Panel VII: State & Federal Programs to Support the Battery Industry

“U.S. Army’s Ground Vehicle Programs & Goals”

Sonya Zanardelli
Energy Storage Team Leader, U.S. Army TARDEC, DOD Power Sources Member
sonya.zanardelli@us.army.mil  586-282-5503
July 27, 2010
Overview

- Energy Storage Goals & Mission
- Program Collaboration & DOD Customers
- DOD Applications & Approach
- Power & Energy Requirements
- Energy Storage R&D Challenges

- Army Ground Vehicle Energy Storage R&D Programs
  - Roadmap
  - Functional Breakdown
  - Highlighted R&D Programs & Projects

- Summary
Energy Storage Goals

- Develop **safe and cost effective** energy storage systems
- Reduce **battery weight & volume burden** (Increase Energy & Power Density)
- Reduce logistics and fuel burdens
- Extend **calendar and cycle life**
- Enhance performance and increase operating time (silent watch, etc)

Energy Storage Mission

- Develop and **mature** advanced ES technologies for transfer to vehicle platforms
- Test & evaluate ES technologies for prequalification and to assess their TRL
- Identify **technology barriers** and develop technical solutions
- Provide technical support to customers, other teams and government agencies for all ES requirements
- Provide **cradle-to-grave** support for all Army ES systems
Program Collaboration & DOD Customers

PEO Soldier

DOD Customers

PEO GCS

PEO CS/CSS

Battery Developers

Material Developers

Battery Partners

Industrial Developers

Soldier

Ground

Air

OEMs (Commercial / Defense)

DOE

Universities

National Labs

ANL

USABC

Battery Developers

Material Developers

Industrial Developers

Battery Partners

Industrial Developers
Power & Energy Requirements

Energy (kWh)

Power (kW)

- Commercial Hybrids
  - HEV: 5kWh
  - PHEV: 16kWh
  - EV: 40+ kWh
  - xEV: 40-60 kW

- Abrams M1E3 Silent Watch
- GCV Silent Watch
- Long Endurance UAV
- Single Engine Cruise
- EM Rail Gun (2020+)
- Laser Weapon (2020+)
- Free Electron Laser (2020+)

- Active Denial (2014)
- Laser Weapon (2016)
- Single Engine Cruise

- Energy (MWh)
- Power (MW)

UNCLASSIFIED
DOD Applications & Approach

• **Air Force: (mass restrictions)**
  - Major Applications:
    - Aircraft Emergency Power
    - Small Unmanned Aerial Vehicle (UAV)
    - Long Endurance UAV / Persistent Munitions
  - Approach
    - High Energy component
    - High Power component
    - Power Management

• **Navy: (volume restrictions)**
  - Major Applications:
    - Unmanned Underwater Vehicles (UUV)
    - Shallow Water Combat Submersible (SWCS)
    - Submarine Small Distributed Power Systems
    - Surface Ship Fuel Economy
    - Surface Ship Pulsed and High Power
  - Approach
    - Modular, scalable approach to support multiple applications
• **Army Applications/Drivers:**
  
  **CERDEC - Soldier**
  
  - Major Applications
    - Soldier Power – *(Soldiers carry as much as 30lbs of batteries to support Mission Essential Equipment)*
    - Advanced C4ISR Systems
  
  - Approach
    - Standard Form Factor (BB2590)
    - Fuel-Cell/Battery Hybrid Power Sources

  **TARDEC - Ground**
  
  - Major Applications
    - Robotics
    - Survivability
    - Weapons Systems
    - Electromagnetic Armor (EM Armor)
    - Silent Watch
    - Starting, Lighting and Ignition (SLI)
    - Hybrid Vehicle Acceleration and Regenerative Breaking
  
  - Approach
    - Standard Form Factor (6T)
    - Ultra-capacitor/Battery Hybrid Power Sources
**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)
Battery Power & Energy
Versus Time

Increasing Power & Energy Provides:
- Reduced Volume with Same Power OR
- Increased Power with Same Volume

Additional Capabilities for:
- Increased communication power
- Electronic Warfare
- Electric Weapon Systems
- Electromagnetic Armor

Lead Acid
- ~30-50 W-hr/kg
- 150 W/kg

Nickel-Cadmium
- ~45-80 W-hr/kg
- 200 W/kg

Nickel-Metal Hydride
- ~60-120 W-hr/kg
- 250-1000 W/kg

Lithium-Ion

Improved Lithium battery

Power Cell
- 60 W-hr/kg
- 4.8 kW/kg

Energy Cell
- 300 Wh/kg
- 500 W/kg

10 Year Life
- $1000/kWh
- 1000 cycles

20 Year Life
- $300/kWh
- 5000 cycles

~1000 W-hr/kg
(High Energy, Low Power)

*Metrics are based on cell data
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 lithium-iron phosphate
- Absorbed Glass Matt lead acid battery for 24V military 4HN battery

Manufacturing
- High Power, High Energy Density Li-Ion Battery Manufacturing Program
- Lithium-Ion 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
Its all about the War Fighter!

Thank you

UNCLASSIFIED