



Energy Storage Requirements & Challenges For Ground Vehicles



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- TARDEC & Energy Storage Team Mission
- Vehicle Requirements for Energy Storage
- Army Ground Vehicle Power & Energy Challenges

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- A photograph of a military Humvee in a desert environment. A soldier is visible in the driver's seat, and the vehicle is equipped with various antennas and equipment. The background shows a vast, arid landscape under a clear sky.
- Provides ***full life-cycle engineering*** support and is provider-of-first-choice for ***all DOD*** ground combat and combat support weapons and vehicle systems.
 - Develops and integrates ***the right technology solutions*** to improve Current Force effectiveness and provide superior capabilities for the Future Force.

***Ground Systems Integrator for the
Department of Defense***

Responsible for Research, Development and Engineering Support to **2,800** Army systems and many of the Army's and DOD's Top Joint Warfighter Development Programs

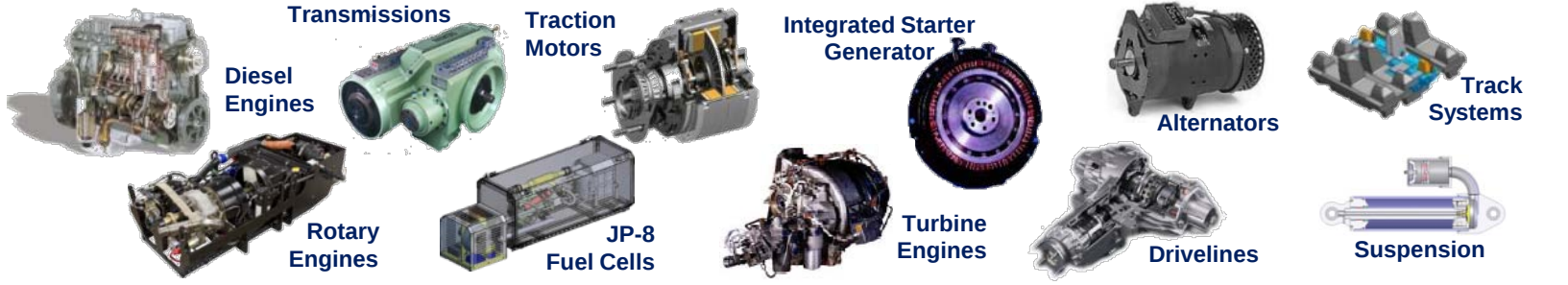


TARDEC invests in targeted Ground Vehicle Energy Solutions



Ground Vehicle Power and Energy Technology

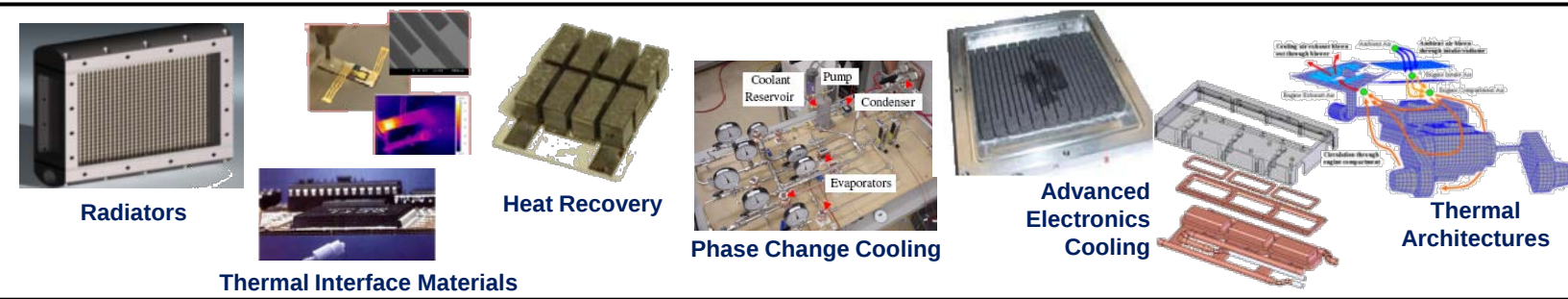
Prime & Non-Primary Power



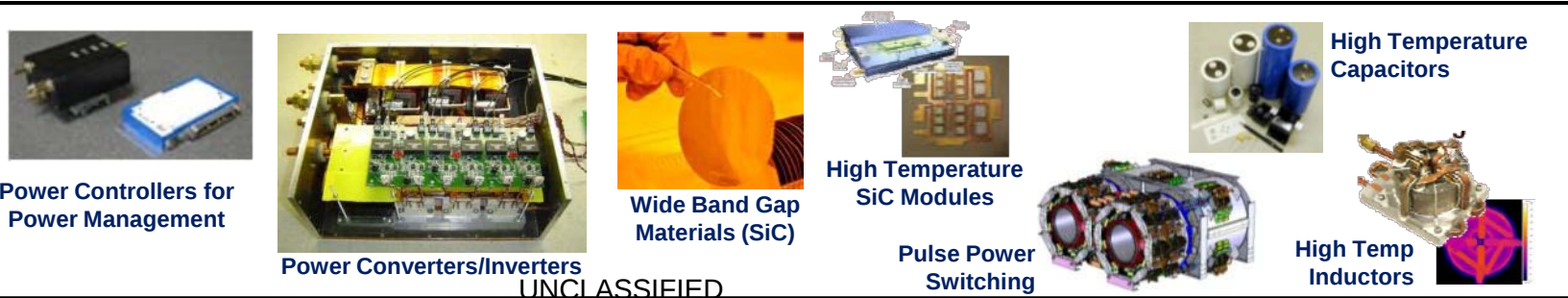
Energy Storage



Thermal Management



Power Management



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- Pursue energy storage technology research, development, component test and evaluation for CURRENT and FUTURE ground vehicle fleet
- Identify technology barriers and develop technical solutions
- Provide technical support to customers, other teams and government agencies in all energy storage



Battery Technology Evaluation Lab



Module Test & Eval



Cell Test & Eval

There are three distinct requirements for Military Energy Storage:

- ***Starting, Lighting and Ignition***

Batteries provide electric power to start the vehicle power generation (Engines / APUs)

- ***Hybrid Vehicle Boost Acceleration and Regenerative Braking Energy Capture***

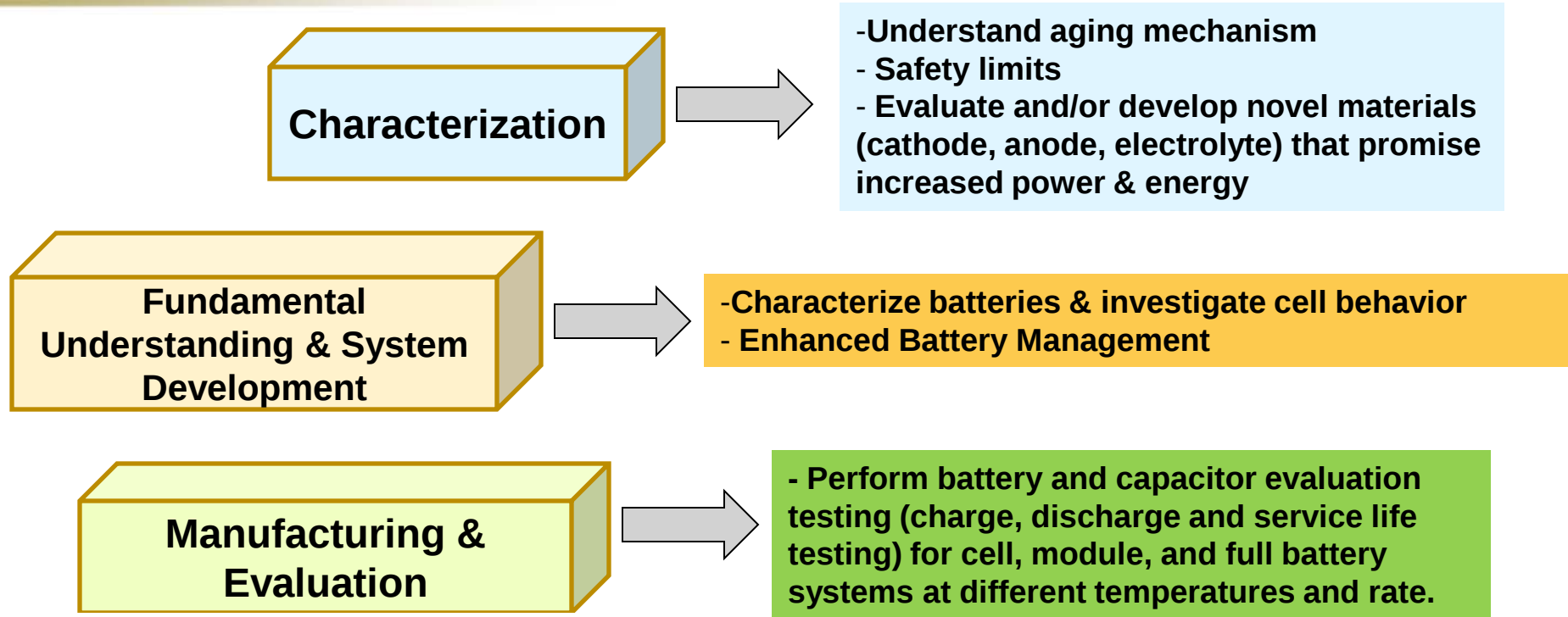
In hybrid vehicle powertrains, batteries have the ability to supplement main engine power for burst accelerations.

In addition, batteries can be used to recover wasted energy in vehicle braking

- ***Silent Watch***

Batteries can provide the energy storage capability to power mission equipment with main engine off while the vehicle is stationary

- **Li-Ion**: Future replacement for Lead-Acid in military applications and hybrid electric vehicle boost power
- **Alternative Chemistries**
- **UltraCaps**
 - Starting Assist
 - Hybrid Application
- **Lead-Acid**: Support existing power needs, Starting and Silent Watch utilizing 6T, 2HN & 4HN format batteries.
 - Flooded Cell
 - VRLA
 - Absorbed GlassMat
 - Gel
 - Advanced improvements: increased energy density
 - Qualify additional sources

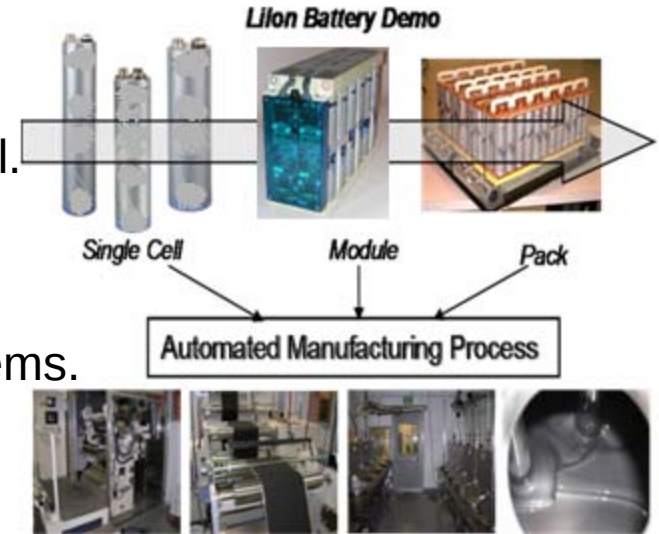


Ongoing R&D:

- Focused investigations on novel materials (cathode, anode, electrolyte) for increased power and energy & reduced cost
- Develop advanced diagnostic tools and battery management system.
- Develop and apply advanced models for batteries and components
- Advanced battery design techniques
- Advanced battery manufacturing techniques

Energy Storage

- Power vs. Energy trade-off design optimization.
- Manufacturing process development and cost control.
- Thermal management.
- Cell & system safety & reliability.
- System control & cell and battery management systems.
- Alternative electrochemical improvements.
- Thermal runaway process and its control.



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TARDEC Energy Storage Projects



3D Advanced Battery Technology
Mechanism of Battery Thermal Runaway
Advanced Military Hybrid Technology
Advanced Materials Development
Ballistic Impact Testing
Research Calorimeter/Test Rig
HE-HMMWV Battery Pack
Integrated Platform Battery Test & Evaluation
Large Format Lithium Iron Phosphate Cells
Advanced Li Iron Phosphate Battery system
Li Ion Battery Manufacturability
Prismatic Cell w/liquid cooling
Ultra High Power Batteries
Auxiliary Power Unit

Cell Evaluation
Ultracapacitor Characterization
6T Li
Nickel Zinc Batteries
Ni-Zn Battery Module
Rolled -Ribbon Lithium ion Cells
GS Yuasa Evaluation of LFP Cells & Modules
C4ISR Auxiliary Power Unit (APU) Soldier Tactical
HEV Battery System for FCS
Li-Titanate Evaluation
Cell Evaluation
Battery Aging Phenomenon
Battery SOC/SOH Determination Modeling
ARM 100 Lilon APU
Lion Cell Evaluation
Cell Evaluation

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“Power and energy is not only the greatest enabler of the Warfighter, it is also the most significant limitation.”

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