



U.S. Army's Ground Vehicle Energy Storage R&D Programs & Goals



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- **DOD Power & Energy Requirements**
- **DOD Energy Storage R&D Challenges**
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- **Summary**



Energy Storage Goals and Mission



Energy Storage Goals

- Develop **safe, reliable and cost** effective energy storage systems
- Reduce **battery weight & volume burden** (Increase Energy & Power Density)
- Reduce logistics and fuel burdens
- Enhance performance, extend **calendar and cycle life**

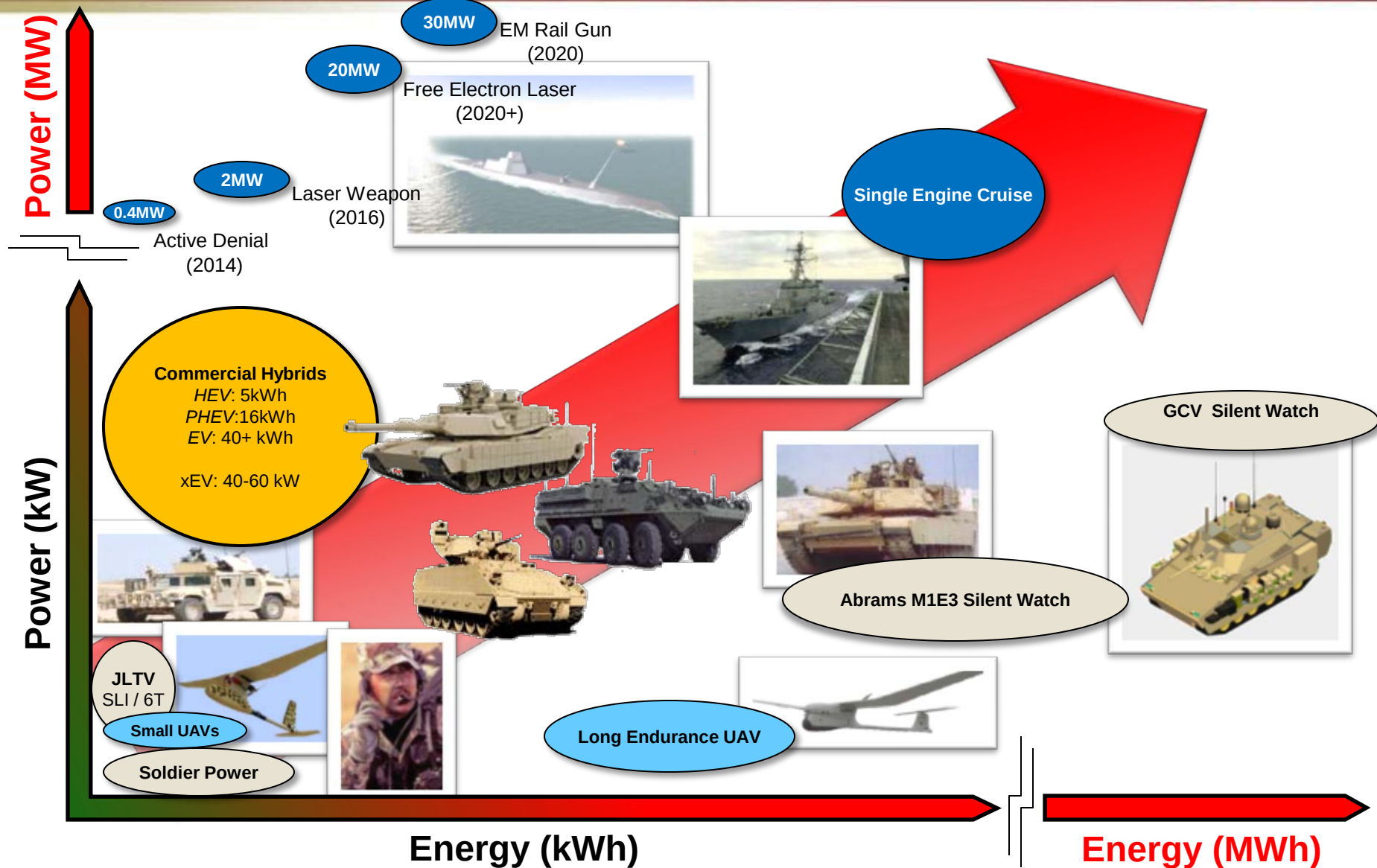
Energy Storage Mission

- **Develop** and **mature** advanced ES technologies for transfer to vehicle platforms
- Test & evaluate ES technologies for prequalification and to **assess TRL (Technology Readiness Level)**.
- Identify **technology barriers** and develop technical solutions
- Be recognized as the team of experts in ES components and systems
- Provide technical support to customers, other teams and government agencies for all ES requirements
- Provide **cradle-to-grave** support for all Army ES systems



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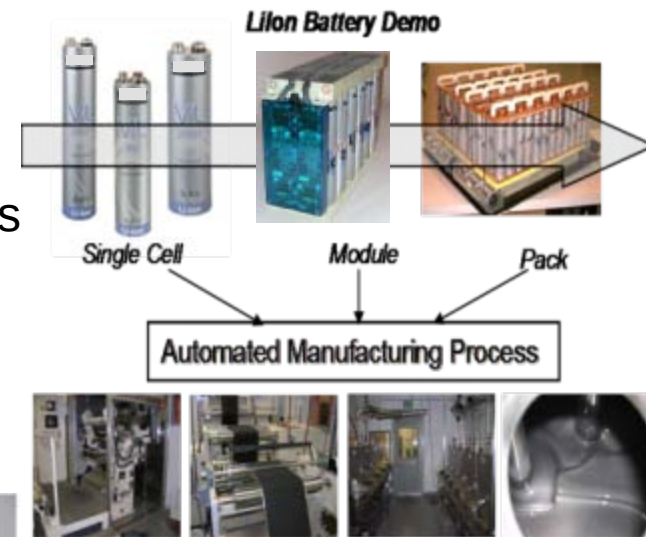
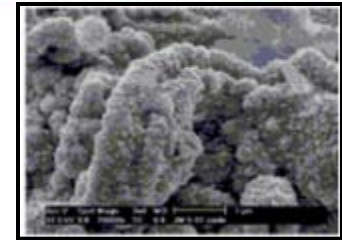
DOD Power & Energy Requirements



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Energy Storage Challenges:

- Cell & system safety & reliability
- Higher energy / higher power designs & chemistries
- Power vs. energy trade-off design optimization
- Manufacturing process development and cost control
- Thermal management
- System control and cell & battery management systems
- Alternative electrochemical improvements
- Thermal runaway process and its control
- Standardization of cells, modules and packs (logistics)



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• Army Applications/Drivers:

TARDEC - Ground

– Major Applications

- Robotics
- Survivability
- Weapons Systems
- Electromagnetic Armor (EM Armor)
- Starting, Lighting and Ignition (SLI)
- Hybrid Vehicle Acceleration and Silent Mobility
- Silent Watch



Hit Avoidance



Targeting Systems

– Approach

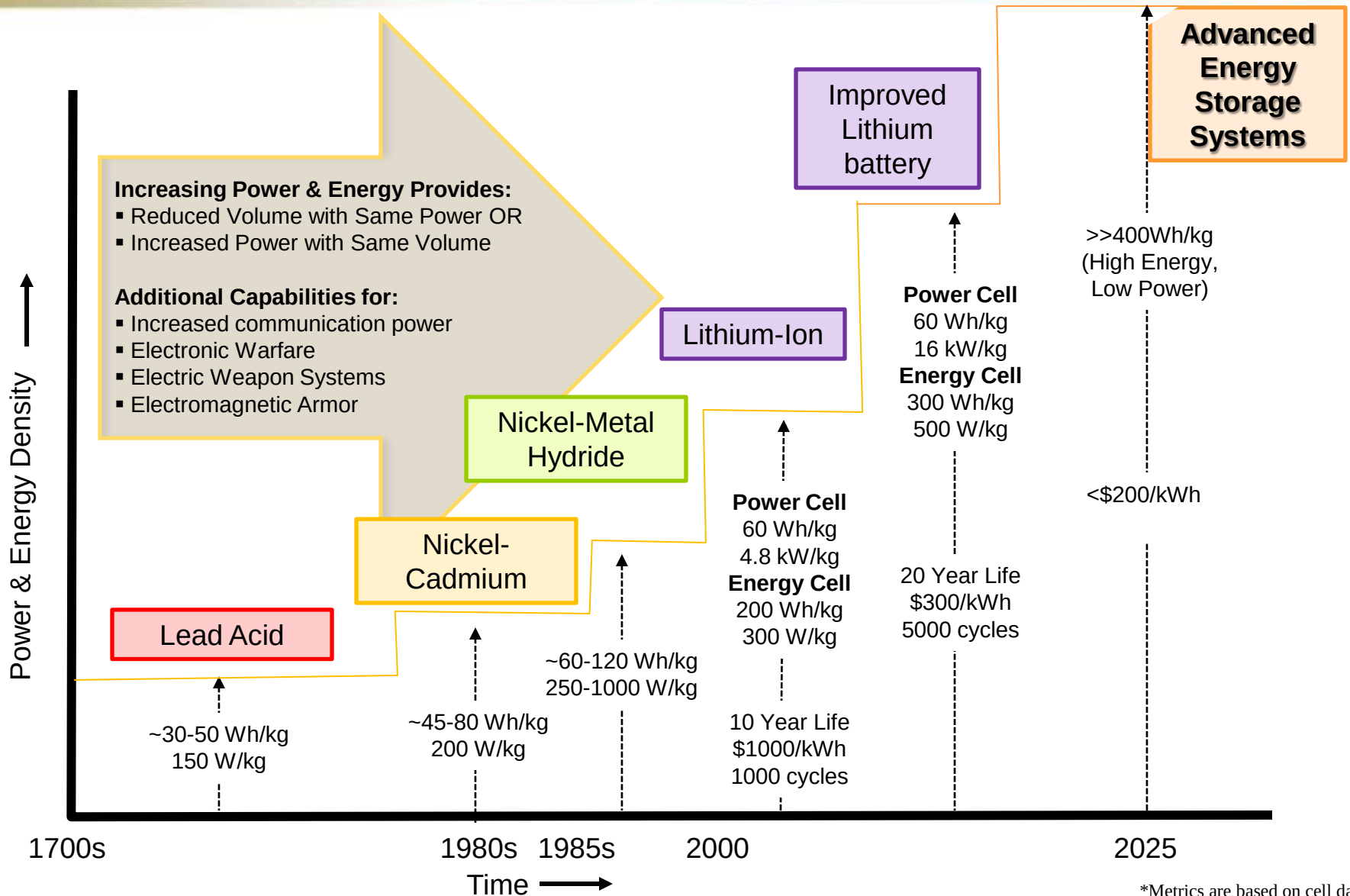
- Standard Form Factor (6T)
- Ultra-capacitor/Battery/Fuel Cell Hybrid Power Sources



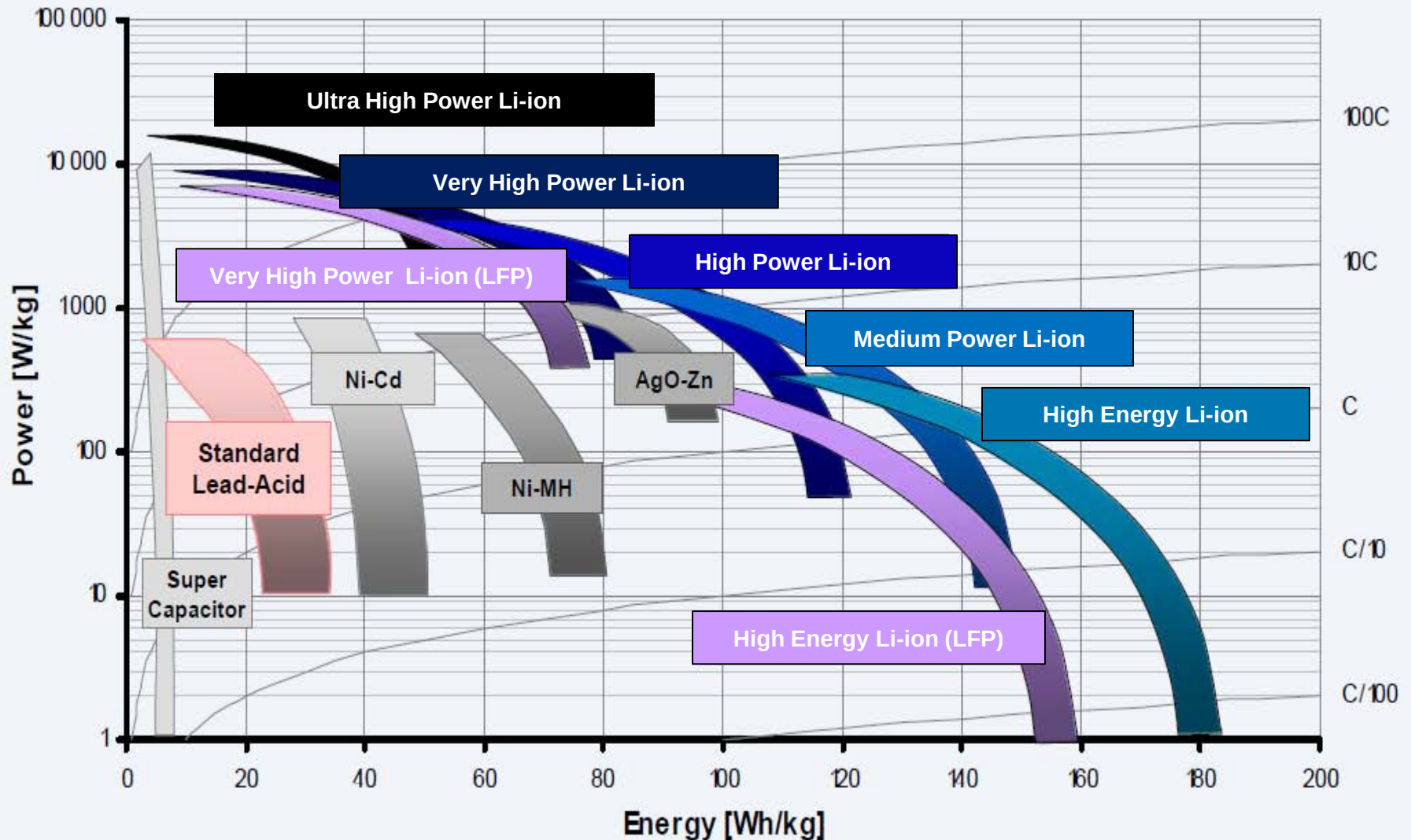
– Energy Storage Team Focuses on Batteries:

- True silent watch and silent mobility
- Serves as reservoir to store energy to meet power demands and manage platform power
- Provide power source for advanced weapons.

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Energy Storage Technology Trade-Offs & Capabilities

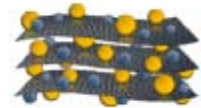


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TARDEC Programs

Functional Breakdown

Energy Storage Functional Breakdown



Basic Research

- Lithium plating phenomenon in Li-ion batteries
- **Study on the mechanism of thermal runaway in VRLA Batteries and Methods of Suppression**
- Study of electrode/current collector interface & safe separator for Li-ion batteries
- Development of high energy density anode materials for improved Li-ion batteries
- Alternative electrolyte for use in lithium-ion batteries (higher voltage, improved performance)

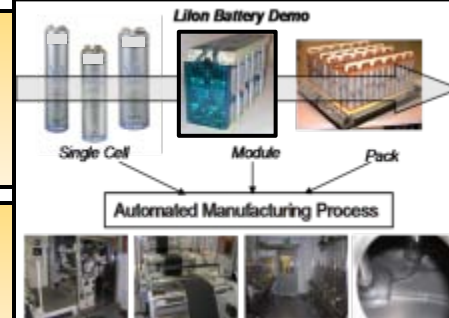
Applied / Applications Research

- Electromagnetic Armor Power Maturation
- Nickel-Zinc 6T Battery Development
- **Development of 6T battery for SLI and silent watch using Li-ion chemistries**
- Absorbed Glass Matt lead acid battery for 24V military 4HN battery



Manufacturing

- High Power, High Energy Density Li-Ion Battery Manufacturing Program
- **Lithium-Ion Cell/Battery Pack Manufacturing**
- Advanced battery material scale-up facility



Battery Management / Safety

- **In-House BMS evaluation for PM HBCT & new laboratory**
- Universal BMS using novel algorithms for battery health
- Ballistic and abuse tolerance studies on cells, module and packs
- Development of advanced diagnostic tools for cycled cells

Alternative Systems

- Hybrid Power Module
- Lithium-Titanate Hybrid Vehicle Pack Integration
- **Characterization of ultra-capacitors for SLI and high power applications**



Summary

- **Army has a diversified energy storage portfolio supporting a wide-range of customers**
- **Army has and is actively seeking collaboration with other Government Agencies, and Commercial & Military OEM's**
- **Army has projects supporting several different functional areas in Energy Storage including: basic research, applied research & applications, manufacturing, battery management & safety, and alternative systems**
- **Army labs currently perform a wide variety of testing activities and has an established program for technology maturation and technology readiness level verification**
- **Army is actively involved in the development of battery standards and standard vehicle battery products**

Thank you. Questions?



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