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· August 15-18, 2010 · Dallas, Texas ·
· Dallas Convention Center ·

Power Access and Control Technology for Military Microgrids and Tactical Shelters

Tarek Abdallah (U.S. Army)
Barton Bennett (Odyssian Technology)

Presentation Outline

Tarek Abdallah

- Introduction
  - Need for Improved Power Systems & Efficiency
  - Energy Policy Guidance
- Technology Needs and Challenges

Barton Bennett

- Insights Into Innovative Solutions
  - Case Study 1: Microgrid for Fixed Army Installations
  - Case Study 2: Phase Balancing for Army Tactical Shelters
- Conclusion
- Q&A

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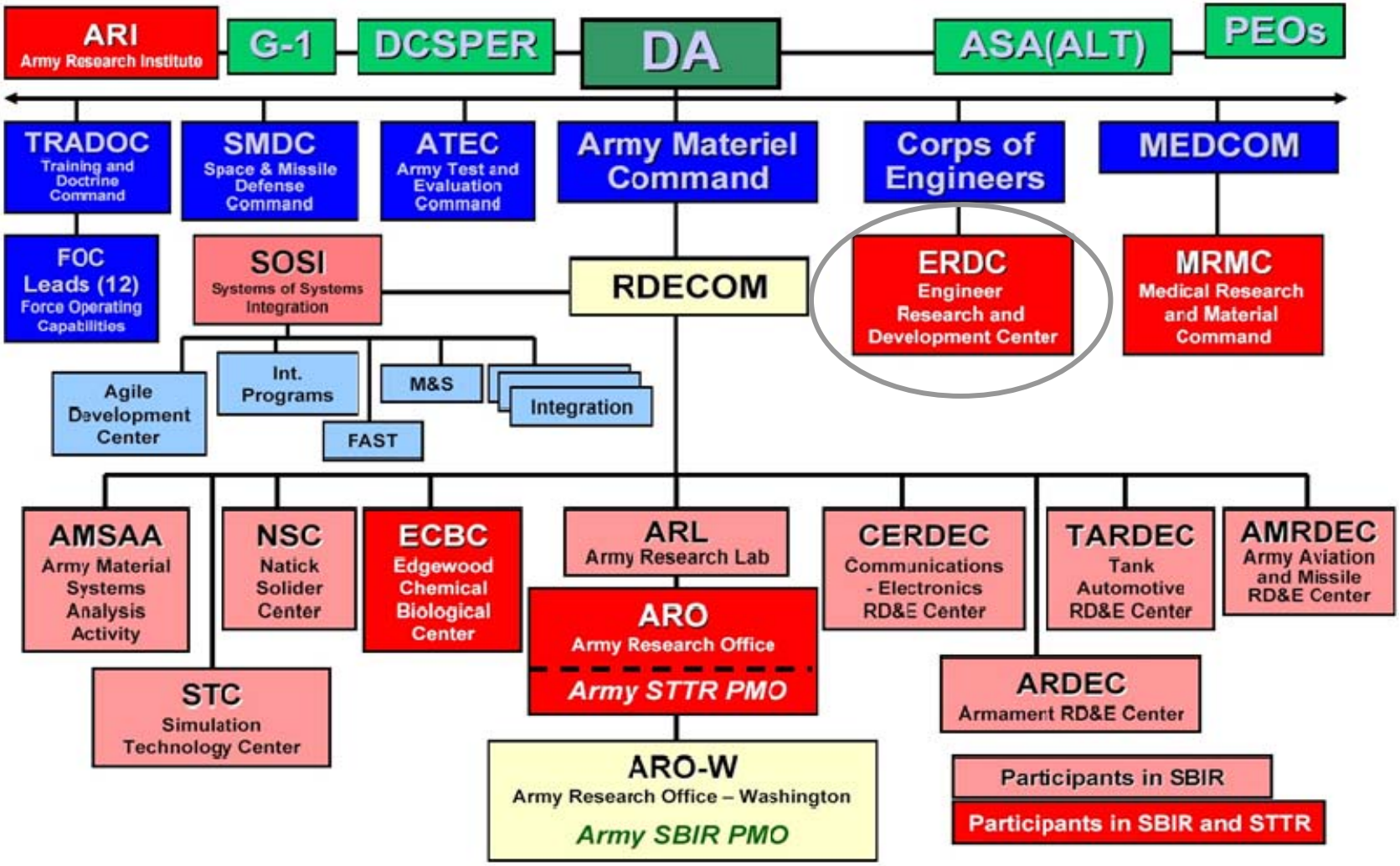
ARMY R&D Organizations



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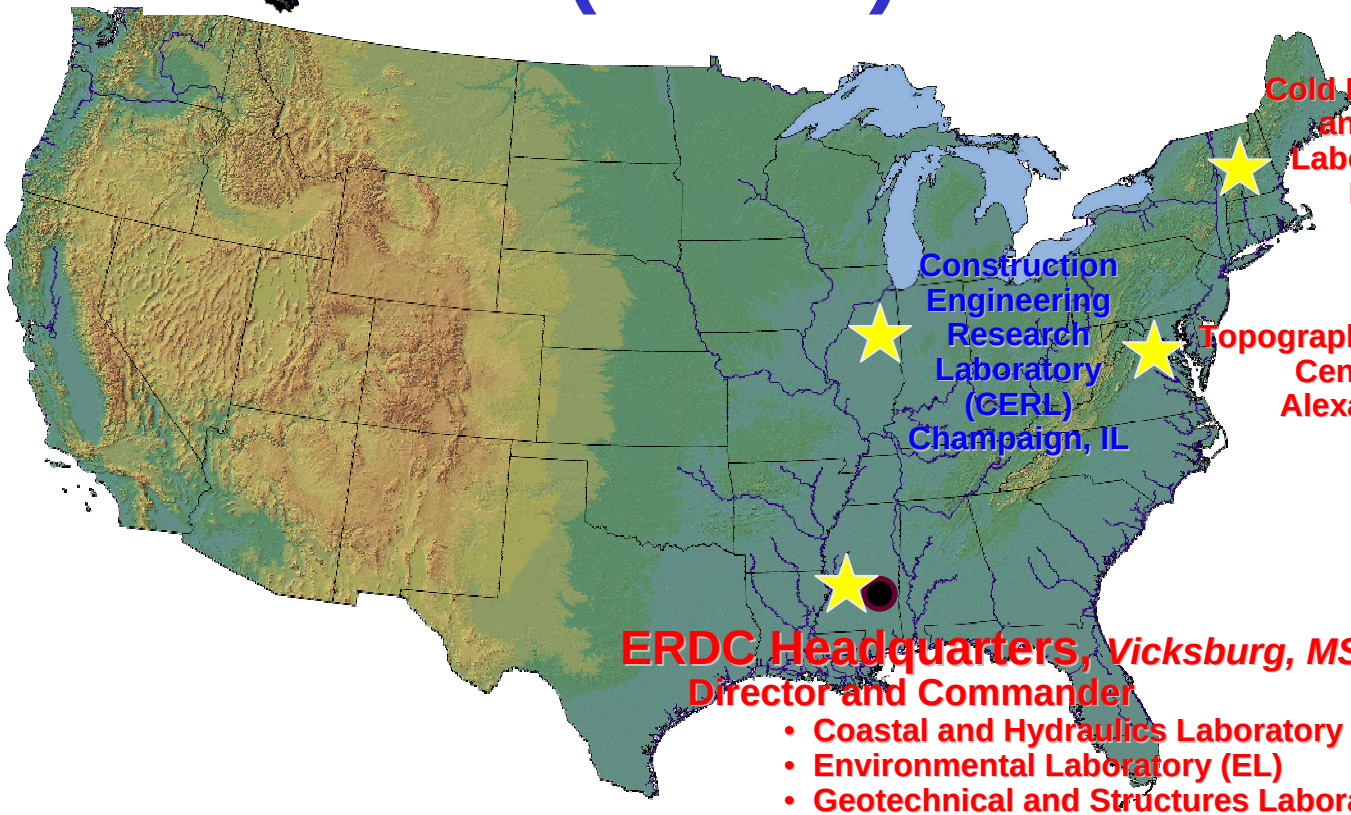
Engineer Research and Development Center (ERDC)



ERDC Headquarters, ***Vicksburg, MS***

Director and Commander

- **Coastal and Hydraulics Laboratory (CHL)**
- **Environmental Laboratory (EL)**
- **Geotechnical and Structures Laboratory (GSL)**
- **Information Technology Laboratory (ITL)**

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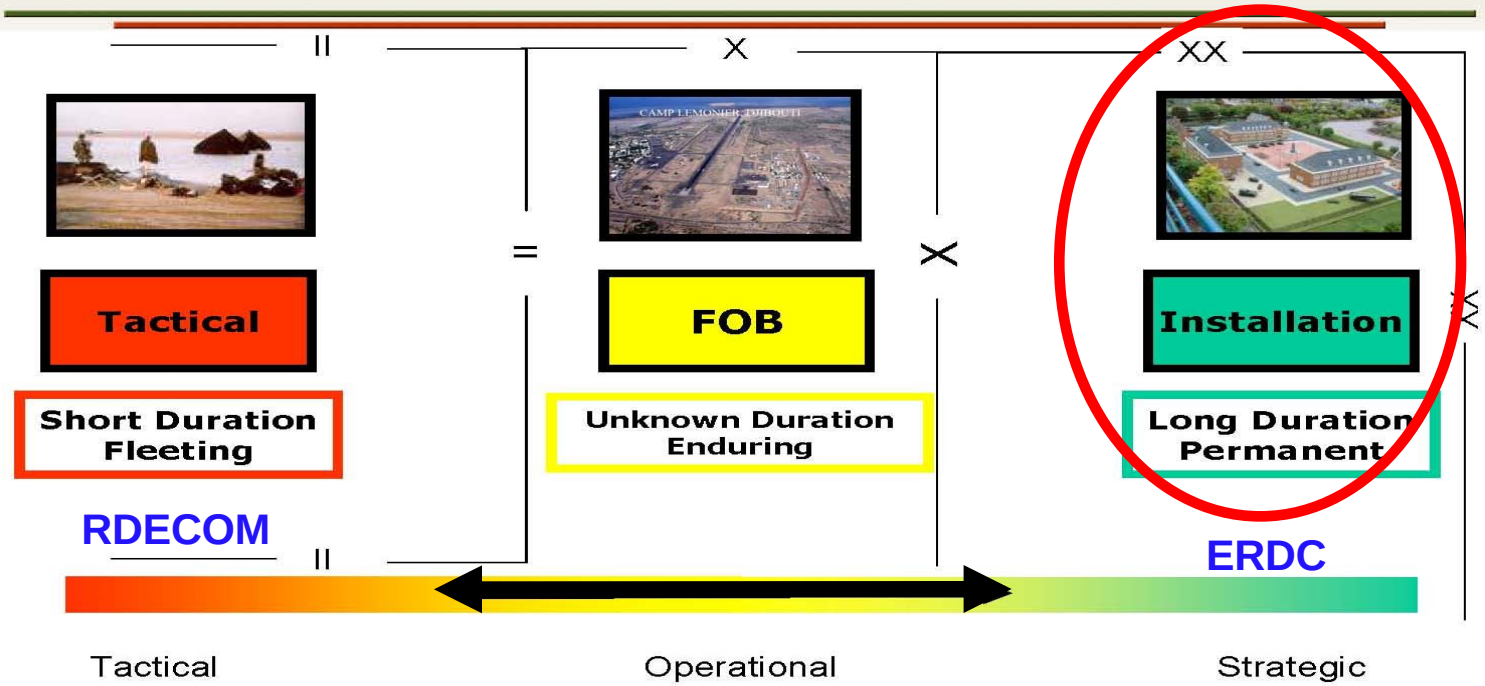
Spectrum of Army Power & Energy

Support Full Spectrum Power & Energy

Home Station – to – Foxhole



* D. Nolan, REF, Tactical Power Sources Summit, Jan 2007

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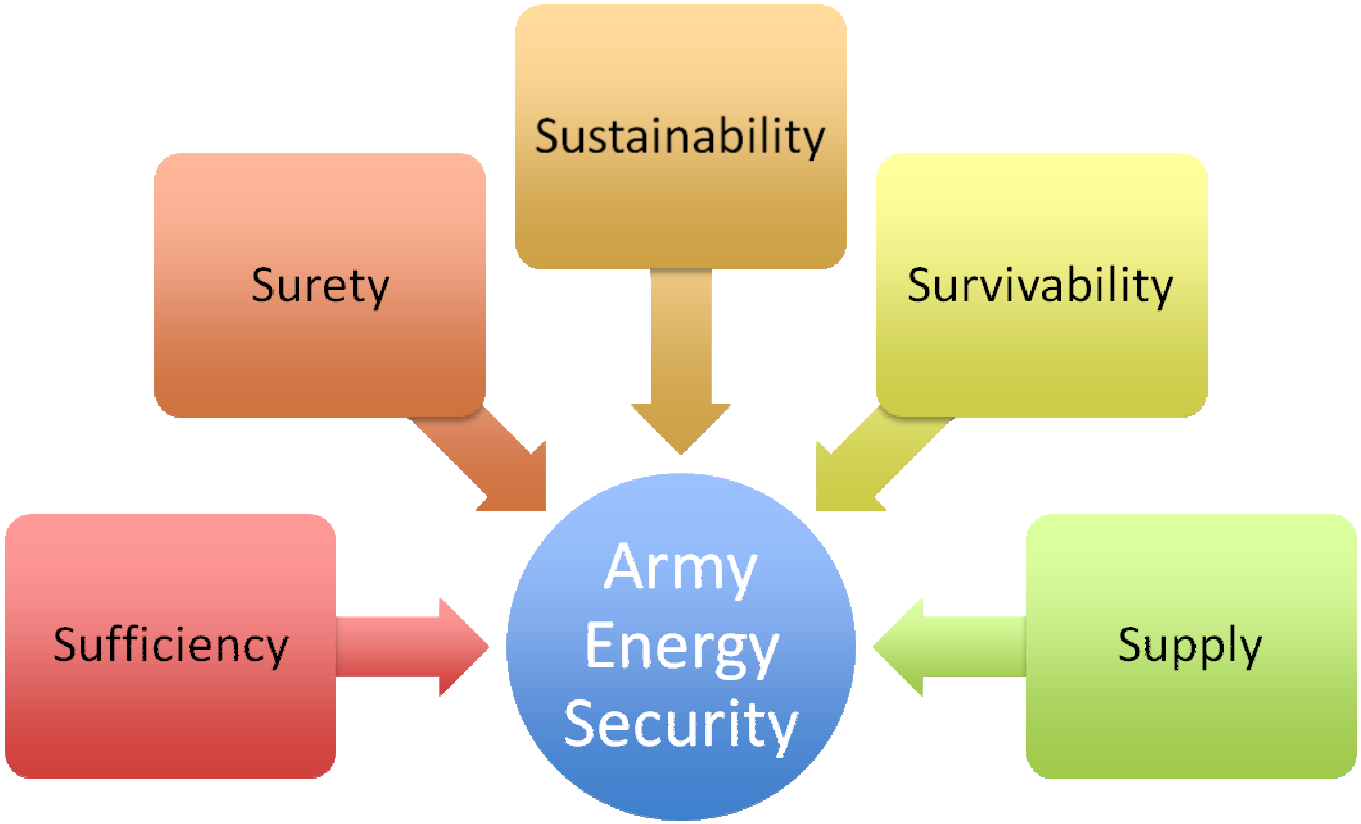
Army Energy Security



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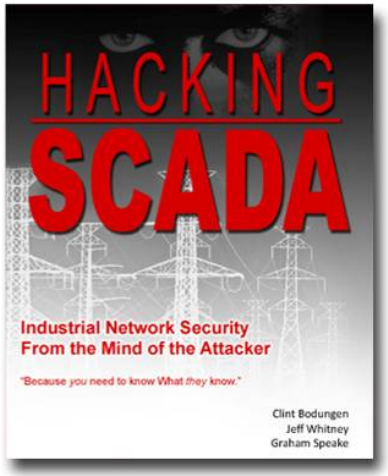
U.S. Power Systems Are Vulnerable

- Physical attacks to the grid is a long-know issue
  - Lovins' "Brittle Power" in early '80s
- CIA discloses to public they have information of cyber attacks against power system controlled from outside the US.
  - Have resulted in multi-city outages
  - Extortion is a motivation
- US Power systems have been probed
- Connectivity to substations & digital hardware exist
  - NERC Survey (modems, SCADA, internet, etc…)
  - Restoration time is critical, availability is priority
- Parallels exist to EMP threat; mitigation strategies
- Short Term Outages well understood/contingency ops executed regularly for Wx, system failures



Extended Grid Outages an Unknown Experience in the US

Recent Energy Policy Guidance

- Energy Policy Act of 2005
- Army Energy Strategy for Installations - 2005
- Executive Order 13423 - 2007
- Energy Independence & Security Act - 2007

Energy Policy Act of 2005

- **Effective on August 8, 2005**
- **Federal Facilities Provisions**
  - Energy Reduction Goals - 20% by FY 2015 (rel. to 2003)
  - Energy Efficient Buildings - 30% better than ASHRAE standards
  - Renewable Energy – Purchase 7.5% or more in 2013 and beyond
    (DoD Internal Guidance is 25% by 2025)
  - Energy Efficient Products – Install Energy Star or FEMP designated products

Army Energy Strategy for Installations

- The 2005 Strategy sets the general direction for the Army in five major initiatives:
  - Eliminate energy waste in existing facilities
  - Increase energy efficiency in new construction and renovations
  - Reduce dependence on fossil fuels
  - Conserve water resources
  - Improve energy security

Executive Order 13423

- Signed on January 24, 2007
- Federal Facilities Provisions:
  - Reduce Energy Intensity 30% by 2015 (rel. to 2003)
  - Reduce greenhouse gas emissions through reduction of energy intensity by 3% annually or 30% by 2015
  - At least 50% of current renewable energy purchases must come from new renewable sources (in service after January 1, 1999)
  - Construct or renovate buildings in accordance with sustainability strategies, including resource conservation, use, site criteria, and indoor environmental quality

Energy Independence & Security Act

- Effective on December 19, 2007
- Federal Facilities Provisions
  - Energy Reduction Goals - 30% by FY 2015 (rel. to 2005)
  - Increased use of Energy Savings Performance Contracts (ESPCs – Third Party Financing)
  - Fossil Fuel Generated Energy Reduction (rel. to 2003 levels)
    - 55% by 2010
    - 65% by 2015
    - 80% by 2020
    - 90% by 2025
    - 100% by 2030

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Use of Alternative Energy Technologies

- **To meet renewable energy, "Net Zero" energy, and energy security goals, DoD installations are beginning to install relatively large, on-site distributed generation technologies.**

- **Today, these systems are connected to the local utility grid or to the building for which they are providing emergency back-up power.** ***They are <u>not</u> interconnected and networked as an integrated system, to serve multiple loads or perform multiple functions*.**

- **New networking and control approaches are needed to maximize the use of these distributed renewable energy technologies, which improve environmental sustainability, power supply reliability, and energy security at military installations.**

Technology Advances Needed to Achieve Full-Spectrum Power Delivery Architecture (Ref)

- **Smart power delivery system**
- **Advanced distribution automation**
- **Fast simulation and modeling**
- **Integrating distributed energy resources**
- **Distributed storage technologies**
- **Power system operation and control**
- **Reduce vulnerability to natural disaster & attack**
- **Improve power quality**

Army challenge → adapt national tech advancements to blend with & scale the power vision home station-to-foxhole

Ref: *Power Delivery System and Electricity Markets of the Future*, EPRI, Palo Alto, CA: 2003. 1009102

What is the technical challenge

- **Avoid adverse mission impact from energy disruptions caused either by natural, accidental or intentional events.**

  - Seamless transition from Power Grid to Island Mode

- **Development of advanced distribution and control technology for hybrid intelligent microgrids.**

  - Allows use of a variety of distributed energy resources

- **Load to source balancing**

  - Metering and rapid switching

  - Balance load to supply according to mission priorities

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Odyssian Technology

Barton Bennett
President – Technology Development

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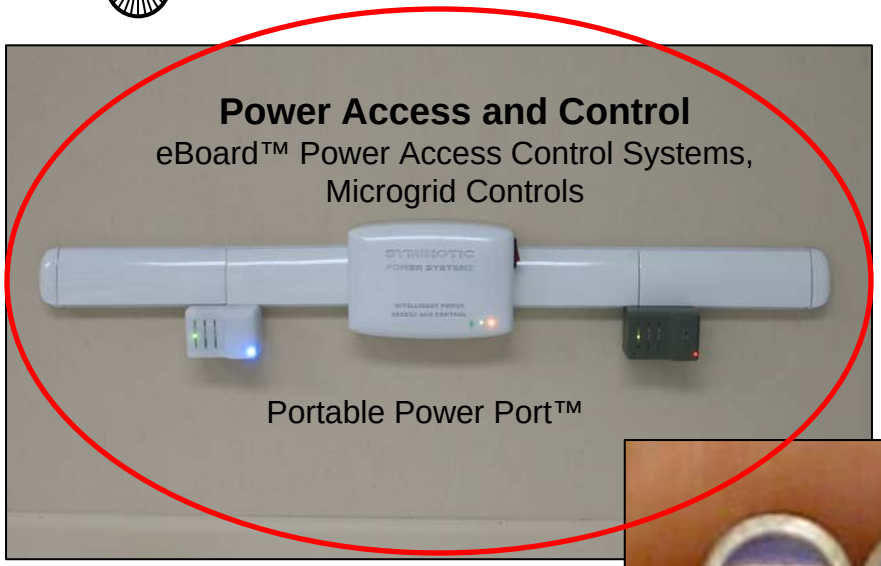
About Odyssian Technology

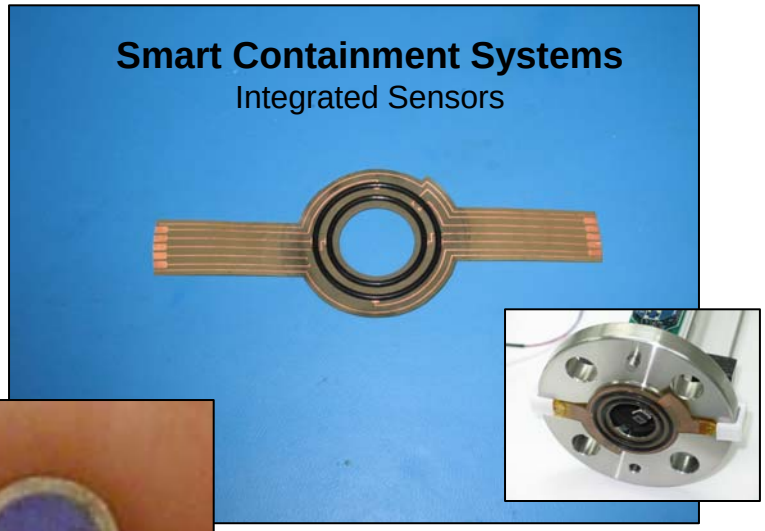
- Technology Development Company
  - Started 2002

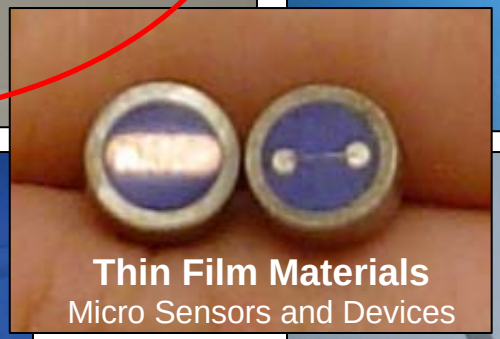
- Core Enabling Technology Areas,
  - Multifunctional, Smart structure
  - Composite Structure
  - Thin Film Processing
  - Power Access and Control

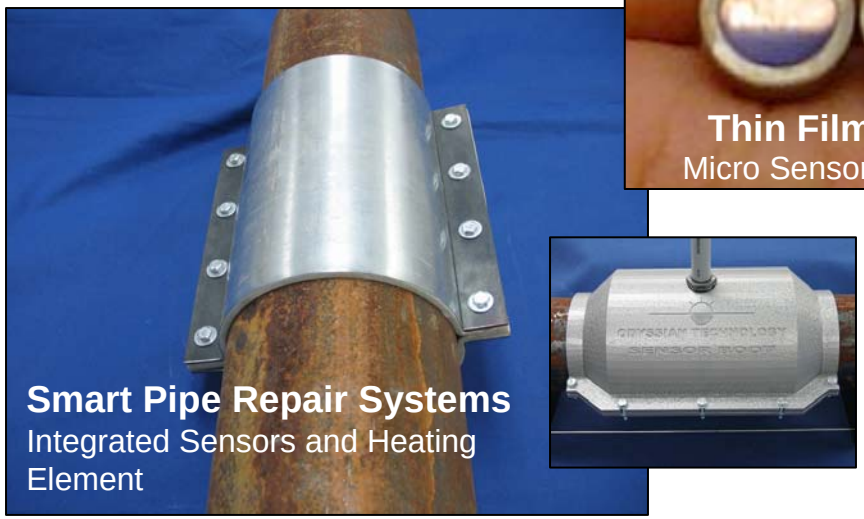
- Product Dev Portfolio,
  - ① Smart Pipe/Sealing Systems
  - ② Multifunctional Structures for UAS
  - ③ Thin Film Igniters for Missile Systems
  - ④ Power Access and Control Systems (e-Board™, etc.)
  - ⑤ Smart Composite Pipeline Repair Systems

Odyssian Technology









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Innovation in

POWER ACCESS AND CONTROL

Symbiotic Power Systems™

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Power
Consumer Access

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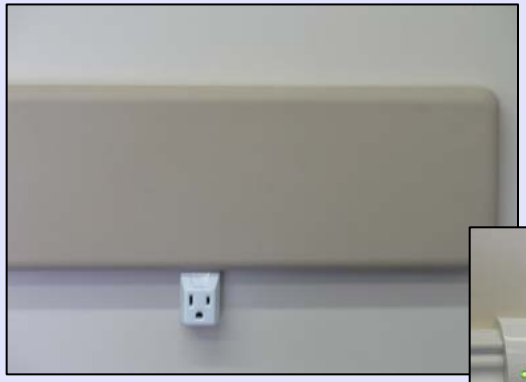
Power Access Technology

eBoard™
Power Track System

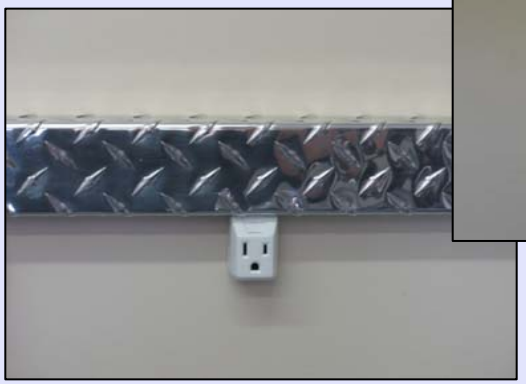


Industrial Wall Guard Systems

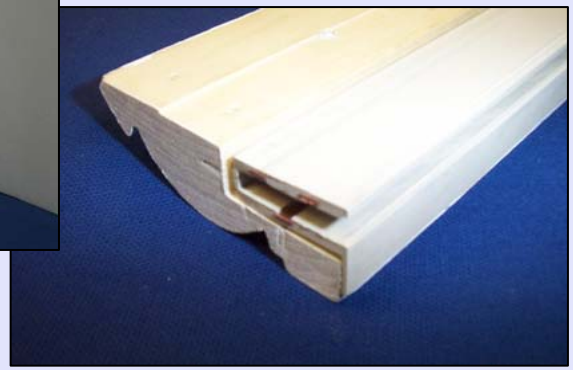
Plug-in Adapters

Power Control Module
- Wireless control
- Power conditioning
- Overload and safety protection

Home and Office Systems



Garage and Workshop Systems



Power Track

*- May include low voltage signal circuit

US Patent 7,374,444 Other patents pending

Structural eBoard™

Case Study 1: Microgrid Control

- Comprehensive interconnected mesh network to control distributed generation assets in concert with system loads through multi-layer intelligent load shedding. Device level power access and load control provided using technology called eBoard™.
- Fast response lower level control maintains system stability while upper level control optimizes the balance of electrical load to available capacity.
- Offers a novel solution of an integrated intelligent control design that allows for the plug-and-play of a diverse range of various distributed power generation assets.

US Army Corps of Engineers
Engineer Research and Development Center

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Advanced Distribution and Control for Hybrid Intelligent Power Systems

(Army Phase II STTR)

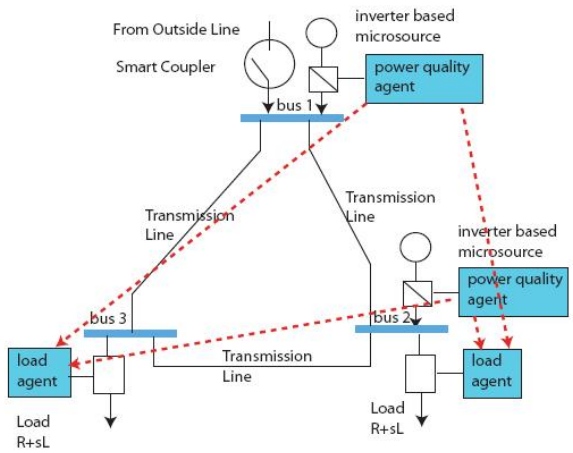
Scope

Develop intelligent microgrid control and power distribution/access system

Objectives

Develop and demonstrate,

- ✓ Distributed control strategy for mesh microgrids
- ✓ Intelligent power distribution and control
- ✓ Device level load control



Funding

U.S. Army: ~$750K over 2 years

Program Customer

Construction Engineering Research Lab (CERL)
CERL COR: Tarek Abdallah

Program Participants

Odyssian Technology (prime), UIUC, UW-Madison, University of Notre Dame, AEP

Phase II STTR Technical Activity

- ✓ Develop Microgrid Design & Simulation
- ✓ Develop Distributed Control Technology
- ✓ Develop Novel Power Access and Microgrid Load Control Technology (eBoard™ derivative)
- ✓ Develop Microgrid Inverters

Time Line: November 2009 – October 2011

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Power microgrid definition:

1. A relatively small capacity power grid made up of distributed renewable and non-renewable power generation assets, storage assets, and controllable loads.

2. Secondary power grid (subgrid) that can be isolated and reconnected to a main or primary high capacity power grid.

Army STTR Program
"Advanced Distribution and Control for Hybrid Intelligent Power Systems"

Unique microgrid requirements:

1. Limited capacity and low mass synchronous generation devices requires higher level of quick response control to maintain grid stability and utility.
2. Highly dynamic environment of Army Installation requires intelligent control with multiple control schemes.
3. Potentially disruptive environment during battle requires redundancy in power and control networks.
4. Potentially long term isolation from primary power grid and need for continued operations under adverse conditions requires "consequence modeling" and control algorithms that are specific to possible mission scenarios.

Army STTR Program

"Advanced Distribution and Control for Hybrid Intelligent Power Systems"

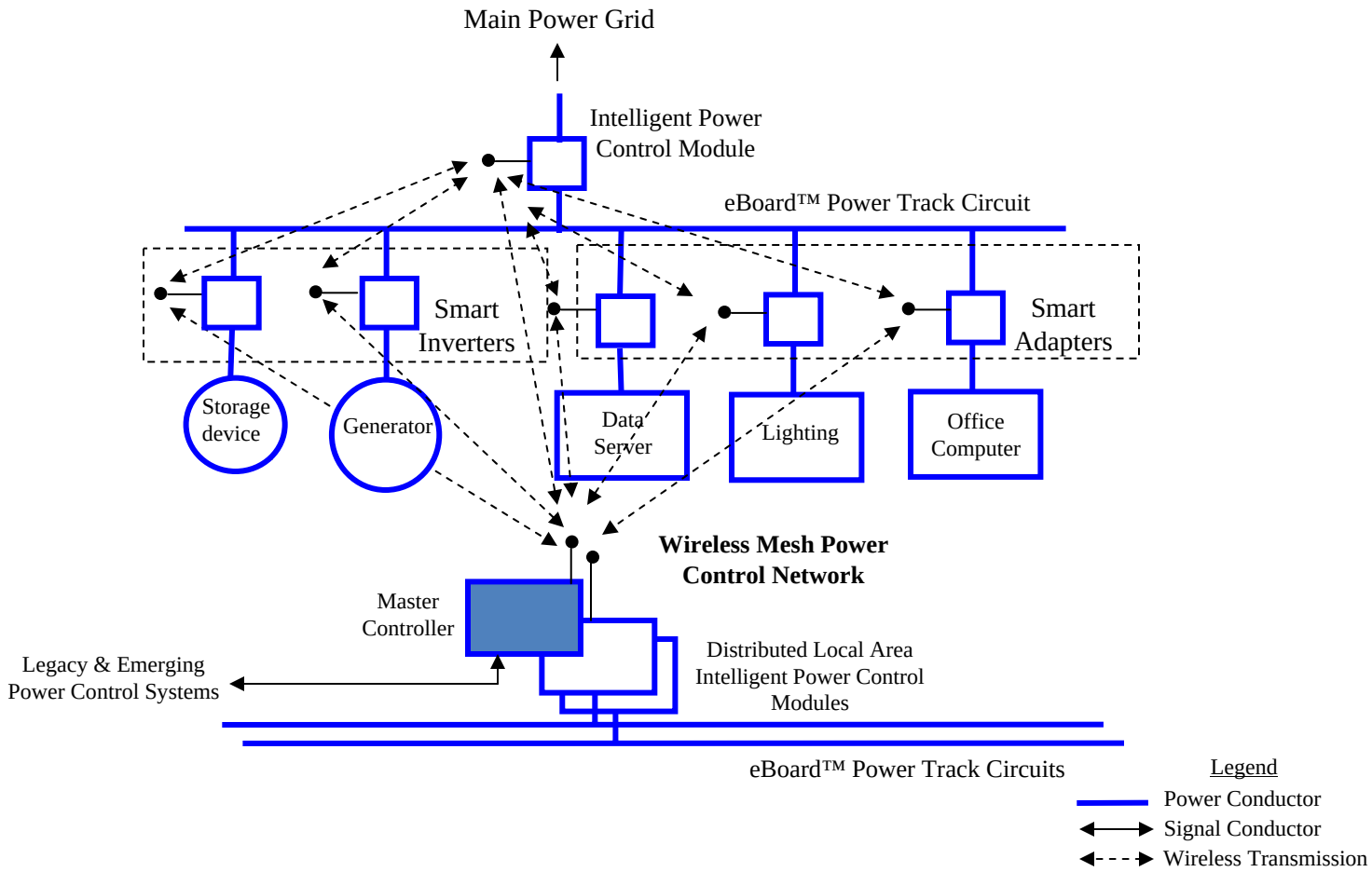
Army microgrid attributes:

1. *Two layer control architecture*
   a. Instantaneous condition-based distributed control to maintain stability.
   b. Wireless or wired distributed control for dynamic reconfiguration and recovery.
   c. Distributed GUI control for monitoring and manual over-ride.

2. *Power microgrid with distributed renewable and non-renewable generation assets, storage assets, and loads.*
   a. Synchronous and non-synchronous generation devices.
   b. Smart Inverters for source monitoring and control.
   c. Smart Adapters for load monitoring and control.

3. *eBoard™ power access and load control.*
   a. Multi-level and device-level load control

Mesh Communication Network Between Distributed Generators, Storage, and Load Controls to Maintain System Stability and Control



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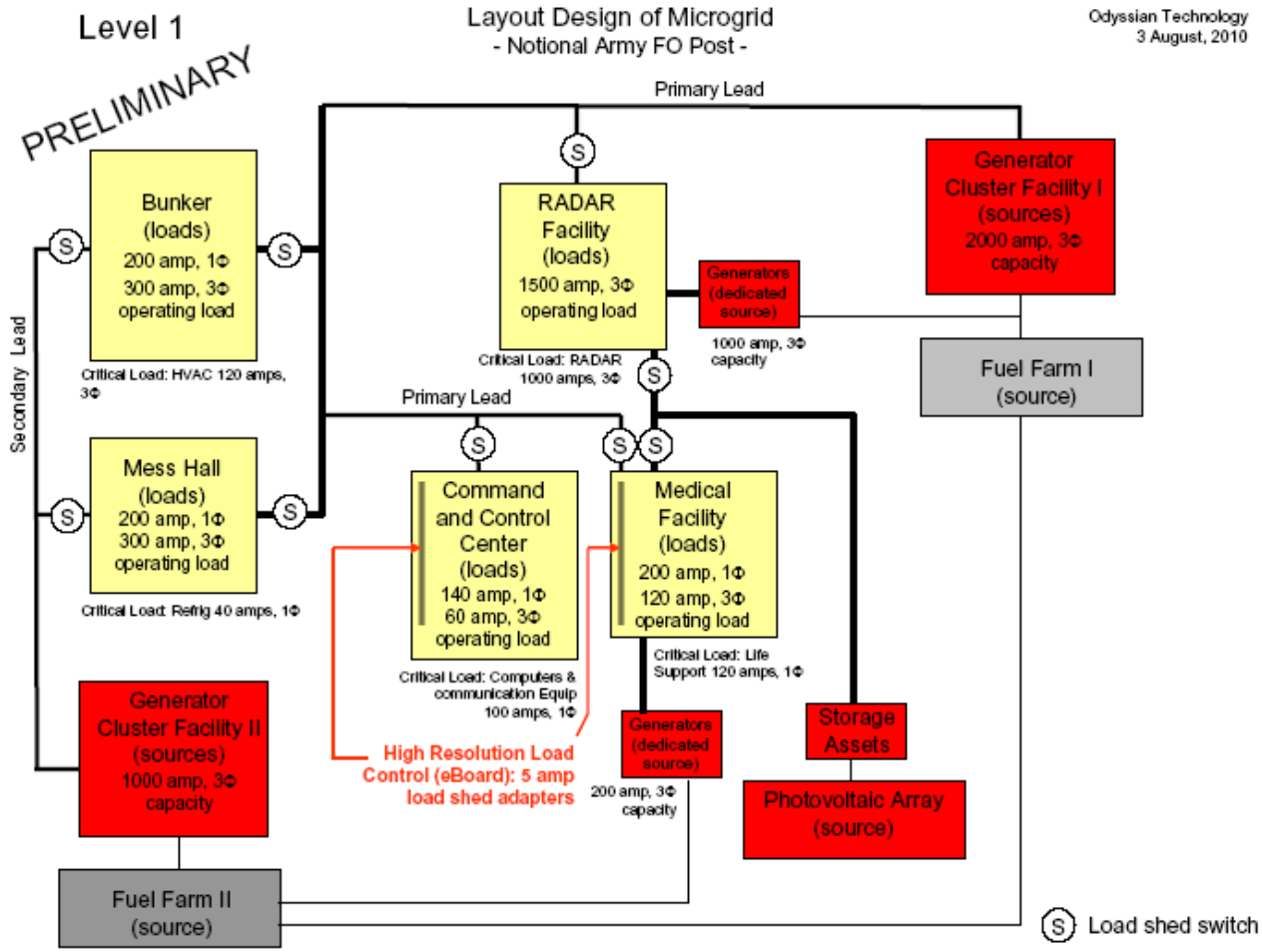
Notional Military Microgrid



Military MicroGrid for Dynamic Environment

Hardened with grid redundancy, non-centralized generation assets and fast-response distributed intelligent control.

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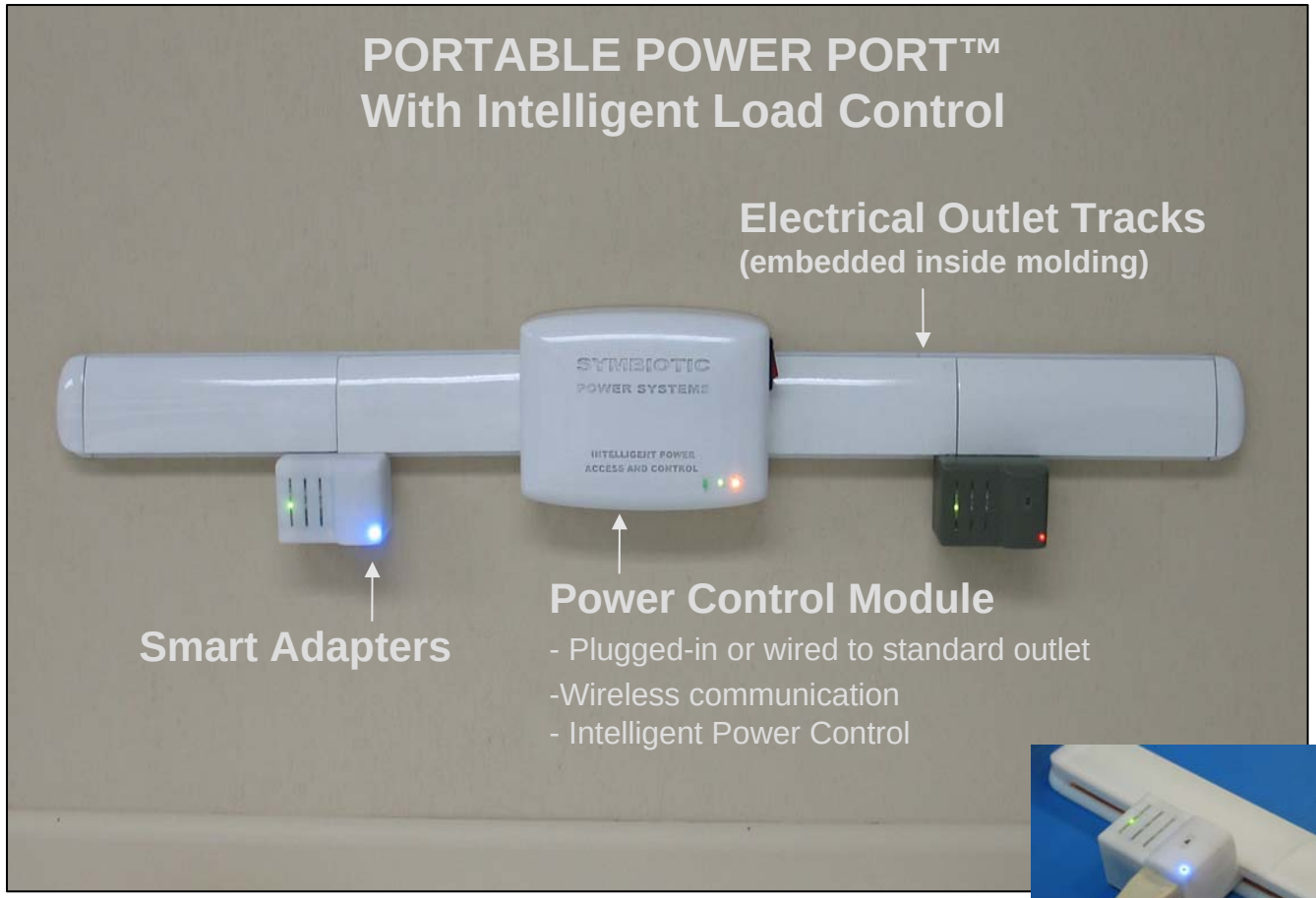

Patented: US 7,374,444 B1 (other Patents Pending)

eBoard™
Power Track System Integrated within Molding

US Patent 7,374,444 Other Patents Pending

eBoard™
Power Track System Integrated within Molding

US Patent 7,374,444 Other Patents Pending

Case Study 2: Phase Balancing

- Phase balancing between legs of a 3-phase system
  - Device level within Army Tactical Shelters
  - Improve efficiency and power quality
  - Reduce thermal signature
- Fast acting switching to balance loads
- Use of capacitive and resistive load cells for power factor correction and fine load balance

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Power Access And Control Technology For Use In Army Shelter Systems

(Army Natick R&D BAA)

Scope

Develop technology for assigning and balancing device-level electrical loads across a 3-phase circuit within an Army shelter system.

Objectives

- ✓ Practical, reliable, safe, and convenient means for balancing electrical loads
- ✓ Improve convenience in accessing power
- ✓ Reduce time to install electrical system

Funding

U.S. Army: $1.4M over 2 ¾ years (if fully funded)

Program Customer

U.S. Army Natick Soldier RD&E Center

Natick COR: Richard Manzano

Time Line: November 2009 – June 2012

Major Program Activity

- ✓ Base: Power System Study
- ✓ Option 1: Dev non-intelligent prototype system
- ✓ Option 2: Develop intelligent prototype system
- ✓ Option 3: Manufacture, install, and validate production ready intelligent 3-phase load balancing system

eBoard™ Smart Adapter
Metering and Switching to Achieve Load Balancing

Conclusion

- Power system vulnerability and military energy policy requires changes in power access and control.
- Device level metering and control integral to future microgrid control systems.
- Device level metering and control used for load balancing and power quality improvements within tactical shelter.
- eBoard™ provides an innovative option for improving access to power while metering at the device level.
- Multi-level metering and high-resolution load control are key elements in future military hardened power grids.

Questions?