks, auto-encoding and other dimension reduction techniques, and applications to natural language processing. The software package R and high-performance parallel or distributed computing will be used to demonstrate these techniques.

Prerequisite: OA4106 or consent of instructor.

OS4621 - Critical Infrastructure Analysis and Defense (4 - 0)

The premise of this course is straightforward: our dependence on critical infrastructures makes us vulnerable to both deliberate and non-deliberate events that can disrupt our physical, economic, and social welfare. This course develops the literacy and competencies necessary to understand potential problems and realistic solutions for critical military and civilian infrastructure in the United States. Students gain experience in the use of "red teaming" analysis for evaluating infrastructure vulnerability through case studies on civilian and DoD/DoN systems, and through a course project.

Prerequisite: NS3180 or OA4202 or consent of instructor. Cross-Listed as: Cross-listed with NS4721.

OS4661 - Advanced Modeling and Simulation in Test and Evaluation (4 - 0)

This course addresses advanced issues in the application of modeling and simulation as a complement to physical testing in support of systems evaluation. It introduces pre-test simulation using experimental designs to identify the most important factors to be used in live testing scenarios. Detailed analysis methods of testing and simulation results including military and statistical significance are addressed. Additional topics include reliability modeling and life testing and various enabling architectures in distributed simulation. Applications to Analysis of Alternatives and rapid acquisitions are discussed. Various forms of simulation in support of test planning, test execution, and systems analysis are described including simulation facilities and test ranges. Students in groups will conduct a comparative analysis of competing systems using experimental design and simulation methods.

Prerequisite: OS3661.

OS4680 - Naval Systems Analysis (4 - 0)

This course covers the techniques for the analysis of proposed and existing systems. It includes analysis of alternatives and models in decision making, optimization in design and operations, queuing theory and analysis, Markov analysis, and selected topics to support project work. Students analyze case studies and complete a course project. Students also use spreadsheet software for modeling and analyzing design alternatives, and develop communication skills by writing reports of analyses.

Prerequisite: OS2080 or OS3180, OS3380 and OS3680.

OS4701 - Manpower and Personnel Models (4 - 0)

The objective of this course is to introduce the student to the major types of manpower and personnel models for estimating the effects of policy changes on the personnel system. Topics include longitudinal and cross-section models, optimization models, data requirements and validation. Application in the form of current military models are included.

Prerequisite: MN3041 and GB4043, or OA3103, or permission of the instructor.

OS4702 - Cost Estimation II: Advanced Concepts in Cost Estimating (3 - 0)

This course is the second of three sequential cost estimation courses. It provides a broad-based understanding of the cost estimating principles applied to various fields of the acquisition and support of DoD systems. It introduces topics such as Cost Estimating Relationships, non-Ordinary Least Squares methods, Software Cost Estimating, Labor Pricing, Source Selection Process, Cost Management, EVMS, and higher level Regression Applications.

Prerequisite: OS3701 or OA4702.

OS4703 - Cost Estimation IV: Applied Cost Analysis (3 - 0)

This course is the third of three sequential cost estimation courses. It provides a broadbased understanding of the cost estimating principles applied to various fields of the acquisition and support of DoD systems. It focuses on the analysis of cost methods and topics such as Specialized Cost Estimating, Portfolio Analysis, Cost Benefit Analysis, Industrial Base Analysis, Supply Chain Management, and Labor Rates.

Prerequisite: OS4702, OA4702.

PC

PC2911 - Introduction to Computational Physics (3 - 2)

An introduction to computational physics, simulation, and

data analysis. Covered topics include: basic programming flow and syntax, numerical integration of ordinary and partial differential equations, digital signal processing and filtering, and an overview of regression analysis and curve fitting. Special emphasis will be placed on solutions to problems relevant to combat systems (e.g., ballistics simulations, spectral filtering of audio signals, etc.). The course is self-contained and assumes no prior programming experience.

PC3014 - Intermediate Applied Physics Laboratory (3 - 4)

This course continues with the instrumentation and signal processing topics begun in PC2013. Included are: controllable oscillators and RF modulation/demodulation techniques, basic electrical noise sources, device damage and failure modes, elementary digital logic gates and Ics. Also included are an overview of relevant microcomputer topics, such as digital encoding schemes, analog and digital interfacing, and serial communications and networking. At the discretion of the instructor, hands-on projects incorporating the course material, may be assigned. Typical projects are: in-air sonar systems, radio receivers and transmitters, and opto-electronic communications links.

PC3172 - Physics of Weapons Systems: Fluid Dynamics of Weapons, Shock Waves, Explosions (4 - 2)

This course provides the basic physical principles applicable to air-borne and water-borne missiles, as well as the fluid dynamics of shocks and explosions. Topics include: Elements of thermodynamics, ideal fluid flow, elementary viscous flows, similitude and scaling laws, laminar and turbulent boundary layers, underwater vehicles, classical airfoil theory, supersonic flow, drag and lift of supersonic airfoils with applications to missiles, fluid dynamics of combustion, underwater explosions.

Prerequisite: PH2151, PH3991.

PC3200 - Survey of Electromagnetic Sensors and Detection (4 - 0)

A survey of the physics of active and passive electromagnetic sensor technologies and detection methods used in surface, air, space, and undersea warfare. Topics include basic radiometry; detector figures of merit and noise characteristics; types of visible and infrared detectors; radar basics, including modes of detection, range resolution, target cross-sections, and the range equation; and magnetometry basics and detectors. Applications of these topics to combat systems will be discussed, including optical and thermal imaging, heat signatures, magnetic signatures, night vision, target/background discrimination, and missile seekers.

PC3400 - Survey of Underwater Acoustics (4 - 0)

Introduction to the physics of the generation, propagation, and detection of sound in the ocean. Topics include the active and passive sonar equations; radiation of sound; acoustic wave equation and wave propagation; the ray approximation, normal mode propagation, the parabolic equation approximation; propagation uncertainty; reflection of plane waves from plane boundaries; speed of sound and absorption; transmission-loss and detection-threshold models; horizontal and vertical linear arrays. Discussions include literature reviews and assignments focus on modeling of sonar equation components and data processing.

PC3800 - Survey of Weapons and their Effects (4 - 0)

Physics and chemistry of explosives including enthalpy and oxygen balance calculations. Detonation/deflagration waves within energetic materials. Material response to elastic, plastic, and shock impact conditions. Interior, exterior, and terminal ballistics (including armor design). Shape charges and explosively formed penetrators. Directed energy weapons including fundamentals of solid state lasers and atmospheric effects on laser propagation. Chemical and nuclear warhead design and effects.

PC4015 - Advanced Applied Physics Laboratory (3 - 4)

Students must integrate the material that they learned in the previous two courses (SE2013 and SE3014), along with additional material on embedded microprocessors and controls. A working introduction to control systems theory is provided and incorporated into an autonomous weapon system or "robot." Collaborative and autonomous engagement of the robots will be performed with RF modems and Ethernet communications. The principles of cooperative engagement will be emphasized. For the final exam, teams will compete in 2-on-1 or 2-on-2 engagement contests. These contests will test the students' assimilation of both the formal and the practical aspects of the course material.

Prerequisite: PC2911 or other C/C++ programming course, PH2013 and PC3014..

PC4022 - Combat Systems Capabilities (4 - 0)

An advanced study of the technical capabilities of current acquisition programs within DoD. The course begins with an overview of the Navy acquisition community and the acquisition process. This is followed by weekly presentations by program managers and their technical experts. Overviews of each program are followed by an in-depth analysis of the critical physics and engineering issues, design trade-offs, risk areas, reliability issues, use of simulation and modeling, testing and evaluation rationale, interoperability concerns, software development issues, interfacing issues, etc. Topics of the course are dictated by the availability of program office personnel. Requires a SECRET clearance. Prerequisites: None.

Security Clearance Required: Secret.

PC4860 - Modern Missile Systems (4 - 1)

This course provides an overview of the components and underlying technologies of modern missile systems. The course gives an introduction to missile aerodynamic design considerations, motion and control, propulsion & range, navigation & guidance, IR and radar seekers, and conventional warheads, followed by an introduction to the physics of missile intercept and lethality considerations.

Prerequisite: An understanding of introductory mechanics and a familiarity with Matlab (or other high level programming language) is assumed..

PH

PH0810 - Thesis Research (0 - 8)

Every student conducting thesis research will enroll in this course.

PH0820 - Integrated Project (0 - 12)

The Naval Postgraduate School provides many opportunities for students to participate in campus-wide interdisciplinary projects. These projects encourage students to conceptualize systems which respond to current and future operational requirements. An integral part of the project involves working with other groups to understand and resolve issues involved with system integration. This course is available to Combat Systems Science and Technology students who are participating in a campus-wide integrated project. Course is graded on a pass/fail basis.

PH0999 - Physics Colloquium (0 - 1)

(NO CREDIT) Discussion of topics of current interest by NPS and outside guest speakers.

PH1000 - The Nature and Structure of Physics (4 - 0)

The concepts and laws of physics are explored, from the ancient science of Aristotle and Ptolemy through the beginnings of classical physics with Galileo and Newton, through the modern quantum and relativity physics of Schrodinger and Einstein, to the physics of quarks and neutrino oscillations. Physics concepts are explored and their relevance to every day and military technologies is highlighted. The course is designed for students who will not take a physics based curriculum, but will encounter technologies impacted by physical concepts. The goal in this course is to convey an appreciation for physics as an intellectual endeavor and an understanding of the principles underlying modern technology. Prerequisites: None.

PH1121 - Mechanics (4 - 2)

This course covers the fundamentals of calculus-based mechanics: Kinematics and dynamics of particles, statics of rigid bodies, work, energy, systems of particles, collisions, rotations of rigid bodies, angular momentum and torque, mechanical properties of solids, elasticity, harmonic motion, fluids.

Prerequisite: A course in calculus or concurrent registration in a calculus course and approval of the instructor.

PH1322 - Electromagnetism (4 - 2)

Basic electromagnetism: electric charge, electric and magnetic fields, forces on charges in fields, electric potential, Gauss's law, Ampere's law, Faraday's law, resistance, capacitance, inductance, DC and AC circuits, magnetic properties of matter, transient currents in circuits, Maxwell's equations, electromagnetic waves.

Prerequisite: PH1121 or approval of the instructor.

PH1992 - Special Topics in Elementary Physics (V - 0)

Study in one of the fields of elementary physics selected to meet the needs of students without sufficient undergraduate physics to meet the prerequisites of their curriculum. The course may be conducted either as a lecture course or as supervised reading.

Prerequisite: Consent of the Department Chairman.

PH1993 - Special Topics in Elementary Physics (V - 0)

Course Description: Study in one of the fields of elementary physics selected to meet the needs of students without sufficient undergraduate physics to meet the prerequisites of their curriculum. The course may be conducted either as a lecture course or as supervised reading.

Prerequisite: Consent of the Department Chairman.

PH1994 - Special Topics in Elementary Physics (4 - 1)

Course Description: Study in one of the fields of elementary physics selected to meet the needs of students without sufficient undergraduate physics to meet the prerequisites of their curriculum. The course may be conducted either as a lecture course or as supervised reading.

Prerequisite: Consent of the Department Chairman.

PH1995 - Special Topics in Elementary Physics (4 - 1)

Course Description: Study in one of the fields of elementary physics selected to meet the needs of students without sufficient undergraduate physics to meet the prerequisites of their curriculum. The course may be conducted either as a lecture course or as supervised reading.

Prerequisite: Consent of the Department Chairman.

PH2001 - Research Seminar in Physics (1 - 0)

This course will present the research expertise of the

physics faculty. The course is designed to support Combat Systems Science and Technology students in their third quarter in the selection of their concentration and area for thesis research. The course is given in the Pass/Fail mode.

Prerequisite: CSS&T students in their first quarter or consent of Academic Associate.

PH2013 - Introductory Applied Physics Laboratory (3 - 4)

This course is an introduction to basic electronic test instrumentation and basic passive and active circuit components, with emphasis on extensive, practical hands-on exposure to laboratory hardware and devices. Included are the measurement and signal processing of analog signals and analog sensors/transducers. Operational amplifiers are introduced as building blocks of analog systems. Passive LRC filters and active filters are studied with an emphasis on applications. Some background in laboratory instrumentation and simple DC and AC circuit elements is assumed.

Prerequisite: College-level basic physics and mathematics, plus simple electrical circuits (e.g., PH1322).

PH2151 - Particle Mechanics (4 - 1)

After a review of the fundamental concepts of kinematics and dynamics, this course concentrates on those two areas of dynamics of simple bodies which are most relevant to applications in Combat Systems: vibrations and projectile motion. Topics include: damped and driven oscillations, projectile motion with atmospheric friction, satellite orbits, and rotating coordinate systems.

Prerequisite: PH1121 or equivalent; MA2121 or equivalent course in ordinary differential equations (may be taken concurrently).

PH2351 - Electromagnetism (4 - 1)

Electrostatic fields in vacuum and dielectrics, electrostatic energy and capacitors. The magnetic field of steady currents, Biot-Savart and Ampere's Laws, vector potential, magnetic properties of matter. Faraday's law. Magnetic energy. Maxwell's Equations. Prerequisites: Basic course in electricity and magnetism, multivariable calculus, vector calculus, and differential equations.

Prerequisite: PH1322, MA1116, MA2121.

PH2514 - Introduction to the Space Environment (4 - 0)

Plasma concepts. Solar structure and magnetic field, particle and electromagnetic emissions from the sun, the geomagnetic field, and the magnetosphere, radiation belts, structure and properties of the earth's upper atmosphere, ionosphere, implications of environmental factors for spacecraft design.

Prerequisite: PH1322.

PH2652 - Modern Physics (4 - 1)

An introduction to modern physics. Theory of relativity; blackbody radiation; photoelectric effect; matter waves; atomic spectral lines; Bohr model of the atom; uncertainty relations (position-momentum and time-energy); the Schrödinger equation (time dependent and independent); probability interpretation; infinite, finite and parabolic potential wells; tunneling (single and double barriers); electron spin and exclusion principle; the periodic table; molecular energy levels; quantum statistics (Bose-Einstein, Fermi-Dirac).

Prerequisite: PH1121, PH1322.

PH3002 - Non-Acoustic Sensor Systems (4 - 0)

This course covers the physical principles underlying the operation of a number of operational and proposed non-acoustic sensor systems. Geomagnetism, magnetometers and gradiometers, MAD signatures, optical and IR transmission in the atmosphere and in sea water. Image Converter, FLIR and radar systems for USW. Exotic detection schemes.

Prerequisite: PH1322.

PH3011 - Thesis Proposal Preparation (1 - 0)

The course is designed to support Combat Systems Science and Engineering students in their fourth quarter in the selection of an area for thesis research culminating in the development of their thesis proposal. The course is given in the Pass/Fail mode, evaluated by the submission of an approved thesis proposal by the end of the quarter. Graded on a pass/fail basis only.

Prerequisite: CSS&T students in their fourth quarter or consent of Academic Associate.

PH3052 - Physics of Space and Airborne Sensor Systems (4 - 0)

This inter-disciplinary course explores the physical principles underlying the sensor systems needed for satellites and tactical aircraft, as well as limitations imposed by the atmosphere and operating environment on these systems and their communication links. Topics include: satellite orbits, the satellite environment, ionospheric interactions and atmospheric propagation, phased array and pulsed compressed radars, imaging synthetic aperture and inverse synthetic aperture radars, noise resources, thermal radiation, principles of semiconductor devices, optical and infrared imaging detector systems, and their resolution limitations and bandwidth requirements.

Prerequisite: Basic physics class. Must be familiar with the concepts of energy and wave motion..

PH3119 - Oscillation and Waves (4 - 2)

An introductory course designed to present mechanics to students studying acoustics. Kinematics, dynamics, and work and energy consideration for the free, damped, and driven oscillators. The wave equation for transverse vibration of a string, ideal and realistic boundary conditions, and normal modes. Longitudinal and transverse waves in bars. Transverse waves on rectangular and circular membranes. Vibrations of plates. Laboratory periods include problem sessions and

experiments on introduction to experimental techniques and handling of data; the simple harmonic oscillator analog; transverse waves on a string; and transverse, longitudinal, and torsional waves on a bar.

Prerequisite: PH3991 or equivalent.

PH3152 - Analytical Mechanics (4 - 0)

Dynamics of systems of particles, including rockets. Hamilton's principle, Lagrangian dynamics, and the role of physical symmetry. Velocity-dependent potentials. The inertia tensor and rotational dynamics of rigid bodies. Small-amplitude oscillations of systems of particles, and normal modes.

Prerequisite: PH2151.

PH3280 - Introduction to MEMS Design (3 - 3)

This is the first course introducing students to Micro Electro Mechanical Systems Design (MEMS). Topics include material considerations for MEMS and microfabrication fundamentals; surface and bulk micromachining; forces and transduction; forces in micro-nano- domains and actuation techniques. The laboratory work includes performing exercises to become proficient in computer aided engineering (CAE) software for the design of MEMS devices. Grading will be based on homework from the textbook, midterm and final exams, and a design project.

Prerequisite: PH1322, EC2200, MS2201. Cross-Listed as: EC3280 and ME3780.

PH3292 - Applied Optics (4 - 2)

This is an intermediate-level course in optics with emphasis on optical systems used by the DoD. It includes a review of basic geometric and physical optics, laws of reflection and refraction at interfaces, imaging systems, and aberrations. Matrix methods for paraxial ray tracing and optical systems analysis and design are covered. Common optical instruments and systems are studied. In wave optics, interference of light, Michelson's and Fabry-Perot interferometers are addressed. Huygens-Fresnel principle, Fraunhofer and Fresnel diffraction, Young's double slit experiment, multiple-slit systems, and diffraction gratings are studied. Finally, polarization of light is studied, including mathematical models and instrumentation. All topics will be enriched with applications, practical examples and laboratory work.

Prerequisite: PH3352 (can be taken concurrently).

PH3352 - Electromagnetic Waves (4 - 0)

Maxwell's equations, energy density and Poynting vector, boundary conditions. Polarization. Propagation of uniform plane waves in vacuum, dielectrics, conducting media (with emphasis on sea water) and low-density neutral plasmas. Reflection and refraction at plane dielectric and conducting boundaries, at normal and oblique incidence. Rectangular waveguides.

Prerequisite: PH2351.

PH3401 - Introduction to the Sonar Equations (3 - 0)

A discussion of the fundamental principles behind each term of the sonar equations. Starting with the acoustic wave equation and the basic properties of sound waves, topics include ray acoustics, normal mode theory, simple transmission loss models, coherent and incoherent sound, directivity, beamforming, scattering, noise sources and properties, and the detection threshold. This course can be taken online as part of the ASW Certificate program.

Prerequisite: Single-variable calculus.

PH3451 - Fundamental Acoustics (4 - 2)

Development of, and solutions to, the acoustic wave equation in fluids; propagation of plane, spherical and cylindrical waves in fluids; sound pressure level, intensity, and specific acoustic impedance; normal and oblique incidence reflection and transmission from plane boundaries; transmission through a layer; image theory and surface interference; sound absorption and dispersion for classical and relaxing fluids; acoustic behavior of sources and arrays, acoustical reciprocity, continuous line source, plane circular piston, radiation impedance, and the steered line array; transducer properties, sensitivities, and calibration. Laboratory experiments include longitudinal waves in an air-filled tube, surface interference, properties of underwater transducers, three-element array, speed of sound in water, and absorption in gases.

Prerequisite: PH3119, PH3991.

PH3452 - Underwater Acoustics (4 - 2)

This course is a continuation of PH3451. Lumped acoustic elements and the resonant bubble; introduction to simple transducers; normal modes in rectangular and cylindrical enclosures; steady-state response of acoustic waveguides of constant cross section, propagating evanescent modes, and group and phase speeds; transmission of sound in the ocean, the Eikonal Equation and necessary space conditions for ray theory, and refraction and ray diagrams; sound propagation in the mixed layer, the convergence zone, and the deep sound channel; passive sonar equation, ambient noise and doppler effect and bandwidth considerations; active sonar equations, target strength and reverberation. Laboratory experiments include Helmholtz resonators, normal modes in rectangular, cylindrical, and spherical enclosures, water-filled waveguide, noise analysis, impedance of a loudspeaker.

Prerequisite: PH3451.

PH3655 - Semiconductor Device Physics (4 - 0)

Formation of solids, crystal structure of semiconductors, X-ray diffraction, lattice vibrations, defects, electrical and thermal properties, free electron model, Seebeck effect, thermionic emission, photoemission, effects of periodic potential, formation of energy bands, E-k relation, band structure of Si and GaAs, electrons and holes, doping and

impurity levels, mobility, diffusion, continuity equation, Schottky and ohmic contacts, optical properties, Formation of p-n junction, I-V characteristics, bipolar and field effect transistors, fabrication technology, semiconductor alloys, quantum effect devices, fundamental limits to semiconductor device technology.

Prerequisite: PH2652.

PH3700 - Fundamentals of Energy (4 - 0)

This course provides a study of the underlying science of all aspects of energy, including energy availability, production, conversion, storage, and delivery. Topics covered will emphasize basic physics and chemistry of: work, power, units and unit conversion; fossil fuels, heat engines and power plants; solar thermal and solar voltaic sources; wind, hydro, and tidal power; geothermal and biomass energy; transportation, including electric and hybrid vehicles, batteries and fuel cells; nuclear energy; and energy conservation. Quantitative problem solving will be emphasized, including development of tools for energy systems analysis. Student will present briefs addressing energy topics with DoD/Don relevance at the end of the course.

Prerequisite: Introductory physics at the algebra/trigonometry level.

PH3782 - Thermodynamics and Statistical Physics (4 - 0)

Entropy, temperature, Boltzmann factor and Gibbs factor are developed from a quantum point of view. Blackbody radiation, chemical potential, partition function, Gibbs sum and applications to an ideal gas are covered. Fermi-Dirac and Bose-Einstein statistics and applications to degenerate systems; Gibbs free energy, Helmholtz free energy, enthalpy, kinetic theory, phase transformations, chemical reactions.

Prerequisite: PH2652.

PH3855 - Nuclear Physics (4 - 0)

This is the first in a sequence of graduate specialization courses on nuclear weapons and their effects. This course deals with the underlying principles of nuclear physics, including nuclear forces, models, stability, reactions and decay processes, and interaction of high energy particles with matter.

Prerequisite: PH3152 and PH2652 or equivalents.

PH3858 - Railgun Technology (2 - 0)

This course provides a basic introduction to the fundamentals of railgun theory, design, and practice. Requirements for both the Army and Navy applications are discussed. Acceleration of projectiles, pulsed power sources for the railgun, barrel life, mechanical stress, projectile design, and thermal considerations will be discussed.

Prerequisite: PH1121, PH1322.

PH3991 - Theoretical Physics (4 - 1)

Discussion of heat flow, electromagnetic waves, elastic waves, and quantum-mechanical waves; applications of orthogonal functions to electromagnetic multipoles, angular momentum in quantum mechanics, and to normal modes on acoustic and electromagnetic systems. Applications of complex analysis to Green Function in quantum mechanics and electromagnetism. Application of Fourier series and transforms to resonant systems. Applications of partial differential equation techniques to equation of physics.

Prerequisite: Basic physics, multivariable calculus, vector analysis, Fourier series, complex numbers, and ordinary differential equations.

PH3992 - Special Topics in Intermediate Physics (V - 0)

(Variable hours 1-0 to 4-0.) Study in one of the fields of intermediate physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading in different topics. The course may also be taken on a Pass/Fail basis, provided the student has requested so at the time of enrollment.

Prerequisite: A 2000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH3993 - Special Topics in Intermediate Physics (V - 0)

Study in one of the fields of intermediate physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading in different topics. The course may also be taken on a Pass/Fail basis, provided the student has requested so at the time of enrollment.

Prerequisite: A 2000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH3994 - Special Topics in Intermediate Physics (V - 0)

Study in one of the fields of intermediate physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading in different topics. The course may also be taken on a Pass/Fail basis, provided the student has requested so at the time of enrollment.

Prerequisite: A 2000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH3995 - Special Topics in Intermediate Physics (V - 0)

Study in one of the fields of intermediate physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading in different topics. The course may also be taken on a Pass/Fail basis, provided the student has requested so at the time of enrollment.

Prerequisite: A 2000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH3996 - Special Topics in Intermediate Physics (V - 0)

Study in one of the fields of intermediate physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading in different topics. The course may also be taken on a Pass/Fail basis, provided the student has requested so at the time of enrollment.

Prerequisite: A 2000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH3997 - Special Topics in Intermediate Physics (V - 0)

Study in one of the fields of intermediate physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading in different topics. The course may also be taken on a Pass/Fail basis, provided the student has requested so at the time of enrollment.

Prerequisite: A 2000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH3998 - Special Topics in Intermediate Physics (V - 0)

Study in one of the fields of intermediate physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading in different topics. The course may also be taken on a Pass/Fail basis, provided the student has requested so at the time of enrollment.

Prerequisite: A 2000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH4001 - Physics Thesis Presentation (1 - 0)

This course provides students with the opportunity to develop the ability to deliver a briefing on a technical subject by presenting their thesis to other students and faculty. This course is required of all students working for a degree from the Physics Department and of all Combat Systems students not presenting their thesis in some other department. Graded on Pass/Fail.

Prerequisite: At least two quarters of thesis research.

PH4153 - Advanced Classical Mechanics I (4 - 1)

The first course in a two-course sequence covering classical mechanics at the advanced graduate level. Newtonian mechanics of single-particle and two-body central force systems, including orbital motion and scattering . Constraints, Lagrangian dynamics and generalized coordinates. Euler's formulation of rigid body mechanics. Small oscillations and systems of coupled oscillators.

Prerequisite: PH3152, PH3991.

PH4154 - Advanced Classical Mechanics II (4 - 1)

The second course in a two-course sequence covering classical mechanics at the advanced graduate level.

Kinematics and dynamics of relativistic systems from the Lagrangian perspective. Hamilton's equations of motion and conservation laws. Poisson brackets and commutation. Hamilton-Jacobi formulation of mechanics and action-angle variables. Introduction to nonlinear dynamics and chaotic systems. Introduction to classical perturbation theory.

Prerequisite: PH4153.

PH4171 - Physics of Explosives (4 - 0)

The goals of the course are to provide in-depth and advanced understanding of explosives from theoretical and practical standpoints, to formulate the bases for evaluating competitive and alternative explosive systems, and to provide criteria for crisis management. This course covers advanced topics in explosive physics and chemistry: Molecular energetics of the explosive molecule including molecular orbital and valence bonding and resonance stabilization concepts and practical implications of sensitivity and energy potential, oxygen balance and thermodynamic, reaction rate theory, hot-spot theory, shock physics and detonation theory. Special topics in explosive technology and application as applied to metal driving, mine detection and neutralization, chemical and biological dissemination, and computational modeling are offered per student's interests.

Prerequisite: SE3172 and PH2652.

PH4271 - Laser Physics (4 - 1)

Review of atomic and molecular energy levels, time-dependent perturbation theory, radiative transitions, transition rates. Einstein A and B coefficients for spontaneous and stimulated radiative transitions, blackbody radiation. Optical attenuation and amplification, rate equations. Basic laser theory, gain saturation, homogeneous and inhomogeneous effects. Optical resonators, laser modes, coherence. Q-switching, mode locking, pulse compression, laser pumping, and tuning mechanisms. Gaussian beams. Introduction to multiple-mode and single mode optical fibers.

Prerequisite: PH3292, PH3352, PH2652.

PH4272 - Photonics & Electro-Optics (4 - 1)

This course provides an introduction to fundamental aspects of photonics and electro-optics with an emphasis on devices used in the DoD. General aspects of photodetectors, thermal detectors, light intensifiers, night vision devices, focal plane arrays (CCD, CMOS), fiber optics, electro- and acousto-optical devices are discussed. Light emitting diodes (LED), liquid crystal displays (LCD) are also addressed. The physics behind the devices are explained through the development of mathematical models to support an understanding of the specifications, figures-of-merit, noise sources, limitations, and how they fit into the applications.

Prerequisite: PH3292 and PH3655, or permission of instructor..

PH4274 - Physics of Combat Systems Radar (4 - 1)

This interdisciplinary course explores the physics of radar and EW systems, highlighting the development of new capabilities (e.g., adaptive radar signal processing, ultra-wideband radar, coherent change detection, and jamming techniques). The characteristics and components of various practical radar systems are considered including transmitter, receiver, and arrays, as well as the limitations imposed by the operating environment. Scattering concepts are introduced and propagation phenomena are considered (such as target cross-section, polarization effects, and atmospheric absorption), as well as signal processing techniques to mitigate these effects and perform detection in complex environments. Several lectures will connect the course content with current defense technology, trends, efforts, and limitations in radar systems.

Prerequisite: Some background in electromagnetism and calculus is assumed..

PH4280 - Micro Electro Mechanical Systems (MEMS) Design II (2 - 4)

Same as ME4780 and EC4280. This is the second course in Micro Electro Mechanical Systems (MEMS) Design. This course will expose students to advanced topics on material considerations for MEMS, microfabrication techniques, forces in the micro- and nano-domains, and circuits and systems issues. Case studies of MEMS-based microsensors, microactuators, and microfluidic devices will be discussed. The laboratory work includes computer aided design (CAD) and characterization of existing MEMS devices. The grades will be based on exams, lab projects, and a group design project.

Prerequisite: EC/PH3280 or ME3780 or consent of instructor.

PH4353 - Topics in Advanced Electricity and Magnetism (4 - 0)

Topics selected from: Electromagnetic radiation, including radiation from antennas and accelerating particles, and radiation scattering from charged particles. Additional topics may include Cerenkov radiation, free electron lasers, and the relativistic formulation of electrodynamics.

Prerequisite: PH3152, PH3352, PH3991.

PH4409 - Engineering Acoustics Capstone Project. (2 - 4)

(Same as EO4409) The capstone project provides DL students with an opportunity to apply the principles and techniques covered in the coursework to a current problem of interest. Students will formulate a novel research question, conduct a literature review, analyze the problem using theory, experiment, and/or simulations, draw conclusions, and effectively communicate the results. This course satisfies the capstone requirement for students pursuing the non-thesis degree option. Students pursuing the thesis degree option are encouraged to use their work in this course towards their thesis.

Prerequisite: PH4454, PH4455, and EC4450 or equivalents.

PH4454 - Sonar Transducer Theory and Design (4 - 2)

A treatment of the fundamental phenomena basic to the design of sonar transducers, specific examples of their application and design exercises. Topics include piezoelectric, magnetostrictive and hydromechanical effects. Laboratory includes experiments on measurement techniques, properties of transducer materials, characteristics of typical navy transducers, and a design project. A field trip to visit one or more transducer manufacturers is normally scheduled during the course.

Prerequisite: PH3452 (may be taken concurrently).

PH4455 - Sound Propagation in the Ocean (4 - 0)

An advanced treatment of the subject. Topics include: reflection of spherical waves from ocean boundaries; normal mode propagation of sound; inhomogeneous wave equation and the point source in cylindrical coordinates; shallow water channel with fluid and solid bottoms; the deep sound channel and the WKB approximation; range-dependent channels; adiabatic normal modes and the parabolic equation; multi-path propagation; application to matched field processing and source localization.

Prerequisite: PH3452 or consent of instructor.

PH4656 - Quantum Mechanics (4 - 1)

Free particles and wave packets, the uncertainty principle, Schrodinger equation, eigen states and eigen functions, stationary and scattering states, identical particles and the exclusion principle, atomic energy levels, quantum theory of angular momentum, hydrogen atom, coupling of angular momentum with spin, the periodic table, nuclear structure and radioactivity; fission and fusion, time independent perturbation theory, time dependent perturbation theory; selection rules for dipole radiation, magnetic effects (MRI, GMR etc.), quantum computing.

Prerequisite: PH2652, PH3152, PH3991.

PH4670 - Quantum Computing (4 - 0)

Same as CS4670. This interdisciplinary survey course explores the evolution and direction of quantum computing technology. Topics include quantum circuits, quantum algorithms (including factoring and search), and quantum key distribution.

Prerequisite: Familiarity with basic notions of computing, quantum theory, and linear algebra, consistent with the material covered in any of CS3000, PH2652, MA3042 or PH3991..

PH4771 - Advanced Statistical Physics (4 - 0)

Review of thermodynamics. Phase transitions and critical exponents. Ginzburg-Landau theory. Stochastic dynamics and Brownian motion: master equation, Langevin equation, and Fokker-Planck equation. Phase space

motion, Liouville theorem. BBGKY hierarchy. Boltzmann equation, H theorem, and entropy. Kinetic theory. Review of equilibrium statistical mechanics and ensemble theory. Information theory. Bose-Einstein condensation, photon gas. Degenerate Fermions: heavily doped semiconductors, degeneracy pressure. Paramagnetism, Curie theory. Ising model of magnetism. Glauber model of time-dependent Ising spins. Widom, Kadanoff scaling theories. Renormalization theory. Onsager relations, linear response theory, fluctuation-dissipation theorem.

Prerequisite: PH3782.

PH4857 - Terminal Ballistics and Shock Physics (4 - 2)

This course explores the key physics underlying the lethality of conventional weapons. Particular focus is given to two broad areas: armor penetration and damage from shock and blast waves. Detailed topics covered in the course include: an overview of modern warheads; basic mechanics of materials; high strain-rate deformation of materials under intense loading; terminal ballistics of projectiles, ranging from small-caliber rounds up to shaped charge jets; shock waves in solids and spall phenomena; blast waves from explosive charges and nuclear weapons; and underwater weapons effects.

PH4858 - Directed Energy Weapons (4 - 1)

This course teaches the physics and engineering concepts underlying directed energy (DE) weapons. Topics include an introduction to laser physics, history of DE, advantages/disadvantages of DE, types of DE technologies, output power requirements for different missions, current Navy and DoD programs, target damage mechanisms, beam propagation through the atmosphere, thermal blooming, power and cooling considerations, and beam control. Where appropriate, both high energy lasers and high power microwave technologies will be discussed. The course will include modeling of the propagation of a high energy laser beam through the atmosphere and of damage effects.

Prerequisite: PC2911 or familiarity with MATLAB. PH3352 or permission of the instructor..

PH4859 - Technical Aspects of Weapon Proliferation, Control and Disposal (3 - 0)

This course address technical issues of detection of nuclear weapon materials, covert explosions, disposition of weapon grade material and nuclear reactor fuel, control and disposition of chemical and biological weapons, policy issues of arms proliferation and arms control.

Prerequisite: Consent of instructor.

PH4860 - Nuclear Warfare Analysis (4-0) (4 - 0)

This final course in the nuclear weapons effects graduate specialization sequence deals with technical aspects of strategic and tactical nuclear war. Effects which nuclear weapons explosion environments have on various defense platforms and systems are considered, together with methods of hardening to reduce system vulnerability in each of the effected areas: blast and shock, thermal radiation, transient effects on electronics. EMP, biological effects from contamination, atmospheric and ionospheric effects on communication, detection and surveillance systems.

Prerequisite: PH4171. Security Clearance Required: Secret.

PH4911 - Simulation of Physical and Weapon Systems (3 - 2)

The role of computation physics in modern weapons development and combat simulations is studied. The programming language is C within the UNIX, Apple, or Windows operating systems. Applications emphasize physical principles of weapons development, systems engineering, and the use of graphics. Subject matter includes random number distributions, projectile and fragment dispersion, missile defense, free electron laser simulation, laser beam propagation in a turbulent atmosphere, thermal blooming, diffraction and numerical integration methods. Optional topics include molecular dynamics in solids, liquids, and gases, wave propagation in various media, chaos, and quantum mechanical wave functions.

Prerequisite: PH3996.

PH4984 - Advanced Quantum Physics (4 - 0)

Quantum mechanics in the Dirac format. Angular momentum, spin, and spin resonance. Additional topics may include group theoretical applications to selection rules and crystal fields, variational principles, self-consistent fields in the many-electron atom, scattering theory, and polyatomic molecules.

Prerequisite: PH3152 and PH4656.

PH4990 - Advanced Theoretical Physics (4 - 0)

A graduate-level introduction to the methods of theoretical physics. Beginning with complex variable methods as a tool for solving problems in physics, the Kramers-Kronig formulas are derived (connection between analyticity and causality in stable physical systems), together with the Hilbert transform and its role in defining the analytic signal and the extension of phasors to time-varying systems. The stationary phase approximation is derived as a method of treating the high-frequency behavior of oscillatory integrals, important for wave transmission and scattering.The method of Green functions for solving inhomogeneous differential equations is developed, with applications of Green functions as propagators affecting the response of physical systems to the influence of sources. An introduction to integral equations provides the foundation for scattering problems in physics, both electromagnetic and quantum. The essentials of tensor calculus aredeveloped, the language of the general theory of relativity (necessary for understanding the Global Positioning System and other physical systems) and of

physical processes in anisotropic media.

Prerequisite: PH3991 or equivalent coverage of partial differential equations, special functions, and Fourier analysis..

PH4991 - Relativity and Cosmology (4 - 0)

This course is a graduate level introduction to the current thought on the origin of space, time and matter. Topics covered are: the discovery of the cosmic evolution, description of space in Newtonian and Einsteinian terminology, kinematics and dynamics of the Einstein cosmological models, the thermal history of the universe, the very early universe, the problems of a possible quantum origin of the universe and the possible future of the universe.

Prerequisite: PH2652, PH3152, PH3352, PH3991.

PH4992 - Special Topics in Advanced Physics (V - 0)

(Variable hours 1-0 to 4-0.) Study in one of the fields of advanced physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading. The course carries a letter grade and may be repeated in different topics. It may also be taken on a Pass/Fail basis if the student has requested so at the time of enrollment.

Prerequisite: A 3000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH4993 - Special Topics in Advanced Physics (V - 0)

Study in one of the fields of advanced physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading. The course carries a letter grade and may be repeated in different topics. It may also be taken on a Pass/Fail basis if the student has requested so at the time of enrollment.

Prerequisite: A 3000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH4994 - Special Topics in Advanced Physics (V - 0)

Study in one of the fields of advanced physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading. The course carries a letter grade and may be repeated in different topics. It may also be taken on a Pass/Fail basis if the student has requested so at the time of enrollment.

Prerequisite: A 3000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH4995 - Special Topics in Advanced Physics (V - 0)

Study in one of the fields of advanced physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading. The course carries a letter grade and

may be repeated in different topics. It may also be taken on a Pass/Fail basis if the student has requested so at the time of enrollment.

Prerequisite: A 3000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH4996 - Special Topics in Advanced Physics (V - 0)

(Variable hours 1-0 to 4-0.) Study in one of the fields of advanced physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading. The course carries a letter grade and may be repeated in different topics. It may also be taken on a Pass/Fail basis if the student has requested so at the time of enrollment.

Prerequisite: A 3000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH4997 - Special Topics in Advanced Physics (V - 0)

Study in one of the fields of advanced physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading. The course carries a letter grade and may be repeated in different topics. It may also be taken on a Pass/Fail basis if the student has requested so at the time of enrollment.

Prerequisite: A 3000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH4998 - Special Topics in Advanced Physics (V - 0)

Study in one of the fields of advanced physics and related applied areas selected to meet special needs or interests of students. The course may be conducted as a seminar or supervised reading. The course carries a letter grade and may be repeated in different topics. It may also be taken on a Pass/Fail basis if the student has requested so at the time of enrollment.

Prerequisite: A 3000 level course appropriate to the subject to be studied, and consent of the Department Chairman.

PH5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

PH5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council.

Prerequisite: Advancement to Candidacy.

SE

SE0811 - Thesis in Systems Engineering (0 - 8)

Thesis course for students pursuing a systems engineering degree. Students are awarded grade of 'T' upon successful completion of their theses.

SE1001 - Mathematics For SE I (4 - 2)

This course provides an introduction to selected pre- and post-calculus topics. Covered will be complex numbers, matrix algebra, and differential equations.

Prerequisite: Enrollment in the SE or SEA curriculum..

SE1002 - Mathematics For SE II (3 - 1)

This course provides an introduction to selected pre- and post-calculus topics. Covered will be complex numbers, matrix algebra, and differential equations.

Prerequisite: SE1001.

SE2003 - Introduction to Mechanical Systems (4 - 2)

The course provides a basic understanding of the physical properties underlying combat systems. It presents calculus based physics covering a broad range of topics in mechanics, heat, and sound. Relevance to military development is discussed. Practical tools are developed to describe motion, Newton's force laws, friction and drag, energy and momentum, rotation, gravitation and orbits, fluids, oscillations, chaos, waves, gases, and thermodynamics.

Prerequisite: SE1001, SE1002.

SE2101 - Introduction to Electromagnetic Systems (4 - 2)

This course provides a basic understanding of the electromagnetic principles underlying combat systems. Relevance to military development is discussed. Practical tools are developed describing electric and magnetic fields, electromagnetic waves, special relativity, atomic energy levels, atomic binding, Schrödinger equation, energy bands in solids, nuclear particles, and radioactive decay.

Prerequisite: SE1001, SE2003.

SE2440 - Introduction to Scientific Programming (3 - 2)

This course offers an introduction to computer system operations and program development using NPS computer facilities. The main goal of the course is to provide an overview of different structured programming techniques, along with introduction to MATLAB/Simulink/GUIDE and to use modeling as a tool for scientific and engineering applications. The course discusses the accuracy of digital computations, ways to incorporate symbolic computations, and presents numerical methods in MATLAB functions. AE2440, EC2440, and SE2440 are the same course. Prerequisites: None.

SE3000 - Systems Engineering Colloquium (1 - 0)

This weekly colloquium has two objectives for students to develop and maintain a knowledge of contemporary issues in systems engineering. The first is to provide a forum for guest speakers from industry, government and academia to discuss the practical application of Systems Engineering, and the second is to provide a forum for the student project teams to present their In Process Reviews (IPR's) and meet with across campus project participants. Prerequisites: None.

SE3011 - Engineering Economics and Cost Estimation (3 - 0)

An introduction to the cost aspects of systems engineering, exploring cost from a decision-making perspective. Examines how cost is used to select alternatives and how the cost of systems can be measured. Concepts covered include economic analysis, cost behavior, cost allocation, system cost, life cycle costs, cost over time, cost estimating techniques, cost uncertainty, and cost risk.

Prerequisite: OS3180 or OS3111.

SE3030 - Quantitative Methods in Systems Engineering (3 - 2)

This course discusses advanced mathematical and computational techniques that find common application in systems engineering. It also provides an introduction to MATLAB, a computational tool useful in obtaining quantitative answers to engineering problems. Among the topics addressed in this course are vector analysis, complex analysis, integral transforms, special functions, numerical solution of differential equations, and numerical analysis.

Prerequisite: SE1002, SE3100.

SE3050 - Introduction to Digital Engineering with Model-Based Systems Engineering (3 - 2)

An introduction to the fundamentals of a digital engineering using a model-based systems engineering approach. The focus is on developing skills expected of all engineers working in a digital engineering environment. At the core of digital approaches to model-based systems engineering is problem-solving in a disciplined and rational manner using modeling languages applied to modeling methods. You will develop abilities to model, design, communicate, and collaborate as engineers applying modeling languages, modeling methods, and ontologies to develop digital artifacts using critical thinking, teamwork, collaboration, communication, and systems thinking. The course includes the application of model-based systems engineering tools and methods to an integrative lab project, as well as development of communication skills through oral presentations and written reports.

Prerequisite: None..

SE3077 - Methods in Engineering Research (3 - 0)

This course teaches the student how to develop a research approach to investigate an issue or problem. Instruction offers an overview of research methodology, basic concepts employed in quantitative, qualitative, and combined or mixed methods, as well as computer applications for research. Experimentation, survey, and case study are some of the basic research designs that the course introduces. Subject matter experts in different research designs will provide lectures during the course. The course establishes engineering reasoning as a framework for developing a research approach. Center to this framework is retroductive thinking, which iteratively applies deductive, inductive, and abductive logic at different phases of the engineering design process. Selection of an appropriate method of inquiry is guided by the logic employed, the design phase, and the design element of interest. At the end of the course, the student will develop and document a viable research plan for an engineering problem.

Prerequisite: None.

SE3100 - Fundamentals of Systems Engineering (3 - 2)

Introduction to systems thinking and the processes and methods of systems engineering. The course covers fundamentals of systems engineering and system architecting, requirements analysis, functional analysis and allocation, preliminary system architecture, systems analysis, system design, and the basics of test and evaluation. Various perspectives, from frameworks, processes, and standards, such as the DoD Architecture Framework (DODAF), DoD Joint Capabilities Integration and Development System (JCIDS), EIA 632, ISO 15288, IEEE 1220, IEEE 1471, and the International Council on Systems Engineering (INCOSE) models, are presented. Student analyze case studies. Students also use spreadsheet software for modeling and analyzing requirements and conceptual design alternatives. The course includes the application of fundamental systems engineering processes and methods to an integrative project, as well as development of communication skills through oral presentations and written reports. Prerequisites: None.

SE3110 - Applied Fundamentals of Combat Systems (3 - 0)

This course will survey the mission or combat systems commonly found on military platforms and explore how these systems are incorporated into the platform architecture, systems, and operations. Mission systems covered include communication, navigation, identification, detection/tracking, electronic warfare and support measures, acoustic detection/tracking, electro-optic and infrared detection, and weapons. The emphasis is on understanding the fundamental functionality and performance of the mission systems and understanding the complexities of how these systems integrate into a total system that provides a combat capability. This course is intended for cohorts who do NOT otherwise have combat systems coursework in their matrix. Coursework, content, and examples will be specifically tailored to the background of the cohort. Prerequisites: None.

SE3112 - Combat Systems Engineering I- Intro to Sensors (4 - 2)

This is the first course of a survey of military sensor technology. It introduces the student to the nature of physical observables and propagators, the effects of the propagation medium on sensor performance, the relationship between signals and noise, and the characteristics of critical sensor functions (including detection, estimation, imaging, and tracking). It is designed to provide a framework for more detailed analysis of specific sensor systems in the follow-on course SE4112.

Prerequisite: SE1002.

SE3113 - Combat Systems Engineering II- Conventional Weapons (4 - 2)

This is a survey of conventional military weapons technology. It introduces the student to both the effects that conventional weapons (artillery, bombs, and missiles) can produce as well as the technologies needed by weapons systems to create those effects. It is designed to provide familiarization of the student with critical weapons concepts that are necessary for enlightened examination of both technology development and military planning.

Prerequisite: SE1002.

SE3116 - Laser and Optical Systems (3 - 2)

This course discusses the fundamentals of lasers and laser optics as systems with an emphasis on design and practical applications. General topics include lasers, laser types, laser components, beam propagation, laser optics, optical materials and instruments, beam scanning, radiometry, detectors and how these concepts are combined to design laser systems with characteristics required for various applications. Laser system topics include a rate equation description of laser action facilitating modeling and performance estimation, wavelength selection options (energy levels and transitions), how prime power is converted into useful laser output (pump mechanisms), laser beam quality and its control (resonators, modes, and mode control), propagation of laser radiation, generation of specific time-dependent outputs (Q-switching, mode-locking, and modulation), frequency conversion and other nonlinear effects. Optical system topics include characteristics and fabrication techniques for optical components, image formation and image quality metrics, aberrations and their correction, devices utilizing polarization, interferometers and spectrometers, control of stray light & unwanted reflections, optical mounting

techniques, gimbaled optical systems, line of sight stabilization, and optical measurement and testing systems.

Prerequisite: None. Knowledge of systems engineering fundamentals is recommended..

SE3117 - Laser Systems Engineering (3 - 2)

This course describes the engineering design and development of laser systems for practical applications. Fundamental systems engineering concepts of conceptualization, design, fabrication, integration, test, and operational use and support are applied to laser systems. This course addresses the components of laser systems, fundamentals of laser operation, the characteristics of different types of lasers, and how these concepts are combined to design laser systems. Emphasis is on the design and engineering of laser systems for specific applications and on factors that influence practical laser operation, rather than on the fundamental physical principles of lasers. The course applies needs analysis, requirements analysis, definition of technical performance metrics, feasibility and trade studies, alternatives analysis, and systems design to laser and optical systems. The course covers laser integration, test, and operational challenges, such as cooling and power needs, atmospheric effects, calibration and optical system testing, and specialized handling and maintenance.

SE3121 - C4ISR Systems (3 - 2)

This course studies command and control (C2) information processing and decision making in the context of adaptive combat organizations and the C4ISR System Infrastructure that support it. Topics include: C2 decision processes [Observe-Orient-Decide-Act Loops, Problem Sensemaking (Identification) – Solution Finding and Implementation Processing], operational architectures, intelligence preparation of the Battlespace (IPB); mission success and organizational fitness.

Prerequisite: SE3112 or SE3122, and SE3113 or SE3123.

SE3122 - Naval Weapon Systems Technology I (3 - 0)

This is the first of two courses that introduce the student to the technologies of combat systems. It starts with a brief survey of military sensor technology. It then introduces the student to effects of the propagation medium on sensor performance, the relationship between signals and noise, and the concepts of signature and signature control. The various sensor technologies involved in military applications of all kinds are presented as well as the essentials of C4ISR and the C4ISr Framework.

SE3123 - Naval Weapon Systems Technology II (3 - 0)

The second of a two course sequence, this course introduces the student to both the effects that weapons can produce as well as the technologies needed by weapons systems to create those effects, including the control elements. It is designed to provide an early initial familiarization of the student with critical weapons concepts. Analytic techniques are presented that allow the student to evaluate the interrelationships between the combat systems.

Prerequisite: SE3122.

SE3201 - Engineering Systems Conceptualization (2 - 4)

Engineering of systems in the Enterprise, Societal and Environmental Context presents a view of how system development moves through four metaphases, Conceiving, Designing, Implementing, and Operating. The chosen terms are descriptive of activities that address hardware, software, and human integration, for product and process industries. Conceptualization begins with consideration of stakeholder capability, market, or opportunity need though early stage or conceptual design, and includes systems thinking and project management. This course on system conceptualization is the first in a series of three consecutive project courses that augments the core education for all resident students enrolled in the NPS Department of Systems Engineering's Master of Science in Systems Engineering curriculum. It is intended to provide authentic, hands-on engineering experience within which to apply learning from the core sequence of systems engineering courses. Specifically, this course provides the opportunity to use the language, terminology, concepts, methods, and tools to develop the competency to be a systems engineer.

Prerequisite: SE3100. Corequisite: SI3400.

SE3202 - Engineering Systems Design (2 - 4)

Engineering of systems in the Enterprise, Societal and Environmental Context presents a view of how system development moves through four metaphases, Conceiving, Designing, Implementing, and Operating. The chosen terms are descriptive of activities that address hardware, software, and human integration, for defense-related products and processes. Designing includes the design process, including phases and approaches, utilization of knowledge, designing for "X" (sustainability, reliability, manufacturability, etc), disciplinary, and multidisciplinary design. This course on system design is the second in a series of three consecutive project courses that augments the core education for all resident students enrolled in the NPS Department of Systems Engineering's Master of Science in Systems Engineering curriculum. It is intended to provide an authentic engineering experience within which to apply learning from the core sequence of systems engineering courses. Specifically, this course provides you the language, terminology, concepts, methods, and tools to develop the competency to be a systems engineer.

Prerequisite: SE3100, SE3201, SI3400. Corequisite: SE3302.

SE3203 - Engineering Systems Implementation & Operation (2 - 4)

Engineering of systems in the Enterprise, Societal and Environmental Context presents a view of how system development moves through four metaphases, Conceiving, Designing, Implementing, and Operating. The chosen terms are descriptive of activities that address hardware, software, and human integration, for generally for defense-related products and processes. Implementing includes hardware, software, and human systems considerations, test and evaluation, as well as design and management of the implementation process. Operating covers a wide range of issues from designing and managing operations, sustainability through logistics and supporting product lifecycle considerations and improvements, all the way through end-of-life planning. This course on system implementation and operation is the last in a series of three consecutive project courses that augments the core education for all resident students enrolled in the NPS Department of Systems Engineering's Master of Science in Systems Engineering curriculum. It is intended to provide an authentic engineering experience within which to apply learning from the core sequence of systems engineering courses. Specifically, this course provides you the language, terminology, concepts, methods, and tools to develop the competency to be a systems engineer.

Prerequisite: SE3202, SE3302.

SE3211 - Systems Engineering Management Capstone I (2 - 4)

This is the first in a sequence of two consecutive project courses culminating the education of students enrolled in a Master of Science in Systems Engineering Management curriculum. It is intended to provide an authentic engineering experience within which to apply learning and demonstrate mastery of tools acquired from the core curriculum of systems engineering management courses. Capstone projects are oriented upon real-world problems with topics provided by sponsor agencies, selected by faculty and assigned to student teams. Once initial capstone project proposals are formulated, teams are formed to critically analyze the selected problems and use systems engineering methodologies to develop conclusions and recommendations. The course sequence spans two academic quarters, allows students to execute their study under the supervision of faculty experts, and must yield a final capstone report and oral presentation/review.

SE3212 - Systems Engineering Management Capstone II (2 - 4)

This is the second in a sequence of two consecutive project courses culminating the education of students enrolled in a Master of Science in Systems Engineering Management curriculum. It is intended to provide an authentic engineering experience within which to apply learning and demonstrate mastery of tools acquired from the core curriculum of systems engineering management courses. Capstone projects are oriented upon real-world problems with topics provided by sponsor agencies, selected by faculty and assigned to student teams. Once initial capstone project proposals are formulated, teams are formed to critically analyze the selected problems and use systems engineering methodologies to develop conclusions and recommendations. The course sequence spans two academic quarters, allows students to execute their study under the supervision of faculty experts, and must yield a final capstone report and oral presentation/review. Prerequisite: SE3211.

Prerequisite: SE3211 Systems Engineering Management Capstone I (2-4) This is the first in a sequence of two consecutive project courses culminating the education of students enrolled in a Master of Science in Systems Engineering Management curriculum. It is intended to provide an authentic engineering experience within which to apply learning and demonstrate mastery of tools acquired from the core curriculum of systems engineering management courses. Capstone projects are oriented upon real-world problems with topics provided by sponsor agencies, selected by faculty and assigned to student teams. Once initial capstone project proposals are formulated, teams are formed to critically analyze the selected problems and use systems engineering methodologies to develop conclusions and recommendations. The course sequence spans two academic quarters, allows students to execute their study under the supervision of faculty experts, and must yield a final capstone report and oral presentation/review..

SE3250 - Capability Engineering (3 - 2)

This course presents a systems engineering approach to determining military capabilities required to execute a mission set. It introduces simulation as a method for assessing performance of a capabilities portfolio. Topics covered include current DOD and Naval practices for capabilities engineering, design and assessment of capability portfolios, and use of custom simulations to analyze capability portfolio performance.

Prerequisite: OS3180 or equivalent, and SE3100.

SE3302 - System Suitability (3 - 2)

This course presents the techniques of system design and assessment for operational feasibility, including reliability, maintainability, usability (including human factors and human performance), supportability, and producibility. Design methods for open architecture of hardware and software are presented. Software integration and management from a systems perspective is presented.

Prerequisite: SE3100, and OS3180 or OS3111..

SE3303 - System Assessment (3 - 2)

Systems under development must be assessed for cost and effectiveness, and both cost and effectiveness must

be managed during systems trades. This course presents a systems engineering perspective for framing such trade decisions. Topics include cost estimation, effectiveness estimation through the test and evaluation process and modeling, techniques for engineering trades, and managing the risk involved. The course applies these fundamental systems assessment processes and methods to an integrative system project, building on work done in SE3100. Development of communication skills is accomplished through oral presentations and written reports.

Prerequisite: SE3302.

SE3321 - Reliability Management and Data Systems (3 - 2)

The course focuses on the practical aspects of reliability analysis and management. Reliability aspects and functions are explained and illustrated using examples and calculus-level mathematics. Topics include: basic tools and methods of reliability for developing complex systems including electronic components, mechanical components, and software; data needs for effective reliability analysis and how to design and implement systems to acquire and store that data; and the principles and practices for developing cost-effective dependable (reliability and availability) systems. Case studies are used to illustrate the material. Prerequisites: None.

Prerequisite: SE1001 and SE1002 or equivalent..

SE3322 - Reliability Centered Maintenance (3 - 2)

The course covers the fundamentals of reliability centered maintenance and current practices following both military and industry standards. It also presents modifications that have been implemented for different applications and explains their suitability. An important aspect of the course is to examine and quantify the role of maintenance on operations, safety, and its economic benefits. Software tools for implementation are presented. The course includes a class project to develop and implement a pilot application of RCM to an identified site need.

Prerequisite: SE3321.

SE3411 - System of Systems Program Definition and Concept Development (3 - 2)

Managing the integration of Large System of Systems (SoS) through a Lead Systems Integrator brings together all developers through a single, central point of communication and control to direct work activities, plan for SoS integration, organize for effective scheduling, and build the team's commitment to successful integration and interoperability. SoS integration often poses confounding problems due to the myriad of interactions between systems and the overall meta-system. This course discusses the special problems of managing the integration of system of systems. Topics include the characteristics of the large scale SoS, program management of SoS integration, uses of SoS design and architecture for decision analysis, feasibility analysis and

approaches for SoS integration, SoS contract management, and execution for SoS acquisitions. Prerequisite: A strong background in systems engineering or approval by instructor. Prerequisites: None.

SE3412 - System of Systems Design and Development (3 - 2)

This course discusses the special problems of managing and engineering system of systems from the LSI perspective. Topics include characteristics of SoS in the LSI management environment, engineering implications of SoS issues, management and engineering methodology of SoS, SoS architecture, analysis of SoS, and tools for engineering and monitoring SoS. Managing the integration of SoS through an LSI requires attention to the meta-systems implications of changes at the systems level. This course discusses the special problems of managing the integration of system of systems from the LSI perspective. Topics from the LSI perspective include the characteristics of the large scale SoS, program management of SoS integration, uses of SoS design and architecture for decision analysis, feasibility analysis and approaches for SoS integration, SoS contract management, and execution for SoS acquisitions.

Prerequisite: SE3411.

SE3413 - System of Systems Integration, Qualification and Lifecycle (3 - 2)

This course discusses these special problems of managing and engineering system of systems from the LSI perspective. Topics include complexity theory in program management (PM), integrated risk management, SoS program assessment strategy, SoS governance, SoS integration design & considerations, SoS performance analysis, SoS leading indicators and reference model strategy.

Prerequisite: SE3411, SE3412.

SE3810 - Systems Engineering Seminar (0 - 2)

This weekly seminar on topics in Systems Engineering is intended to broaden and extend knowledge horizons beyond material covered in regular classes, to provide opportunities for critical discussion of systems engineering topics, to relate course work to the real world and emphasize the implications of engineering choices on a society as a whole, and to promote good lifelong learning habits. The course will provide operational, historical, cultural, and economic contexts for the material studied in the SE curriculum. It will also promote the recognition of, critical analysis of, and planning for development and exploitation of future military capabilities. Students will be required to read, analyze, and discuss in class at least four books per quarter selected by the faculty to address an overall theme that will vary from quarter to quarter. Graded on a Pass/Fail basis only. Prerequisites: None.

SE3811 - Critical Thinking in Systems Engineering (2 - 0)

Students are introduced to the elements, standards and intellectual traits of critical thought for engineering reasoning. They apply these concepts to preparing and evaluating oral presentations, taking notes, completing written assignments and understanding their learning styles inventory. This course is graded pass/fail. Prerequisites: None.

SE3812 - Ethics in Systems Engineering (2 - 0)

Students will examine and debate ethical issues in engineering. The course uses a case study pedagogy with class discussion, team presentations, a written discussion forum and oral presentations to evaluate ethical dilemmas encountered working in large, small or solo private engineering enterprises and work in large governmental engineering endeavors. Also considered is work involved with academic integrity in engineering research. Ethics is relevant to weapon system acquisition, test and evaluation, and other systems engineering activities. This course is graded pass/fail.

Prerequisite: SE3811.

SE3900 - Topics in Systems Engineering Analysis (V - 0)

(Variable hours 2-0 to 5-0.) Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes.

SE3910 - System Evolution and Technology Assessment (4 - 0)

This course discusses technological change, its impact on systems, and ways to predict the impact of future technology developments on system development. General topics include understanding the rate of technological change, how innovations are developed and adopted, methodologies for assessing technology growth and evolution (forecasting), limits on technological growth, and examples of technology assessment. This course uses a seminar approach with out-of-classroom reading and in-class discussions of the reading replacing traditional lectures.

Prerequisite: None.

SE4003 - Systems Software Engineering (3 - 2)

The course is designed to teach students the basic concepts of software engineering and methods for requirements definition, design and testing of software. Specific topics include introduction to the software life cycle, basic concepts and principles of software engineering, object-oriented methods for requirements analysis, software design and development. Special emphasis is placed on the integration of software with other components of a larger system.

Prerequisite: SE3100 or SI4021..

SE4011 - Systems Engineering for Acquisition Managers (3 - 2)

Systems engineers flow requirements down to detailed elements, integrate elements, and verify system performance. This course concentrates on the structural and technical elements of system engineering necessary in the product development domain. Multidisciplinary activities leading to requirements analysis, design trades, and integrated product-process development are complemented by current best manufacturing practices and design for cost principles. Structured methods, decision analysis, and quality engineering foundations are emphasized. Case studies from a variety of industrial contexts are presented and discussed. This course is team taught by experts from several disciplines. Prerequisites: None.

SE4012 - Management of Advanced Systems Engineering (4 - 0)

This course provides the student with an understanding of architecting, Object Oriented Systems Engineering, the Unified Modeling Language, and the control of complex projects with many Systems Engineers through the use of metrics. Specific emphasis is placed on exploring the relationship between science, art, deductive processes, inductive processes, systems engineering, and acquisition management. In order to solve today's complex problems, the student will become familiar with heuristic tools. Prerequisites: None.

SE4030 - Modeling and Analysis of Emergent System Behaviors (3 - 2)

This course covers the construction of and reasoning about models of system behaviors, including any combination of software, hardware, humans, organizations, and surrounding environment. Students will study concepts of emergence and work with selected Monterey Phoenix models to develop cognitive skills for detecting, predicting, classifying, and controlling emergent system behaviors.   Students will then deploy their new knowledge and skills to create their own system behavior models and assess them for the presence or absence of expected and unexpected system behaviors. The concepts and skills taught in this course will help learners think critically and systematically about a system under design, probing automated output for tacit assumptions and overlooked expectations. This course makes use of example system models across a wide range of application domains and invites students to apply their own personal and professional experiences with systems.

Prerequisite: None..

SE4101 - Systems Safety Engineering (3 - 2)

This course introduces the concepts and techniques of

systems safety in relation to the design process. Foundational concepts of system safety engineering are presented. Risk is discussed as the medium for quantifying many systems' safety metrics. As a result, students will model accident scenarios to quantify the probability and consequence of the accident. Introduction to specific methods will cover the Systems-Theoretic Accident Model and Processes (STAMP), System Theoretic Process Analysis (STPA), and the hazard analyses in the system safety military standard (i.e., MIL-STD-882E)).

Prerequisite: OS3180 Probability and Statistics..

SE4112 - Combat Systems Engineering III (4 - 2)

This course applies systems engineering principles to the design of combat systems with emphasis on detection, tracking, and identification systems. Sensor technologies covered include radars, ESM, active and passive sonar, infrared, electro-optical, and magnetic/electric/gravity field sensors. The emphasis is on what the elements contribute to a combat system, their basic principles of operation, their performance limitations, trade-offs, and their interfaces with the rest of the combat system. This course builds on the material offered in SI3112 (Intro to Sensors).

Prerequisite: SE3112, SE3113.

SE4113 - Combat Systems Engineering IV-Unconventional Weapons (3 - 2)

This course extends the coverage of SE3113 (Conventional Weapons) to include unconventional weapons. Topics include: information warfare and weapons (including electronic warfare), directed energy weapons, weapons of mass destruction (nuclear, chemical, biological, and radiological), and nonlethal weapons. It introduces the student to both the effects that unconventional weapons can produce as well as the technologies needed by weapons systems to create those effects. It is designed to provide familiarization of the student with critical weapons concepts that are necessary for enlightened examination of both technology development and military planning.

Prerequisite: SE4112.

SE4115 - Combat Systems Integration (4 - 2)

This course presents systems engineering techniques for integrating combat systems into a common system, including technology development, system development and integration, network integration, and system of systems integration. Lectures and projects exploring engineering design tools and analysis methods to meet specified systems requirements are used. Topics include engineering analysis of interfaces for power, data, mechanical, and other attributes; engineering change management; advanced collaboration environments; technology readiness levels; and integration risk mitigation.

Prerequisite: SE3113 and SE4112, or SE3122 and SE3123.

SE4117 - Directed Energy Systems (3 - 2)

This course addresses systems engineering and design of laser, microwave, and particle beam directed energy weapons. Microwave and particle beam systems and technologies will be discussed, but laser weapons will receive the most emphasis. System architecture, system requirements, key component technologies, technical aspects of device implementation, platform integration, principles of operation and utilization, energy delivery constraints, target kill mechanisms, and systems analysis issues are discussed.

Prerequisite: SE3116 and SE3117 or equivalent courses in optical and laser systems engineering.

SE4150 - Systems Architecting and Design (3 - 2)

The use of models, from stakeholder needs to requirements, to system functional and physical architecture, through performance specification, for the basis for architecting and designing complex technical systems. This course provides the student with the language, terminology, concepts, methods, and tools of system architecting and design, including exploring the relationship between science, art, and deductive and inductive processes. Topics covered include architecture modeling (e.g. Hatley/Hruschka/Pirbhai and Rummler-Brache Methods), architectural frameworks (including Zachman and DoDAF), object oriented modeling approaches using Unified Modeling Language (UML) and Systems Modeling Language (SysML), human and cultural aspects of architecturing and design, requirements generation and definition, and knowledge formation and distribution. Students carry out projects and assignments both individually and as teams.

Prerequisite: SE3100 or SI4021.

SE4151 - Systems Integration and Development (3 - 2)

This course provides the student with an understanding of the context and framework for planning and carrying out integration and development, including emergent behavior, manufacturing, and production of complex systems. Topics covered include systems and SoS integration and production with consideration of multiple suitability aspects, including availability, reliability, maintainability, embedded software, human factors, producibility, interoperability, supportability, emergent behavior, life cycle cost, schedule, and performance. Types of systems considered are large-scale spanning applications from purely technical to socio-technical. Students work in teams to complete a systems engineering project to analyze, integrate, and produce a working prototype system.

Prerequisite: SE4150.

SE4321 - Reliability Growth and Accelerated Testing (4 - 1)

This course covers mathematical and statistical models used in advanced reliability engineering and the art of

their application. Reliability growth models include the AMSSA- Crow, Duane, and Lloyd-Lipow models. Accelerated testing models include the Arrhenius, Eyring, and Inverse-power Law. Statistical and practical issues in model selection and parameter estimation are discussed. Particular emphasis is placed on design of test plans.

Prerequisite: OA4302.

SE4353 - Risk Analysis and Management for Engineering Systems (3 - 2)

This course covers three areas in the risk field - Qualitative Risk Analysis, Quantitative Risk Analysis, and Decision Risk Analysis. Qualitative Risk Analysis presents techniques for risk identification/evaluation, risk handling, risk monitoring and risk management. Quantitative Risk Analysis includes Probabilistic Risk Assessment (RPRA) of system performance and project cost/schedule. Decision Risk Analysis gives the students an understanding of how to apply risk and cost benefit techniques in decision making when one must deal with significant risk or uncertainty. The course will present a framework for balancing risks and benefits to applicable situations. Typically, these involve human safety, potential environmental effects, and large financial and technological uncertainties. Concepts are applied toward representative problems resulting in risk and decision models that provide insight and understanding, and consequently lead to more successful projects/programs with better system performance within cost and schedule. This is the same course as ME4753.

Prerequisite: OS3180, OS3104, or OS3111..

SE4354 - System Verification and Validation (4 - 0)

This course applies the verification and validation (V&V) principles of inspection, demonstration, analysis, and test to confirm the system satisfies the capability needs and system requirements. The course places special emphasis on test and evaluation including inferential statistics methods such as design of experiments (DOE) and analysis of variance (ANOVA), and testing methods such as functional simulation, analysis, examination, software in the loop, hardware in the loop, full system testing, and operational testing; in order to verify that the hardware matches the simulations in the earliest available environment and continuing during the entire lifecycle. The course content will be consistent with Congressional and DoD requirements and guidelines and will include case studies and lessons learned from actual defense system tests. This course is also offered as OA4603.

Prerequisite: OS3180 or OS3111, and SE3100..

SE4414 - LSI - Leadership in System Integration (4 - 0)

Most major DoD acquisition activities are not the development of new systems but the improvement and integration of existing legacy systems. Furthermore, this acquisition activity is made exceptionally complex because the systems need to be integrated with a "Systems-of-Systems" (SoS) approach. SoS acquisition, development, and integration require skills in system integration that exceed those required with standalone system acquisition. These skills are embodied in the role of the "Lead System Integrator" (LSI), previously a contractor, but increasingly a DoD employee. In this course we examine the roles of the LSI, where DoD acquisition skills may need to be strengthened to perform as the LSI, and discuss methods and tools to do so. This course is a capstone to SE3411, SE3412, and SE3413.

Prerequisite: SE3411, SE3412, and SE3413.

SE4420 - Modeling and Simulation in Acquisition (3 - 2)

This course surveys the modeling and simulation (M&S) tools, techniques, and procedures used to support Department of Defense (DOD) acquisition. Multiple M&S approaches and tools are presented with emphasis on the differences in application between model types. Upon completion, students will be able to identify a particular tool and apply it appropriately to support system acquisition and relate specific tools to the decision points that separate the acquisition phases. Students will be able to identify development, application, and analysis considerations related to M&S for a representative system.

Prerequisite: OS3180 or OS3111, and SE3100.

SE4520 - System Manufacturing Development and Production (3 - 2)

This course covers the concepts and problems underlying the design and operation of contemporary production systems. The course provides an understanding of the relationship between traditional manufacturing management and systems engineering activities. Topics covered include the basics of production/manufacturing system design, planning, and implementation activities that complement the concurrent systems engineering and logistics support system design activities that take place on typical large-scale Department of Defense (DoD) acquisition programs (e.g. ships, aircraft, ground vehicles, etc.). This includes the design/build/test and implementation of hardware/software/people configurations used for production/manufacturing within the various DoD Acquisition Life Cycle chart phases. The alignment of basic systems engineering technical and technical management processes with traditional production system design and management processes will also be covered.

Prerequisite: SE3302, SI3400.

SE4900 - Advanced Studies in Systems Engineering (3 - 0)

Directed study at an advanced graduate level based on textbooks, journal literature, experimental projects, or other sources. This course is designed to permit study of a selected topic at an advanced level, and which is not available for study through regularly scheduled courses.

SE4930 - Model-Based Systems Engineering (3 - 2)

Practical systems engineering relies heavily on models during conceptualization, system definition, system design, system integration, as well as system assessment. This course addresses the use of models in all phases of the systems engineering process. Details of widely-used processes for modeling are described and these tools are used in laboratory exercises and projects. This course uses a seminar approach with out-of-classroom reading and in-class discussions of the reading replacing traditional lectures.

Prerequisite: SE3100.

SE4935 - Formal Methods for Systems Architecting (4 - 0)

This course provides students with an introduction to the application of formal methods to system architecture model and design analysis. Students are exposed to theories and practices that use mathematics and formal logic for the formulation, interrogation, assessment and measurement of properties of architecture models and the designs they describe. Drawing on their academic and professional experiences, students practice writing specifications of architecting best practices and lessons learned in both natural language and formal mathematical notation, and applying them in systems engineering tools. DoD system models rich in design patterns are used as a basis for formulation. The aim of this course is to apply systematic and formal thinking to the development and evaluation of system architectures.

Prerequisite: SE4150 and SE3100 or SI4021, or equivalent.

SE4950 - System of Systems Engineering (4 - 0)

Systems of systems (SoS) arise when a number of independently developed systems are integrated to perform tasks of which the independent systems are incapable. This course discusses the special problems of engineering systems of systems. Topics include characteristics of SoS, engineering management of SoS, engineering methodology of SoS, SoS architecture, analysis of SoS, and tools for engineering SoS. This course uses a seminar approach with out-of-classroom reading and in-class discussions of the reading replacing traditional lectures. Case studies are used extensively.

Prerequisite: SE4151.

SE4980 - Enterprise Systems Engineering (4 - 0)

The modeling, analysis, and design of enterprise systems defined as a socio-technical system that comprises interdependent resources of people, information, and technology that collectively fulfills the enterprise's mission. Adopting this view, the Navy is an enterprise system, and this course takes a systems engineering approach to designing these types of socio-technical systems. Topics include enterprise needs analysis; enterprise architecture; process modeling, analysis, and design; information modeling, analysis, and design; organization modeling, analysis, and design; and the

integration of these views.

Prerequisite: SE3100.

SE5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

SE5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council.

Prerequisite: Advancement to Candidacy.

SE5900 - Doctoral Research Initiation (0 - 8)

This course provides program continuity and assistance to doctoral students in finding a dissertation topic and supervisor and subsequently initiating a dissertation research program. Required in the quarter following completion of doctoral-level course work and then continuously each quarter until advancement to candidacy.

SI

SI0810 - Integrating Project (0 - 8)

This course serves as a final synthesis of the entire systems engineering curriculum. The course requires completion of an integrating project where student teams provide solutions using systems engineering methods and project management techniques.

SI3400 - Fundamentals of Engineering Project Management (3 - 2)

This course examines modern techniques of engineering project management from a systems perspective, including project planning, organization, and control. Specific topics include discussion of the systems engineering management process, risk management, scheduling methodologies, the DoD acquisition environment, management of design activities, PERT, CPM, and project control mechanisms. Case studies are used to examine application of principles. Large scale system management, mitigation of technical risk, integrated product and process development, quality management, contracting, and the international environment are discussed. Large-scale systems management problems are examined using commercial software suites. Covers application of fundamental systems project management processes and methods to an integrative system project. Development of

communication skills is accomplished through oral presentations and written reports.

Corequisite: SE3100.

SI4021 - Systems Engineering for Product Development (4 - 0)

Systems engineers flow requirements down to detailed elements, integrate elements, and verify system performance. This course concentrates on the structural and technical elements of system engineering necessary in the product development domain. Multidisciplinary activities leading to requirements analysis, design trades, and integrated product-process development are complemented by current best manufacturing practices and design for cost principles. Structured methods, decision analysis, and quality engineering foundations are emphasized. Case studies from a variety of industrial contexts are presented and discussed. This course is team taught by experts from several disciplines. Prerequisites: None.

SI4022 - Systems Architecture for Product Development (4 - 0)

Systems architects respond to user needs, define and allocate functionality, decompose the system, and define interfaces. This course presents a synthetic view of system architecture: the allocation of functionality and its projection on organizational functionality; the analysis of complexity and methods of decomposition and re-integration; consideration of downstream processes including manufacturing and operations. Physical systems and software systems are discussed. Heuristic and formal methods will be presented. Students are given research assignments that provide opportunities to further learn how systems architecture principles are applied in a variety of application areas. This course provides an integrative forum for PD21 students to stimulate holistic, global, and innovative thinking, and to enable critical evaluation of current modes of architecture. Prerequisites: None.

SS

SS0810 - Space Systems Thesis Research (0 - 8)

Every student conducting thesis research enrolls in this course.

SS1100 - Intro to Programming for Space Applications (2 - 2)

An introductory course to programming for space applications. Basic concepts of programming are introduced, including binary and hexadecimal number systems, information representation and storage in computers, schematic generation, functions,

printing, plotting, and writing and reading data to and from files using languages such as MATLAB and Python. Simulink modeling basics and the Communication Systems Toolbox will also be introduced, focusing on the Fast Fourier Transform of signals. This course prepares students for future coursework and research in Space Systems Engineering and Operations.

SS1300 - Introduction to Nuclear Command, Control, and Communications (NC3) (1 - 0)

This one-credit-hour lecture series will introduce Nuclear Command, Control, and Communications (NC3). This series will provide historical context, policy, and strategy that underpins the current NC3 system and an introduction to the technical systems used for NC3. The class is taught via asynchronous distance learning (DL) using recorded lectures that the student can access online. Classification: Unclassified

Prerequisite: None.

SS1313 - CHUNK Learning Seminar (0 - 4)

This seminar is designed to support Space Systems students throughout their time in the NC3 curriculum providing complementary material to the other courses within the curriculum. Topics will include link budget analysis, antenna theory, early warning systems, etc. The course is given in the Pass/Fail mode, evaluated by the student's ability to pass the assessments linked to each topic.

Prerequisite: None.

SS1810 - Thesis Proposal Preparation (0 - 1)

The course is designed to support Space Systems Operations and Engineering students in the selection of a topic for thesis research culminating in the development of their thesis proposal. The course is given in the Pass/Fail mode, evaluated by the submission of an approved thesis proposal and presentation of thesis quad charts by the end of the quarter.

Prerequisite: For 366 - Space Systems Operations students completing their third quarter, 591 - Space Systems Engineering Students completing their fifth quarter or by consent of Academic Associate..

SS3001 - Military Applications of National Space Systems (4 - 1)

Space Systems and technologies of interest to the military. Strategic and tactical imagery and SIGINT requirements. Tasking and use of national space systems and ground support elements. Vulnerability considerations and impact of current R&D programs. Requires TOP SECRET clearance with access to SCI.

Prerequisite: SS3400 or SS3500; PH3052. Security Clearance Required: Top Secret SCI.

SS3011 - Space Technology and Applications (3 - 0)

An introduction to space mission analysis with an

emphasis on those space missions supporting military operations. Topics include space history, doctrine and organizations, orbital mechanics, communication link analysis, space environment, spacecraft technology, and military, civil and commercial space systems.

Prerequisite: None.

SS3041 - Space Systems and Operations I (4 - 2)

Space systems mission analysis and design. Mission characterization, mission evaluation, requirements determination, cost analysis and estimating, cost and operational effectiveness analysis.

Prerequisite: SS3011, SS3500, MN3331. Corequisite: PH3052. Security Clearance Required: Top Secret SCI.

SS3051 - Military Applications of DoD and Commercial Space Systems (3 - 2)

SS3051 provides the foundational knowledge for space operations analysis and integration. The first half of the course provides the foundational knowledge necessary to begin analysis and integration to include space command and control organizations and functions within the services and joint community to include USSPACECOM and the U.S. Space Force. During this portion of the course, students examine current DoD and Commercial Space Systems, their characteristics, architectures and operations/management. These systems include position, navigation and timing, missile warning, satellite communications, and intelligence, surveillance, and reconnaissance. Students will further develop their understanding by building models of these systems and describing the purpose and function of each of components of that model. The second half of the course provides the foundations necessary to analyze military space operations, to include space control concepts, and integrate space into those military operations. Students will learn and practice the basic analytical framework and conclude the course by completing a tactically focused project that protects and integrates space capabilities and mitigates adversary threats. Requires a SECRET clearance.

Prerequisite: SS3011. Security Clearance Required: Secret.

SS3101 - Ground Systems and Mission Operations (3 - 2)

This course provides a comprehensive understanding of space mission operations and the ground infrastructure necessary to support such operations. The course includes an introduction to major functional areas associated with mission operations and typical ground segment architectures. Students will understand how functions and operations in a modern ground architectures are conducted – both in support of the spacecraft bus and the mission payload. They will understand how modern networking techniques and information assurance keep critical data safe and efficiently distribute these data to end users in support of national security operations. Modern space systems produce a tremendous amount of data, which require sophisticated automation and analysis techniques.

Students will learn how to apply principles of "Big Data" and cloud computing to handle this information efficiently while also keeping the information secure, and in compliance with accepted security norms.   Students will be introduced to modern DOD and Intelligence Community ground architectures, including classified discussions related to national space systems introduced in SS3001. Students will analyze the role of ground systems in mission performance, and consider how ground architectures might be changed to improve overall mission performance and resilience without undue increases in cost and risk.

Prerequisite: SS3500 or SS3400, and SS3001 (or concurrent). Security Clearance Required: Top Secret SCI.

SS3400 - Orbital Mechanics, Launch and Space Operations (4 - 2)

This course provides an understanding of Orbital Mechanics and the associated implications to the use of space-based systems in support of military operations. Fundamental concepts such as conic sections, coordinate systems, coordinate transformations and time are covered, then applied to the understanding and application of Newton's laws, Kepler's laws, orbital elements, perturbations, and orbital maneuvering. Prerequisites: None.

SS3500 - Orbital Mechanics and Launch Systems (4 - 2)

Provides a fundamental understanding of Orbital Mechanics through study of conic sections, coordinate systems, coordinate transformations, and time. Calculation of orbital elements of the two-body problem is covered. Other Orbital Mechanics topics include: Newton's laws, Kepler's equation, orbital perturbations, and orbital maneuvering, including rendezvous and proximity operations. Launch systems topics include: the rocket equation, single and multi-stage rockets, launch windows, launch profiles, ascent and payload delivery performance, and mission design. Supporting lab work utilizes the Satellite Tool Kit (STK) as an orbit analysis tool. The use of Excel and / or MATLAB for solving problems is encouraged. Prerequisites: college level algebra, geometry, trigonometry, logarithms and physics.

SS3600 - Space Systems Modeling and Simulation (2 - 3)

SS3600 provides students with knowledge of modeling and simulation theory and the ability to apply space systems modeling and simulation tools to real world problems. Concepts covered include the development and applicability of models and simulations, with a focus on specific space applications. Students will apply these concepts through laboratory exercises and a project to simulate an end-to-end space architecture, evaluate system performance, and compare alternative solutions.

Prerequisite: SS3400 and SS3500, or permission of

instructor.

SS3610 - Space Communications Systems: Fundamentals and Analysis (4 - 2)

Same as EO3510. With a focus on satellite communications/SIGINT, this course provides an understanding of the basic elements of a communications system and their relationship to system performance. Fundamental concepts such as current/voltage relationships, time and frequency domains, power spectral density, random signals, and communications system components and functions are covered. Following development of the signal to noise equation, system performance will be analyzed with respect to various design characteristics such as modulation, bandwidth and power trade]offs, and the use of spread spectrum techniques.

Prerequisite: PH1322 or permissions of the instructor.

SS3613 - Military Satellite Communications (3 - 0)

MILSATCOM mission analysis, systems design, and applications. This course will cover requirements, tactical employment, system architectures, satellite design and performance, terminal design and performance, associated information systems, link budget calculations, telemetry and control and IO/IW implications. The student will be expected to create SATCOM solutions for Navy and Marine scenarios. U.S. Citizen, Classification: FOUO

Prerequisite: SS3011, or consent of the instructor.

SS3614 - SATCOM Systems and Applications for International Students (3 - 0)

SS3614 is for international students and is academically equivalent to SS3613. This course addresses satellite communications mission analysis, systems design, and applications. This course covers requirements, employment, system architectures, satellite design and performance, terminal design and performance, associated information systems, link budget calculations, telemetry and control and IO/IW implications. Commercial SATCOM systems used are applicable to international militaries.

Prerequisite: SS3011 or consent of instructor..

SS3740 - Nuclear Command, Control, and Communications Systems - Part I (3 - 0)

Same as AE3740 (p. 328). This course is the first of two courses that introduce nuclear command & control concepts as well as a comprehensive, technical view of the US Nuclear Command & Control & Communications (NC3) system. The first course will concentrate on deterrence theory, command & control theory and history behind the US NC3 system, as well as an introduction to NC3 support space systems.

Students will study international as well as domestic law & policy guidance in relation to nuclear weapon employment and proliferation. Nuclear close calls will be analyzed to identify failures in systems & procedures that must be avoided in the future. Students will study the state of nuclear weapons worldwide and understand the US strategy to counter the various nuclear threats. Students will begin a comprehensive study of the US NC3 system, which will continue in the second course.

Prerequisite: SS3011 (or experience with orbital mechanics), SS3613 (or experience with satellite communications and link budgets). Cross-Listed as: Same as AE3740. Security Clearance Required: Secret.

SS3741 - Nuclear Command, Control, and Communications Systems - Part II (3 - 0)

Same as AE3741 (p. 328). This course is the second of two courses that introduce nuclear command & control concepts as well as a comprehensive, technical view of the US Nuclear Command & Control & Communications (NC3) system. There will be a large emphasis on future trends and vulnerabilities, which must be considered for future systems.

Students will understand theory of Command & Control (C2) and operation of highly reliable systems, methods used protect and secure these systems in the extreme adverse environments and ensure their reliability.

Prerequisite: SS3740 (NC^3 Systems Part I). Cross-Listed as: Same as AE3741. Security Clearance Required: Secret.

SS3861 - Spacecraft Payload Design I (2 - 4)

This course focuses on the software and hardware associated with payload design with an emphasis on hands-on lab experience. Students will learn basic payload computing (software and electrical) concepts through lecture and by designing and building a spacecraft payload. Systems engineering principles will be introduced and applied to the payload design. Principles of payload requirements, including design and bus interface requirements, as well as payload integration and testing will be introduced. This course culminates in a preliminary design review and functional prototype of the payload.

Prerequisite: SS1100, EO3525 (or equivalent), EC3230, PH2514, and PH3052; or Consent of Instructor..

SS3900 - Special Topics in Space Systems (V - V)

(Variable hours 1-0 to 5-0.) Directed study either experimental or theoretical in nature. May be taken on Pass/Fail basis if the student has requested so at the time of enrollment.

Prerequisite: Consent of Chairman of Space Systems Academic Group and instructor.

SS4000 - Space Systems Seminars (0 - 1)

Seminars consist of lectures to provide perspective on Space Systems and to expose the student to various space activities such as industry, NASA and DoD laboratories and commands. Security clearance recommended. Course intended for students in Space curricula, others by instructor permission. Prerequisites: None.

SS4051 - Military Space Systems and Architectures II (3 - 2)

This course covers the system level architectural design of selected Space Systems. Emphasis is on a balanced design of all seven components of space systems: space segment, launch segment, ground segment, mission operations, C3 architecture, subject, and orbit and constellation. Additionally, this course introduces alternate perceptions of space systems operations using native-language research translations of open-source material (when available), and unclassified documentation. For resident students, further study of classified sources and material allows greater depth of understanding. Classification: TOP SECRET clearance with access to SCI for resident.

Prerequisite: SS3001, SS3041, SS3400 or SS3500. Security Clearance Required: Top Secret SCI.

SS4055 - Space Operations for the Warfighter (2 - 2)

SS4055 provides the 366 curriculum experience in space operations analysis, integration, and planning. Students will leverage the concepts that they were exposed to during previous courses to analyze a threat driven scenario, culminating in the production of a injects to a Space Operational Plan (OPLAN) or Space Appendix to an OPLAN.

Prerequisite: SS3001, SS3613, and SS3051 or permission of the instructor. Security Clearance Required: Top Secret SCI.

SS4801 - Space Autonomy Laboratory (2 - 4)

This course provides students a hands-on experience in current and advance space autonomy concepts. Students will be exposed to the command, control and operations of a satellite while understanding the engineering ramifications of various space sensors and actuators and the resulting telemetry. Each lab will involve students designing and implementing a space mission in the re-configurable space autonomy testbed. Students will gain hands-on experience in understanding the role of autonomy for tactical and strategic needs. Each laboratory experiment exposes a student to the range of capabilities as well as the limits of autonomy.

Prerequisite: SS3500.

SS4856 - Rendezvous and Proximity Operations (3 - 0)

The objectives of this course are to synthesize the principles necessary to accomplish a rendezvous mission, comprehend proximity operations and associated key implementation issues, and analyze the elements of proximity operations activities. The need for rendezvous and different space control applications for orbital rendezvous will be discussed, and the constraints and trades in such maneuvers will be introduced. Rendezvous techniques, as well as ground-up and day-of-launch rendezvous, will also be covered in this course. The course will culminate in applying guidance and control strategies, including feedback information, for rendezvous and proximity operations activities in a final exam or project. Classification: TOP SECRET clearance with access to SCI.

Prerequisite: SS3500 and SS3600, or instructor consent.. Security Clearance Required: Top Secret SCI.

SS4861 - Spacecraft Payload Design II (2 - 4)

This course builds on the skills, knowledge, and project work gained in SS3861 and focuses on the hands-on experience in the lab, including functional and environmental testing at the payload and integrated system levels, and in the field, culminating in a high-altitude balloon flight of the payload. Payload-specific design consideration topics, including radiation effects, and reliability and fault tolerance, will be covered, along with payload cryogenic cooling. The design of current and planned space-based mission payloads of national interest will be discussed, and case studies will be presented about each payload type.

Prerequisite: SS3861.

SS4900 - Advanced Study in Space Systems (V - V)

(Variable hours 1-0 to 5-0.) Directed graduate study based on journal literature, experimental projects, or other sources. May be taken on Pass/Fail basis if the student has requested so at the time of enrollment.

Prerequisite: Consent of Chairman of Space Systems Academic Group and instructor.

SW

SW0810 - Thesis Research (0 - 8)

Every student conducting thesis research will enroll in this course.

SW2920 - Introductory Topics in Software Engineering (V - V)

(Variable hours 2-4 to 4-1.) Designed to support introductory subject matter of special interest in software engineering, dependent upon faculty availability. Topics will typically augment those offered in the basic core courses. This course may be lecture- or lab-oriented, or self-paced, with prerequisites determined by the instructor. Students may repeat this course for credit with a different topic.

Prerequisite: Consent of instructor.

SW3460 - Software Methodology (4 - 1)

The course is designed to teach students the basic concepts of software engineering and methods for requirements definition, design and testing of software. Specific topics include introduction to the software life cycle, basic concepts and principles of software engineering, object-oriented methods for requirements analysis, software design and development.

Prerequisite: Object Orientated programming experience

(CS2020) or consent of instructor.

SW3800 - Directed Study in Software Engineering (0 - V)

(Variable hours 0-2 to 0-8.) Individual research and study by the student under the supervision of a member of the faculty. The course is intended primarily to permit interested students to pursue in-depth subjects not fully covered in formal class work. Graded on Pass/Fail basis only.

Prerequisite: Consent of instructor.

SW3920 - Topics in Software Engineering (V - V)

(Variable hours 2-4 to 4-1.) Designed to support subject matter of special interest in software engineering, dependent upon faculty availability. Topics will either be drawn from areas not covered by core courses, or be focused treatments of subjects of limited scope. This course may be lecture-or lab- oriented, with prerequisites determined by the instructor. Students may repeat this course for credit with a different topic.

Prerequisite: Consent of instructor.

SW4150 - Programming Tools and Environments (4 - 0)

This course covers the design and implementation of tools to aid software development, including syntax directed editors, version-control systems, language oriented debuggers, symbolic execution vehicles, programming databases, type checkers, and automatic programming tools. These topics are discussed in the context of an integrated, language-oriented programming environment.

Prerequisite: SW3460.

SW4500 - Introduction to Formal Methods in Software Engineering (3 - 1)

This course covers formal methods for specification and analysis of software systems. The course introduces application of mathematical logic to software design, program verification, and formal specification languages. The laboratory sessions will cover special topics and case studies.

Prerequisite: SW3460 or consent of instructor.

SW4510 - Computer-Aided Prototyping (3 - 0)

This course covers the concept and application of computer-aided prototyping to the development and acquisition of DoD software systems. Specific topics include the prototyping software life cycle, system models, design methods, automatic code generation, prototyping languages and tools, and their unique systematic system for increasing productivity, reliability and portability of software development in comparison with other development methods.

Prerequisite: SW3460.

SW4520 - Advanced Software Engineering (3 - 0)

This course covers methods for specifying, designing, and analyzing software systems, with emphasis on automatable techniques and their mathematical basis.

The techniques are applied to construct and check programs using a formal specification language. The course concludes with a summary of current research areas in software engineering.

Prerequisite: SW3460.

SW4530 - Software Engineering Research and Development in DOD (3 - 1)

This course builds on the material covered in SW4500. Fundamental principles of computer system/network security and distributed computing are covered along with advanced methods, techniques and standards aimed at improving the development and acquisition of DoD software systems. Specific topics include: the application of software engineering principles for designing large, secure, embedded real-time computer systems; the application of software engineering principles for the design of distributed systems; automated tools for the specification, design and generation of code for applications; and existing emerging DoD standards for software development, security and acquisition.

Prerequisite: SW3460 or consent of instructor.

SW4540 - Software Testing (3 - 1)

This course covers the theory and practice of testing computer software with the intent of preventing, finding and eliminating bugs in software. Planning and executing software tests are covered, including requirements-based testing, functional testing, static analysis, code reading, symbolic testing, structural testing, and advanced testing techniques. These topics are discussed in the context of a realistic development environment, illustrated using a variety of software testing tools.

Prerequisite: SW3460.

SW4555 - Engineering Network Centric Systems (3 - 1)

This course covers the concepts, methods, techniques and tools for engineering the development of network centric systems. Specific topics include the evolution of client/server models to distributed objects, an introduction to and comparison of CORBA/OpenDoc and OLE/COM, intelligent software agents, application development in distributed environments, security issues in network centric computing, and DoD software system development.

Prerequisite: SW3460.

SW4560 - Software Evolution (3 - 0)

This course covers the concepts, methods, techniques and tools for supporting the evolution and maintenance of software systems. Specific topics include the use of formal specifications to support software evolution, design databases, configuration management, software change merging, and software re-engineering.

Prerequisite: SW3460.

SW4570 - Software Reuse (3 - 0)

This course covers the concepts, methods, techniques and

tools for systematic reuse of software components and systems. Specific topics include design and re-engineering for reuse, mechanisms for enhancing reuse, domain specific reuse and software architectures, reuse of requirements models, specifications and designs, tools for reuse, software library organization, and methods for component search.

Prerequisite: SW3460 or consent of instructor.

SW4580 - Design of Embedded Real-Time Systems (3 - 0)

This course covers the concepts, methods, techniques and tools for supporting the design of embedded real-time systems. Specific topics include real-time systems and concurrency models, object-oriented methods for real-time system design, real-time scheduling, and programming language support for concurrent and real-time systems.

Prerequisite: SW3460 or consent of instructor.

SW4581 - Software Reliability (3 - 1)

This course covers the concepts, methods, and techniques for evaluating and improving the engineering of software reliability. Specific topics include system-level dependability and reliability modeling concepts; software reliability prediction and estimation models and metrics; and techniques for model evaluation, fault/failure forecasting, fault removal, fault prevention, and fault tolerance.

Prerequisite: SW3460 or consent of instructor.

SW4582 - Weapon System Software Safety (3 - 1)

This course provides an introduction to software system safety. The course covers the principles and processes of system safety engineering, including the basics of hazard analysis and risk assessment. Emphasis is placed in this course on both planning and managing acquisition programs involving safety-critical software. Concepts and principles are applied to the acquisition of weapon systems. An advanced course in system safety is offered as SW4920.

Prerequisite: SW3460.

SW4583 - Principles of Software Design (3 - 1)

The course is designed to teach students the role of design in software engineering. Specific topics include the software system design process, design qualities, principles and strategies, design models, design methods, and the use of patterns in the design of object oriented software systems.

Prerequisite: SW3460.

SW4590 - Software Architecture (3 - 1)

This course covers both high- and low-level software architectures, including software patterns and pattern-oriented architectures, from the module level through the enterprise level. Where appropriate, we examine formalisms, and actual software architecture practice. Special attention is given to interoperability of

architectural components. Case studies of existing DoD systems are used throughout the course.

Prerequisite: SW3460 or consent of instructor.

SW4591 - Requirements Engineering (3 - 1)

This is an in-depth treatment of requirements engineering concepts, methods, and tools. The role of requirements engineering within software engineering is explored as well as consistency, cost-benefit analysis, resolving multiple viewpoints, dependency tracing, and automated decision support. Topics are reinforced with examples from DoD applications. Prototyping is introduced as a means of assessing requirements early in the design process.

Prerequisite: SW3460 or consent of instructor.

SW4592 - Software Risk Assessment in DOD (3 - 1)

This course introduces concepts, techniques and tools for software risk management. The course examines various risks of software practice and evaluates them in terms of mathematical models (e.g. probability theory). Students learn techniques for mitigating, avoiding, and handling risks throughout the software life cycle. The course depends on software metrics; we also look at reliability theory and its application to software risk management. Prerequisite: SW3460 or consent of the instructor.

Prerequisite: SW3460.

SW4593 - Advanced Logic & Algebra for Software R&D in DoD (3 - 1)

The aim of this course is to present fundamentals of advanced logic & algebra for software R&D. Specific topics include equational specifications, algebra, characterization of equation classes, the equation calculus, term rewriting, first and second order logic, temporal logic, model theory and generalized induction.

Prerequisite: SW4500 or consent of instructor.

SW4594 - Formal Models for Software Automation (3 - 1)

This course covers the concepts, methods, techniques and tools for designing and developing systems. Specific topics include the use of knowledge-based tools for software evolution and techniques for specification, methods for program derivation and generation, domain-specific program synthesis techniques, and cognitive and planning approaches to software design.

Prerequisite: SW4500.

SW4595 - Lightweight Inference Techniques (3 - 1)

This course covers the fundamental principles and technologies for automated decision support and automated software evolution with an emphasis on techniques for lightweight inference. Specific topics include: decision support systems, software evolution systems, gaps in existing technology that prevent automation, models and methods for lightweight inference, state of the art theory and practice.

Prerequisite: SW4500 or consent of instructor.

SW4596 - Algorithm Design and Analysis in Software Engineering (3 - 1)

This course covers algorithm design and analysis in software engineering. Specific topics include advanced data structures (such as Binomial heaps and Fibonacci Heaps), graph algorithms (such as minimum spanning trees, maximum flow, all-pairs shortest paths, and single-source shortest paths), and advanced design and analysis techniques (such as dynamic programming, greedy algorithms, linear programming, and amortized analysis).

Prerequisite: SW4500 or consent of instructor.

SW4597 - Robust Generation of Control Software (3 - 1)

This course covers the concepts, methods, techniques and tools needed to methodically generate robust software for system control. Specific topics include specification and analysis of control requirements, hard and soft real-time constraints, embedded software control, code generation, software reliability through software reuse and redundancy, and DoD requirements for control systems. A survey of computer-aided tools that support the generation of robust systems is provided.

Prerequisite: SW4500 or consent of instructor.

SW4598 - Software Merging and Slicing Techniques (3 - 1)

The fundamental concepts, methods and tools for software merging and slicing are covered in this course, with applications to software evolution, configuration management, and testing. This is followed by advanced topics including the state of the art in this field.

Prerequisite: SW4500.

SW4599 - Automated Software/Hardware Integration in DoD (3 - 1)

Automated software / hardware integration is a key problem for current software development in DoD. This course covers some important aspects of this field, including software prototyping, interface integration, data integration, and control integration. Automatable decision support methods for software/hardware integration are also discussed.

Prerequisite: SW4500 or consent of instructor.

SW4600 - Automata, Formal Specification and Run-time Verification (3 - 1)

This course focuses on run-time monitoring and verification, a practical software verification technique based on automata and formal specifications. The automata section consists of finite automata (deterministic and non-deterministic), languages, and regular expressions. The formal specification section consists of temporal logics, real-time and time-series constraint specification, statecharts, and TLCharts. The run-time verification section will cover the practical application of formal specifications to monitoring and verification of safety critical systems. The course combines theory, examples, and practical student-driven projects. After taking this course you will know how to apply formal specifications and run-time verification to improve the dependability of defense systems.

Prerequisite: CS3150 and MA2025.

SW4800 - Directed Study in Advanced Software Engineering (0 - V)

(Variable hours 0-2 to 0-8.) Advanced group studies in software engineering on a subject of mutual interest to students and faculty member. Intended primarily to permit students to pursue in-depth subjects not fully covered in formal class work or thesis research. May be repeated for credit with a different topic. Graded on Pass/Fail basis only.

Prerequisite: Consent of instructor.

SW4900 - Research Seminar in Advanced Software Engineering (0 - 2)

This course will examine the current and planned research of Software engineering faculty. The course is designed to support Software Engineering students in the selection of an area for thesis research. Completion of this course requires submission of an approved thesis proposal during finals week. PREREQUISITE: None. Graded Pass/Fail basis only.

SW4910 - Advanced Readings in Software Engineering (0 - V)

(Variable hours 0-2 to 0-8.) Directed readings in software engineering on a subject of mutual interest to student and faculty member. The course allows in-depth study of advanced topics not fully covered in formal class work or thesis research. May be repeated for credit with a different topic. Can be taken Pass/Fail or graded.

Prerequisite: Consent of instructor.

SW4920 - Advanced Topics in Software Engineering (V - V)

(Variable hours 2-4 to 4-1.) Designed to support advanced group study of subject matter of special interest in software engineering, dependent upon faculty availability. Topics will be drawn from areas not covered by other advanced courses, or be focused treatments of subjects of limited scope. This course may be lecture- or lab-oriented, with prerequisites determined by the instructor. Students may repeat this course for credit with a different topic.

SW4931 - Core Area of Software Engineering Doctoral Studies (3 - 2)

Designed to prepare Ph.D. students for the core area of the Software Engineering written qualifying examination - software development process and techniques. It introduces the most important references from each subject areas, highlights the important issues in each area,

and helps students become familiar with the Software Engineering research. Topics covered include: software life cycle models; software engineering concepts and principles; specification and verification of software - modeling, analysis, and assessment; design of large software systems - architectures, patterns, and protocols; maintenance of large software systems - re-engineering, transformations, recovering specs and rationale. Intended for Software Engineering PhD students. Graded on Pass/Fail basis only.

Prerequisite: Consent of instructor.

SW4932 - Advanced Area of Software Engineering Doctoral Studies (3 - 2)

Designed to prepare Ph.D. students for the advanced area of the Software Engineering written qualifying examination - software automation. It introduces the most important references from each subject areas, highlights the important issues in each area, and helps students become familiar with the Software Engineering research. Topics covered include: reducing coding efforts - program generation, synthesis techniques, static checking; computer-aided prototyping - models, languages, methods; software reuse - search methods, library organization; software evolution - models, automation methods, merging and slicing; domain specific systems - real-time systems. Intended for Software Engineering PhD students. Graded on Pass/Fail basis only.

Prerequisite: SW4931 or consent of instructor.

SW4933 - Supporting Areas of Software Engineering Doctoral Studies (3 - 2)

A seminar designed to prepare Ph.D. students for the supporting areas of the Software Engineering written qualifying examination. Topics covered include: Computer science - mathematical fundamentals, algorithms and data structures, compilation technology, artificial intelligence, and security: management and economics - project planning and management, quality assurance, software economics, knowledge bases, decision support, and fundamentals for system modeling; computer systems - real-time systems, networks and distributed systems, hardware/software integration, interoperability of network based systems, computer graphics and interfaces and signal processing and embedded control systems. Intended for Software Engineering PhD students. Graded on Pass/Fail basis only.

Prerequisite: SW4932 of consent of instructor.

SW4934 - Application of Advanced Concepts in Software Engineering (3 - 2)

An advanced seminar designed to assist Ph.D. students to prepare for their written qualifying examination through a combination of lectures and problem solving sessions. Intended for Software Engineering PhD students. Students may repeat this course for credit. Graded on Pass/Fail basis only.

Prerequisite: Consent of instructor.

SW4935 - Software Engineering Dissertation Proposal Preparation (3 - 0)

A seminar designed to introduce Ph.D. students to the open problems in software engineering and teach students the skills to identify research topics, find, read and analyze relevant parts of the research literature, and present their findings in the form of research proposals. Intended for Software Engineering PhD students.

Prerequisite: SW4934.

SW4936 - Seminar on Solving Software Engineering Research Problems (3 - 0)

A seminar designed to assist Ph.D. students to prepare for their oral qualifying examination through a combination of lectures, assigned readings, student presentations, and problem solving sessions. Intended for Software Engineering PhD students.

Prerequisite: SW4934.

SW4937 - Software Engineering Dissertation Research (4 - 0)

A seminar designed to provide a forum for PhD students to present work in progress and critique each other's results. Intended for Software Engineering PhD students.

SW4938 - Communicating Research Results in Software Engineering (4 - 0)

A seminar designed to provide a forum for Ph.D. students to present their dissertations and critique each other's work. Intended for Software Engineering Ph.D. students.

SW5805 - Dissertation Proposal Prep (0 - 8)

Dissertation proposal preparation for doctoral students. Available in the quarter following completion of coursework and then continuously each quarter until advancement to candidacy is approved by the Academic Council.

SW5810 - Dissertation Research (0 - 8)

Dissertation research for doctoral students. Required in the quarter following advancement to candidacy and then continuously each quarter until dissertation is approved by the Academic Council.

Prerequisite: Advancement to Candidacy.

TS

TS3000 - Electrical Power Engineering (3 - 2)

An overview of the principles, concepts and trade-offs which form the foundation for shipboard electric power systems. The composition of electrical power systems for present and future Navy vessels is presented. Theory

necessary to understand interactions among shipboard electric power system components is discussed. The interactions between the electric power system and the various types of loads is introduced. PREREQUISITE: None.

TS3001 - Fundamental Principles of Naval Architecture (3 - 2)

The geometry, hydrostatics and hydrodynamics of floating and submerged bodies are covered in this course. Longitudinal and transverse stability of floating bodies is examined. Other topics include: hull girder strength, Froude similarity, wave and skin friction resistance and powering determination. An introduction to passive survivability principles is also presented.

Prerequisite: ME2201, ME2601 or consent of Instructor.

TS3002 - Principles of Ship Design and Case Studies (3 - 2)

Systems engineering in the design of complex systems; systems architecture and interface engineering and the Navy design environment. The systems development process, including need identification, requirements, feasibility determination, risk reduction, contract and detailed design. The iterative, multilevel ship design process, with affordability as a fundamental feature; modern ship design and construction methods, systems engineering techniques and tools. Case studies, ship design trends, design exercises and illustrative.

Prerequisite: TS3001.

TS3003 - Naval Combat System Elements (3 - 2)

This course will cover combat system detection and engagement elements. This may include radar, EW, active and passive sonar, infrared, communication systems, data links, and countermeasures subsystems. The emphasis will be on what the elements contribute to a combat system, their basic principles of operation, their performance limitations, and their interfaces with the rest of the combat system. Details on specific elements and systems will be limited to those needed to illustrate basic principles and interactions affecting systems engineering.

Prerequisite: ME2503 or equivalent or consent of Instructor.

TS4000 - Naval Combat System Engineering (3 - 2)

Covers the definition and integration of naval combat systems. The emphasis will be on how the various detection, engagement, and control elements interact with each other and on how to combine them into an efficient and survivable combat system. Also addressed will be topside arrangements, signature reduction, readiness assessment, embedded training, and support system interfaces.

Prerequisite: TS3000, TS3003 or by consent of instructor.

TS4001 - Integration of Naval Engineering Systems (3 - 2)

A system-oriented approach to integrating the principles of Naval Architecture and Marine Engineering in the design of ship subsystems. Lectures and projects exploring engineering design tools and analysis methods to meet specified systems requirements are used. Projects on hull, mechanical and electrical ship systems design are emphasized. The impact of systems design on other systems and subsystems and on the ship, including affordability, military effectiveness and survivability at the whole ship level are considered.

Prerequisite: TS3000, TS3001, TS3002 or equivalent, or Consent of Instructor.

TS4002 - Ship Design Integration (2 - 4)

The ship-impact of requirements/cost/performance tradeoffs within technical and acquisition constraints. Conversion of broad military requirements to mission-based ship requirements and specific tasks resulting from those requirements. Exploration of alternative methods of satisfying requirements, leading to combat systems (payload) definition. Conduct of feasibility studies to investigate whole-ship alternatives which meet requirements. Selection of a best design approach. Design considerations for unusual ship types and an assessment of future Navy ship and combat systems needs and trends.

Prerequisite: TS4000 and TS4001or by consent of instructor.

TS4003 - Total Ship Systems Engineering (2 - 4)

The design of a Naval vessel as a single engineering system satisfying mission requirements, with emphasis on affordability and survivability. The interaction and interfacing of various subsystems such as hull, propulsion, and combat systems will be explored through a joint ship "preliminary design" project to produce a balanced ship design based on the alternative chosen from feasibility studies conducted in TS4002. Concepts of design optimization within constraints.

Prerequisite: TS4002 or by consent of instructor.

UW

UW0001 - Seminar (0 - 1)

(No credit) Special lectures, and discussion of matters related to the USW Program.

Prerequisite: Enrollment in the USW Curriculum and SECRET clearance. Security Clearance Required: Secret.

UW0810 - Thesis Research/Group Project (0 - 8)

Students in the USW Curriculum will enroll in this course while doing either an individual thesis or an equivalent group project involving several students and faculty.

UW2001 - History of USW Part I , Mine Warfare (2 - 0)

A study of mine warfare during the 20th century. Starting with the development of mines at the end of the 19th century, the progression of the warfare area is tracked

through the end of the 20th century. The lessons of this history continue to have implications for the future of naval warfare. Numerous lessons reappear from the Russo-Japanese War of 1905 on through World War I, World War II, the Korean conflict, the Vietnam War, the Cold War, Desert Shield/Desert Storm, and Operation Iraqi Freedom. Technical Innovations with significant impact on this historical period are covered as part of this course. Prerequisites: None.

UW2002 - Undersea Warfare - Yesterday, Today, Tomorrow (2 - 0)

A study of Submarine Warfare, Anti-Submarine Warfare, and the new concept of Sub-Sea Warfare using a thematic approach. Each of these Undersea Warfare areas will be taught using applicable themes such as sensor and weapon capabilities, command and control, organization, training, and strategy. A basic Undersea Warfare framework will provide historical perspective in each of the three Undersea Warfare areas, emphasizing the status yesterday, what it is today and why, and where we need to be tomorrow. The new area of Sub-Sea Warfare, which encompasses unmanned vehicles, sea-bed infrastructure, distributed networks, and irregular warfare, will also be introduced and discussed. Upon course conclusion, students will have an appreciation of the current status of Undersea Warfare in the Navy today, where the problems and challenges exist, and how the knowledge gained from their Undersea Warfare curriculum will help the Navy develop solutions to these problems and challenges.

Prerequisite: UW2001 or permission of the instructor.

UW2003 - Undersea Warfare – Yesterday, Today, Tomorrow (2 - 0)

A study of the three Undersea Warfare (USW) areas of Submarine Warfare, Anti-Submarine Warfare (ASW), and Subsea and Seabed Warfare (SSW). This course provides students with a firm understanding of the underlying principles of USW, to include how these principles have been applied for military gain, how each contributed to the evolution and prioritization of the area of Submarine Warfare, ASW, and SSW, and how these are reflected in the challenges and opportunities that the USW community faces today. This course seeks to review historical developments in each area with an analytical eye to pull out the key trends, developments, challenges, and opportunities that have defined USW over time. These elements are then used to review current and future developments, challenges, and opportunities in USW, enabling students to learn from the past and use it to inspire evolutionary and revolutionary solutions to the pressing USW issues of today and tomorrow.

Prerequisite: UW2001 or permission of the instructor. Corequisite: None. Cross-Listed as: None. Security Clearance Required: Secret.

UW3303 - Modeling and Simulation for Undersea Warfare (4 - 1)

Design, implementation and analysis using digital simulation models, with emphasis on physics-based modeling of military systems. Simulation is a discipline that cut across all technical fields complementing both theory and experiment as a component of the scientific method. Course topics include a broad view of analytic simulation, properly designing and structuring simulation problems, extending student programming skills to include the C language (as necessary), use of on-line tutorials, and the use of public-domain X3D model archives. This course provides tools, techniques and repeatable methodology that can be used to support thesis work and projects in other classes. Examples and class projects are typically oriented to problems of military or scientific interests. Prerequisites: None.

UW4999 - Special Studies in Undersea Warfare (V - 0)

(Variable hours 1-0 to 4-0.) A course designed to meet the needs of students for special work in advanced topics related to USW.

Academic Calendars

Registrar's calendars are at
https://my.nps.edu/web/registrar/calendar.

Fall Quarter AY2024

Reporting Date (International)..............................Sunday 10 Sep

2023 Reporting Date...Monday 18 Sep

Instruction Begins..Monday 25 Sep

Columbus Day (Holiday)...................................... Monday 9 Oct

Veteran's Day (Holiday)..Friday 10 Nov

Shift Day: Treat as Fri Class Schedule.........Wednesday 22 Nov

Thanksgiving Day (Holiday) ....Thursday 23 Nov

Pre-graduation Awards Ceremony.......................Tuesday 5 Dec

Last day of classes.. Friday 8 Dec

Final Examinations Begin..................................Tuesday 12 Dec

Final Examinations End...................................Thursday 14 Dec

Graduation..Friday 15 Dec

Winter Break................................... 18 Dec 2023 – 5 Jan 2024

Winter Quarter AY2024

Reporting Date (International)............Wednesday 27 Dec 2023

New Year's (Holiday Observed)..................Monday 1 Jan 2024

Reporting Date…..Tuesday 2 Jan

Instruction Begins...Monday 8 Jan

Martin Luther King's Birthday (Holiday) ....Monday 15 Jan

Shift Day: Treat as Mon Class Schedule..........Tuesday 16 Jan

President's Day (Holiday)..................................Monday 19 Feb

Pre-graduation Awards Ceremony...................Tuesday 19 Mar

Last day of classes...Tuesday 19 Mar

Final Examinations Begin...............................Thursday 21 Mar

Final Examinations End..................................Saturday 23 Mar

Thesis and Research Week......................... 25 Mar – 28 Mar

Graduation...Friday 29 Mar

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