Tactical Microgrids: Mobile and Sustainable Power

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Who We Are

Army Futures Command

Futures and Concepts Center

Combat Capabilities Development Command

Combat Systems

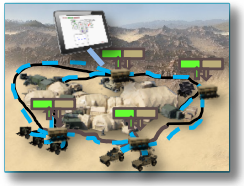
- Armaments Center
- Army Research Laboratory
- Aviation & Missile Center
- **C5ISR Center**
- Chemical Biological Center
- Data & Analysis Center
- Ground Vehicle Systems Center
- Soldier Center

Power Division

Technology Focus Areas


Expeditionary Power Generation & Conversion
Fuel to Electricity, Alternative & Renewable

Advanced Energy Storage
Batteries, Capacitors, etc.

Intelligent Power Management & Distribution

Soldier & Small Unit (up to 2kW)

Tactical Energy for Soldier Lethality

Increased Soldier Lethality through longer runtimes in distributed operations, with limited resupply

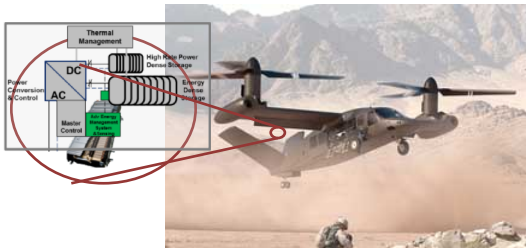
- Energy storage materials for unique battery configurations
- Power generation devices to enable integrated Soldier borne/operated sensors and radios

C5ISR Power & Intelligent Architectures (up to 360kW)

Energy Informed Operations

Increased Operational Reach / Reduced Logistics

- Tactical Microgrid Standards & Controls for Distributed Power Systems
- Energy Predictive Applications for Power Management
- Intelligent Power Architecture Demonstrations



Optimized Energy Storage for C4ISR Power

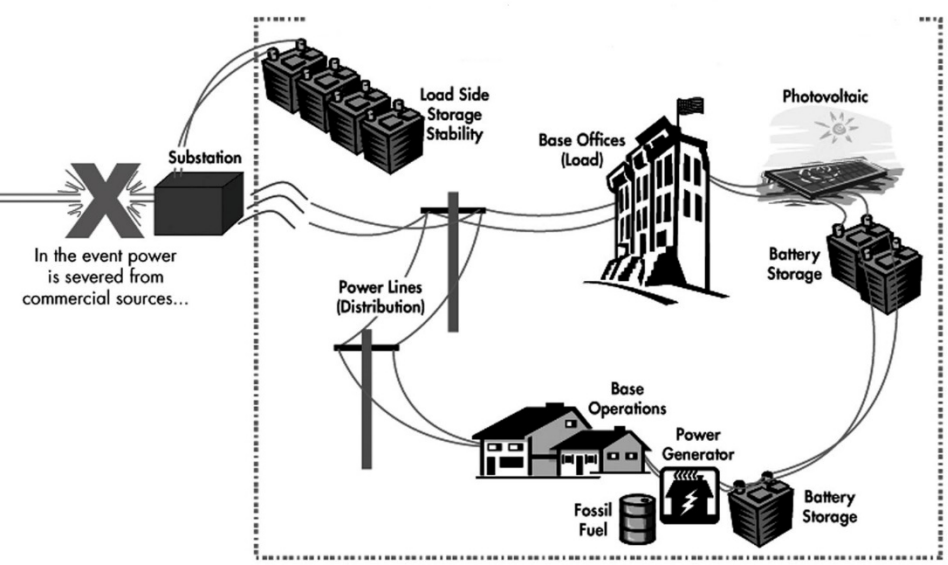
Optimizing platforms to enable C4ISR Dominance

- Pulse Power Energy Storage
- Thermal Analysis & Management
- Control Standards & Distribution

Outline

- Microgrid vs. Tactical Microgrid
- Evolution of Tactical Power
  - Mobile
  - Sustainable
  - Resilient
- Research Efforts
  - Paralleling
  - Tactical Microgrid Standard
  - Energy Storage Integration
  - Vehicle Integration
- Conclusion

Microgrid



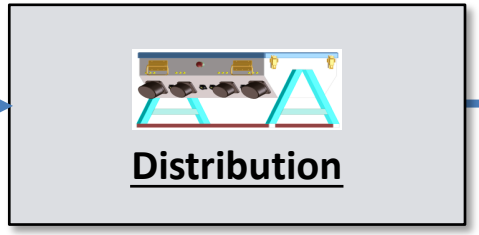
Installation Microgrid

Ft. Hunter Liggett Solar Microgrid

https://grist.org/climate-energy/u-s-military-gets-serious-about-microgrids-which-is-more-exciting-than-it-sounds/

https://www.bothman.com/projects/federal-government/fort-hunter-liggett-phase-2-1-mw-solar-micro-grid

Tactical Microgrid



Power Architecture

- Grouping of power sources, distribution and loads
- Self-contained
- Acts as a single controllable entity

Tactical

- Readily Deployable
- Installed and operated by user

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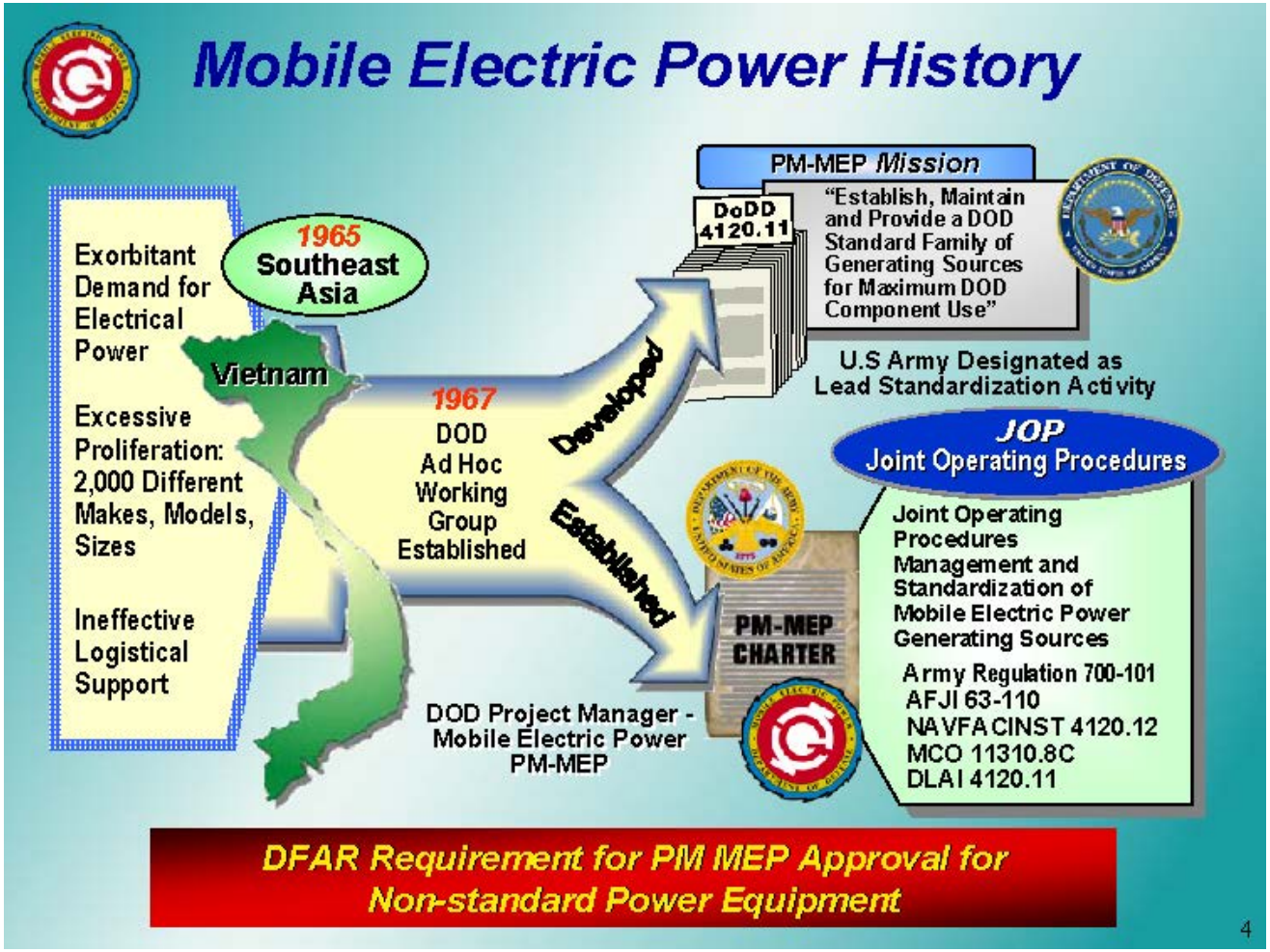
- Power has provided the Warfighter capability for over a century
- Beginnings of mobile power generation

Mobile generator sets mounted on 4-wheel trailers powering anti-aircraft searchlights during World War II

https://olive-drab.com/od_electronics_mep.php

- PM MEP (Mobile Electric Power) currently PM E2S2 (Expeditionary Energy and Sustainment Systems)
- PM E2S2 standardized mobile electric power generating sources

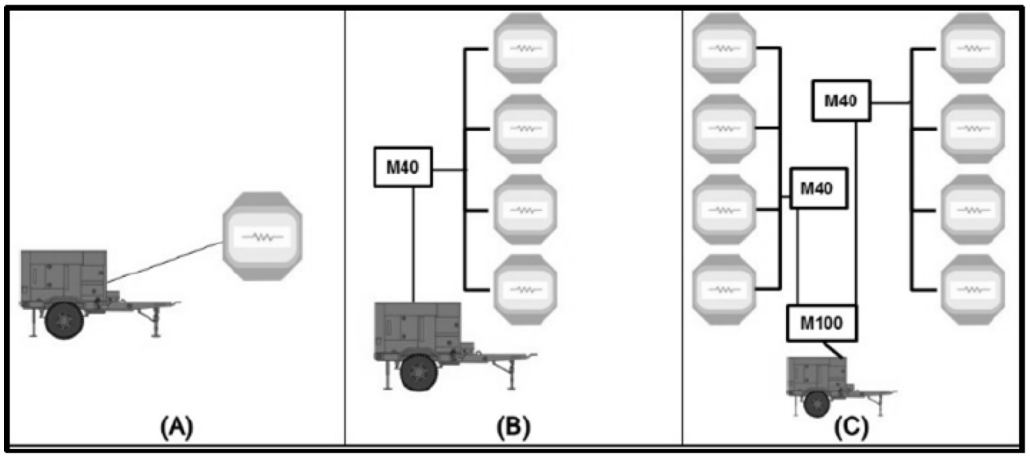


"Mobile Electric Power for Today and Tomorrow" - PM MEP. Joint Service Power Expo

- Fewer units, military standard parts, better performance
- More sustainable tactical power

"Mobile Electric Power for Today and Tomorrow" - PM MEP. Joint Service Power Expo

Spot Generation



ATP 3-34.45 – “Electric Power and Distribution”

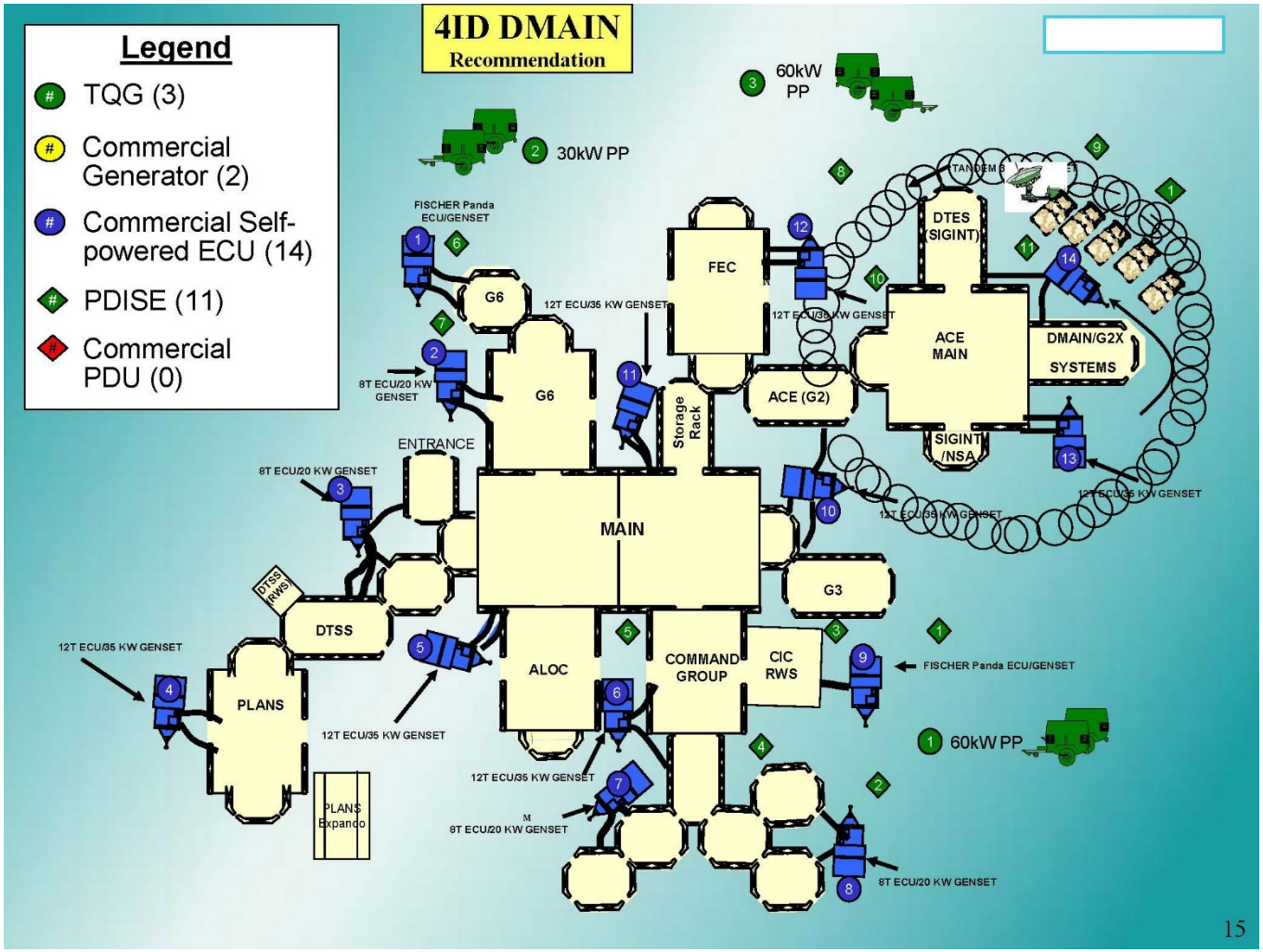
Wet stacking from unburned fuel

http://www.austingenerator.com/wet-stacking-and-load-bank-testing/

Supply often exceeds demand, reducing efficiency, and increasing wear on generators

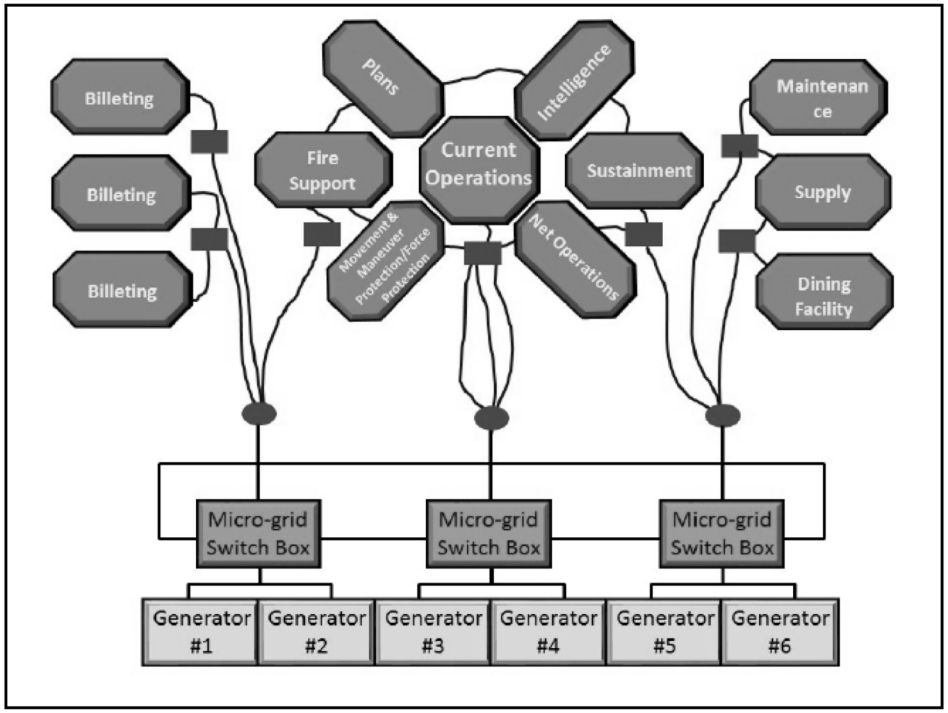
Status Quo

- During counterinsurgency operations, spot generation at a large scale drove up demand for fuel
- Fuel supply convoys were compromised.
- Needed a more resilient solution



Tactical Microgrid

- Optimized Fuel Consumption: Autonomous start-up and shutdown of generators based on demand
- Redundancy: Multiple generators can share load
- More resilient and sustainable



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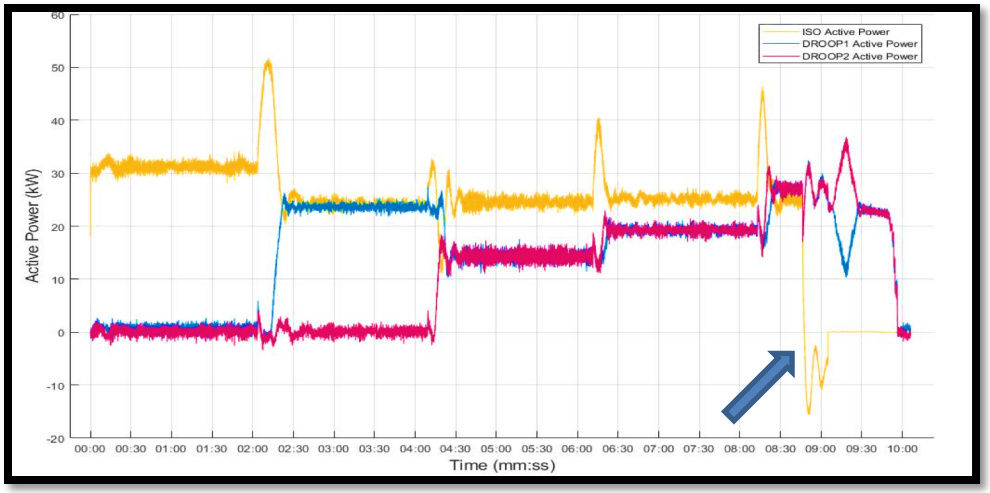
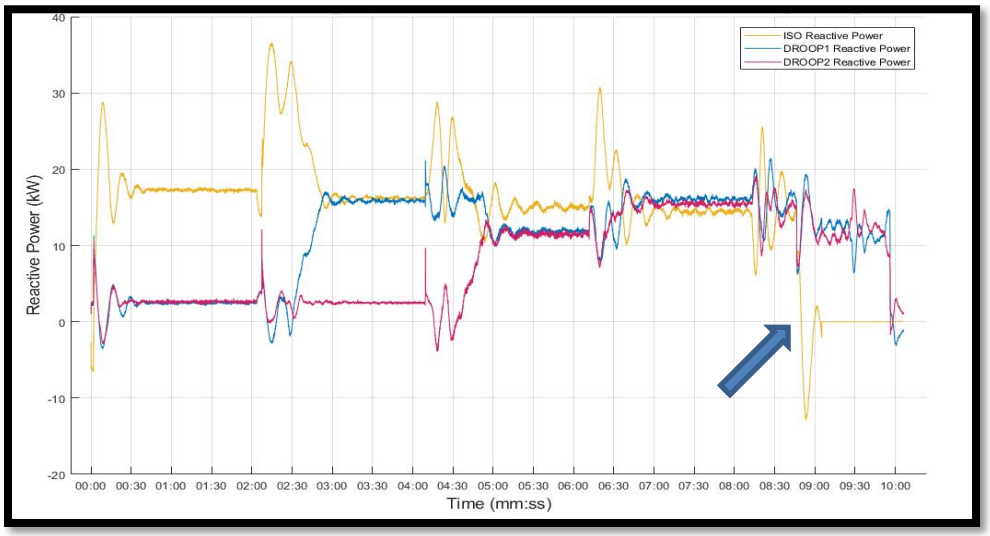
Paralleling Challenges

- Three 30kW generators meet MIL-STD 1332B performance requirements in standalone operation
- Oscillations in both active and reactive power, generator set controllers unable to share load
- Reverse power on ISO unit, opening output circuit breaker, leading to microgrid blackout

Active Power



Reactive Power



Auto-Tuning

Motivation:

- Tuning of paralleled sources is essential for tactical microgrids
- Sources may require re-tuning as tactical microgrid topology changes to mission's demands
- Tuning is a time-intensive process requiring specialized personnel and equipment
- Soldiers do not have the equipment or expertise to constantly retune sources

Objective:

- Develop a vendor agnostic, automated tuning solution, suited for a variety of microgrid configurations

Approach:

- Digital integration of control parameters
- Model Based System Engineering (MBSE) and Parameter Identification

Please refer to the following paper for more information:
"Auto-Tuning for Military Microgrids," 2019 IEEE Energy Conversion Congress and Exposition (ECCE)

AMMPS

- Improved Generator
  - Quieter and lighter
  - Increased fuel efficiency
  - Reduced wet stacking
- Microgrid Capability
  - Auto Start/Stop.
  - Load-sharing
- Proprietary System
  - Hinders communication and coordination with other systems

https://asc.army.mil/web/portfolio-item/cs-css-advanced-medium-mobile-power-source-ammps-microgrid/

Tactical Microgrid Standard (TMS)

Generic Devices

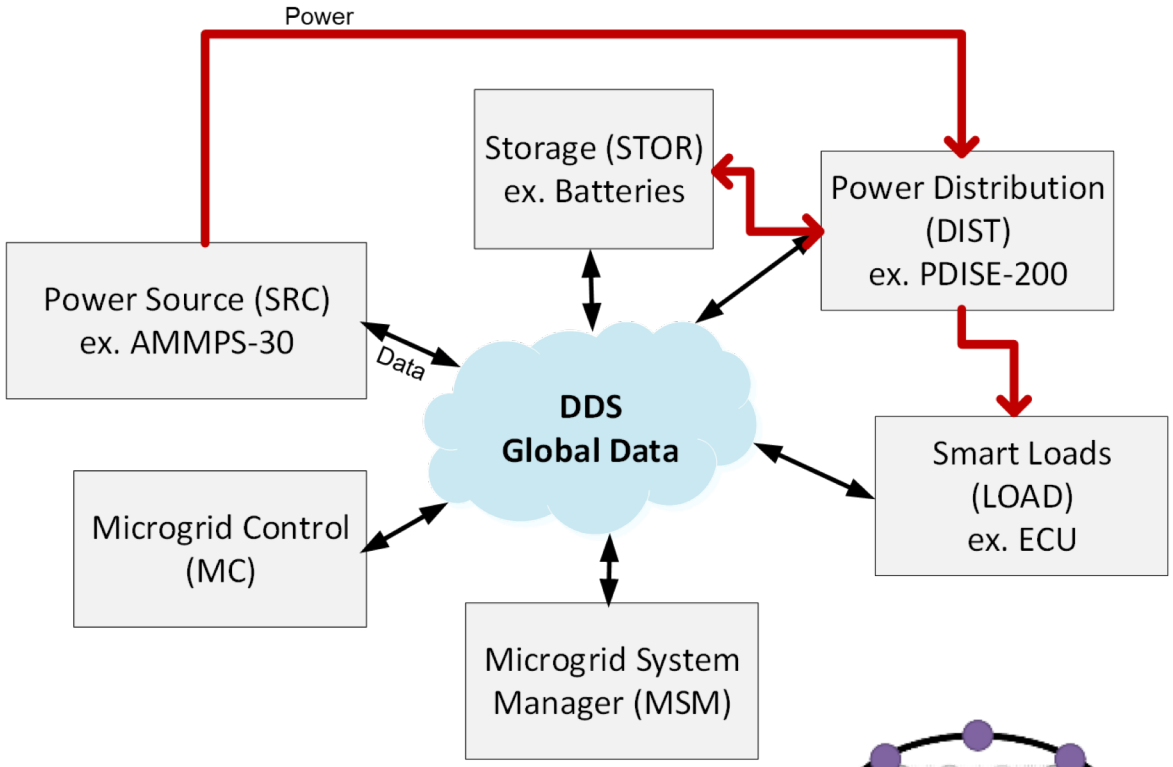
- **SRC, STOR, DIST, MC, LOAD, MSM**

Pub/Sub Architecture

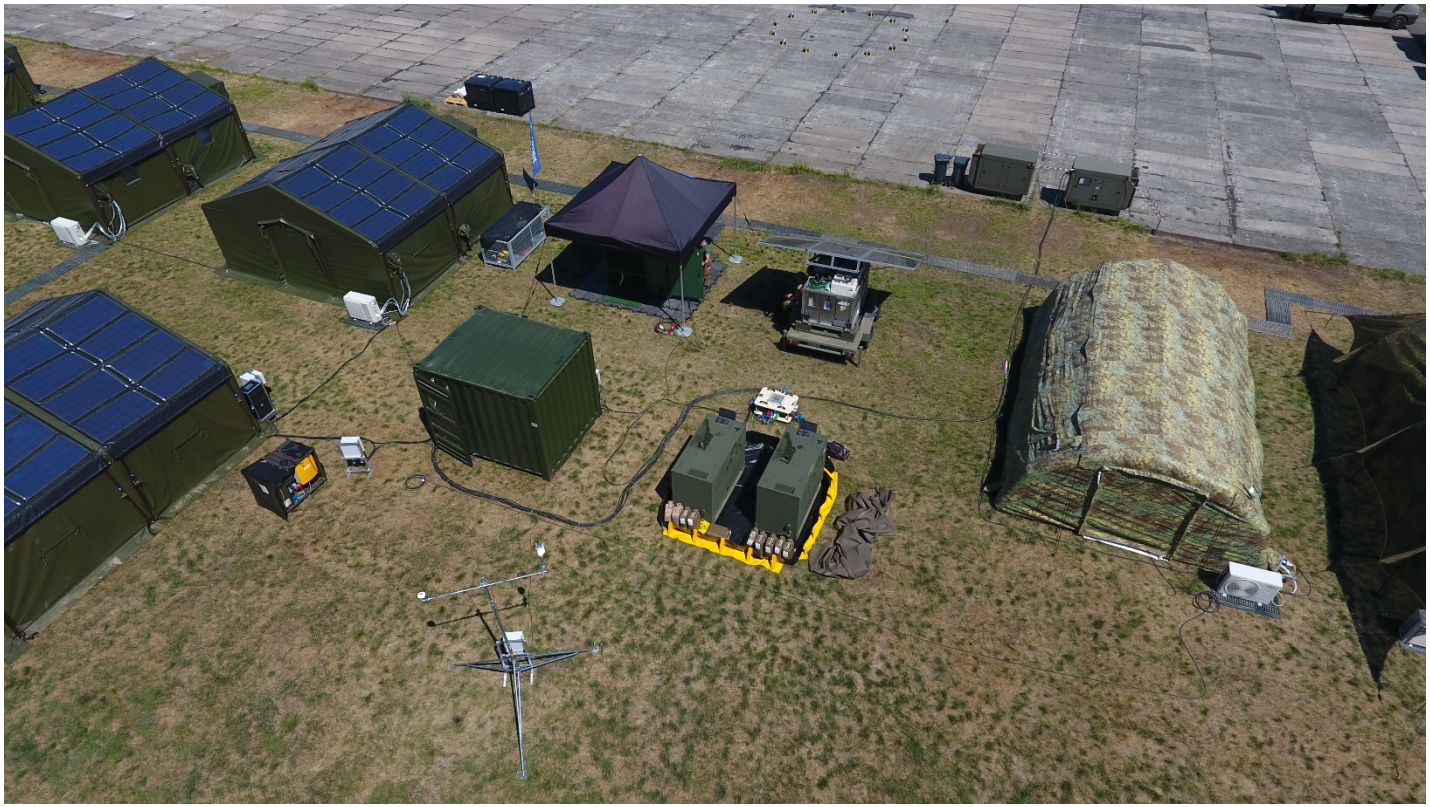
- **Object Model Group (OMG) Data Distribution Service (DDS)**

Default Device Behaviors

- **Communications Loss**
- **Device Discovery**



TMS Demonstration



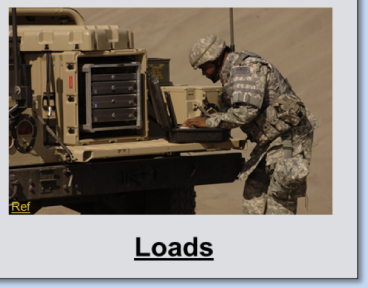
At NATO exercise Capable Logistician 2019 in Poland, U.S. Army and Italian Air Force formed microgrid of 2 AMMPS generators and an Italian battery-based inverter system, via TMS

Multi-Domain Operations (MDO)

Tactical Intelligent Power Architecture

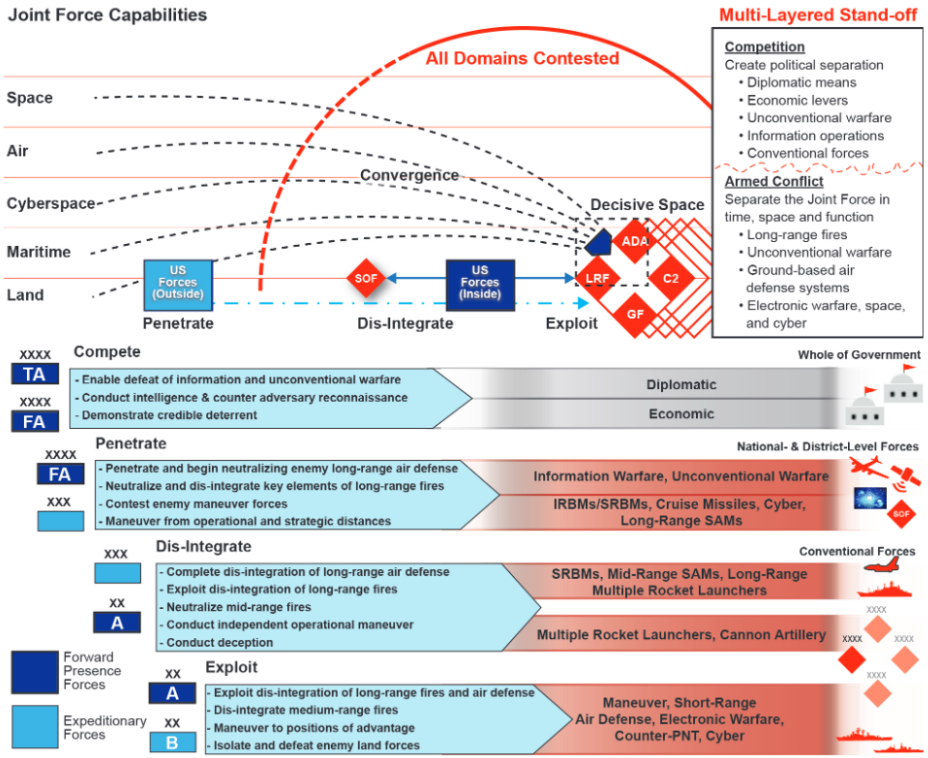
Sources

Distribution



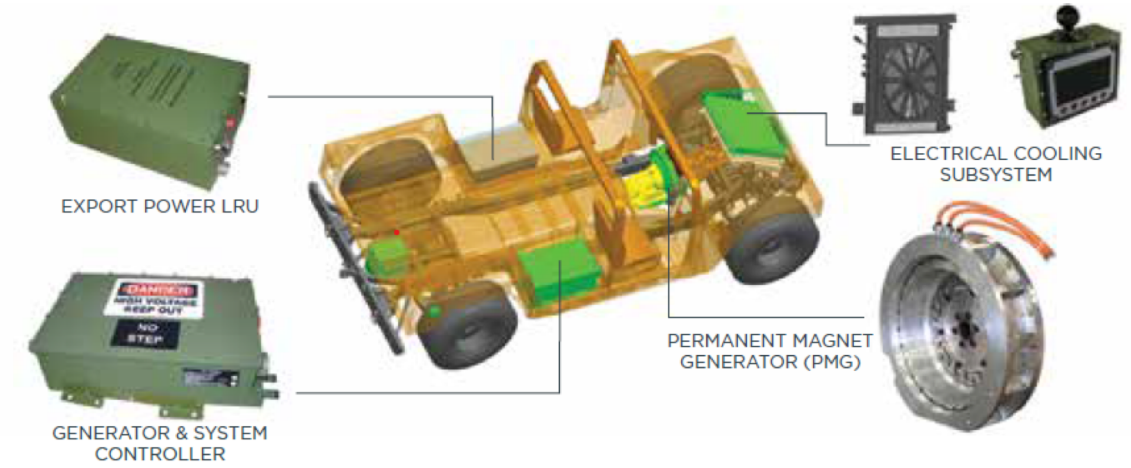
Loads

ENABLES



Vehicle Integration

- On-Board Vehicle Power
- V2G (Vehicle to Grid)
- Rapid deployment of tactical microgrids
- Increased mobility for tactical power in MDO



HMMWV OBVP kit components; the system includes the PMG, power management and cooling.

https://www.leonardodrs.com/media/9027/titan-obvp-brochure.pdf

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Power Enables Capability

- For the past century, tactical power has evolved based on growing demand for power

Preparing for MDO:

- Multi-Domain Operations will require mobile, resilient, and sustainable tactical power

Enabling Technologies:

- Tactical Microgrid Standardization
- Energy storage and Vehicle Integration