



TARDEC Hybrid Electric Program Last Decade



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Report Documentation Page

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Combat Vehicle Demos



M113 HE



Lancer



AHED 8x8



Pegasus



FCS

Technology Base



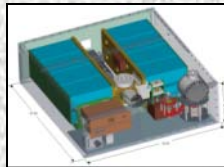
Traction Motors



Energy Storage



SiC Inverters/
Converters



Pulse
Technology



Alternative
Architectures



Modeling and
Simulation

Tactical Vehicles



HMMWV HE



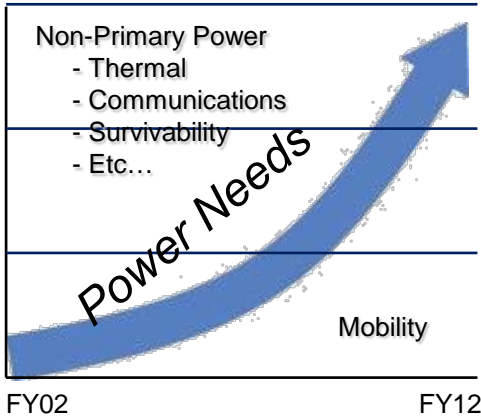
FMTV HE



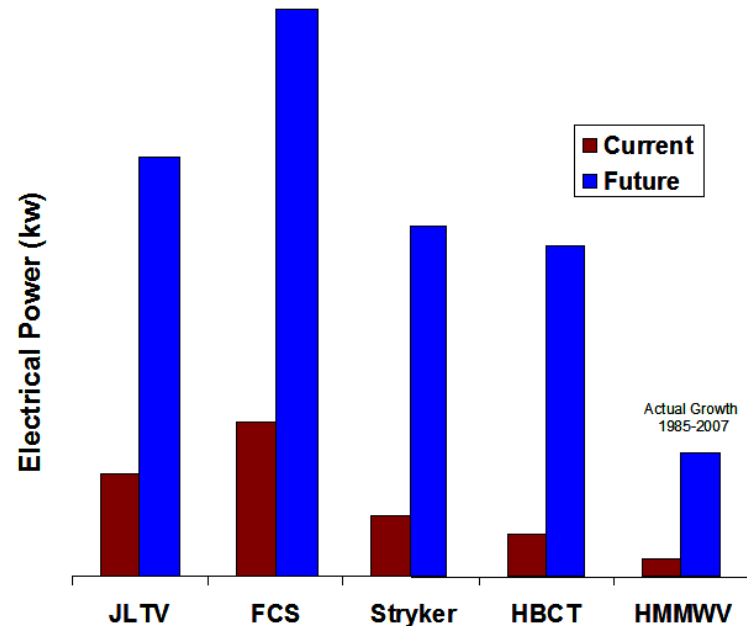
RSTV



FTTS



**Non-Primary Power
Estimated Electrical Power Growth**



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Unprecedented use of emerging technologies never proven in battle field scenarios

- System integration and packaging
 - Power densities of components
 - ❖ Motors, generators, energy storage
 - ❖ Power electronics

- Thermal management
 - Low operating temperature
 - ❖ Large space claims
 - ❖ High power demand from the engine/generator

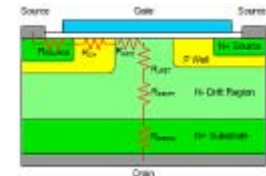
- Silent Watch requirement
 - Energy storage shortfalls
 - Control strategy and limited power budget

- Onboard Exportable power
 - Clean power for Tactical Operating Centers (TOC)
 - Power supply from mobile platforms for other applications

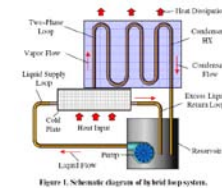
High Power density motor



SiC MOSFET



Phase change cooling



Li-Ion Battery Pack



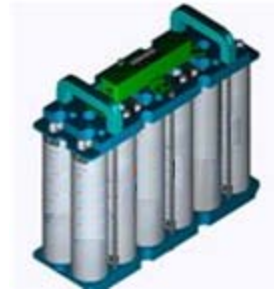
Tactical Operation Center (TOC)



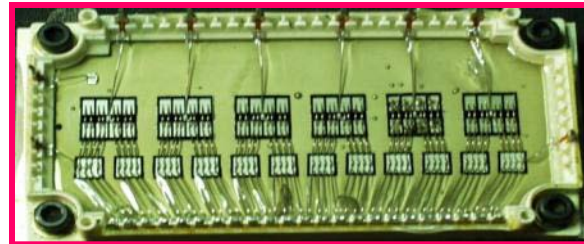
- Traction Motors



- Energy Storage
Li-Ion



- Power Electronics/cooling



- Vehicle tests:
 - ATC
 - AAEF

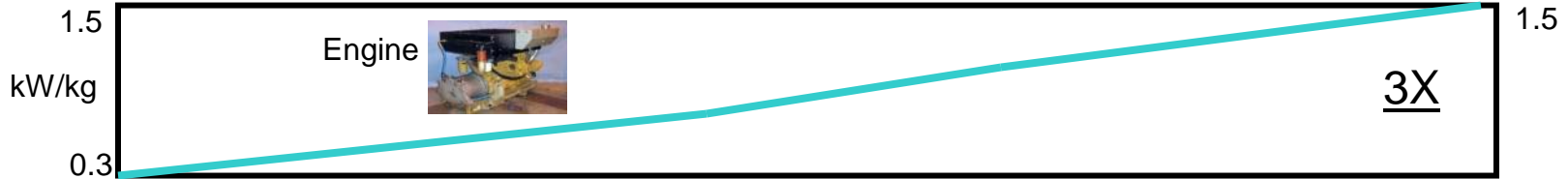


Thermal Management

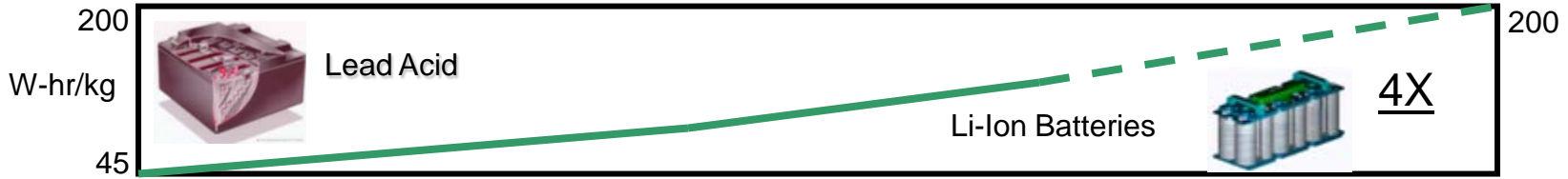
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Prime Power



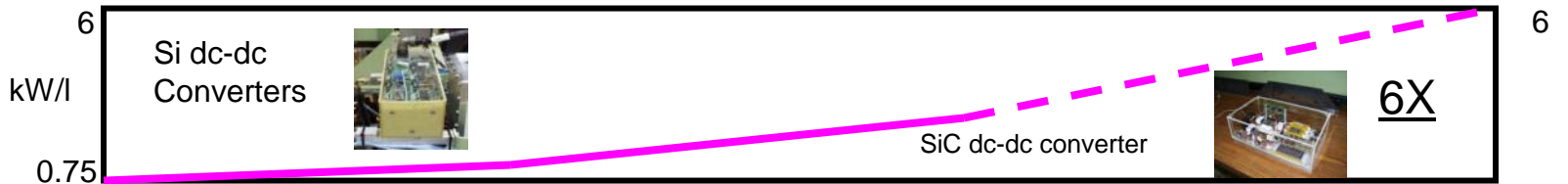
Energy Storage



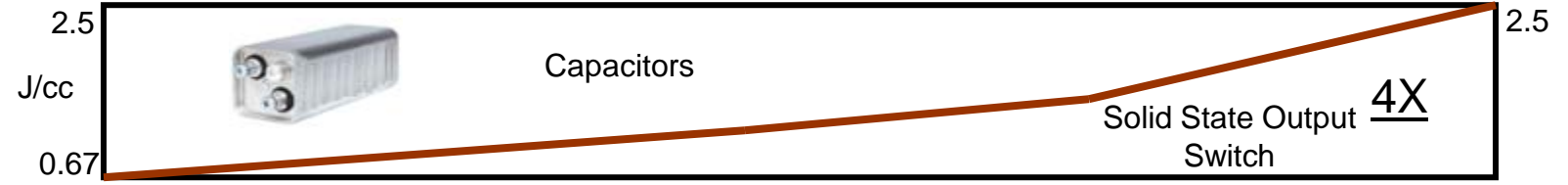
Motors



Power Conditioning



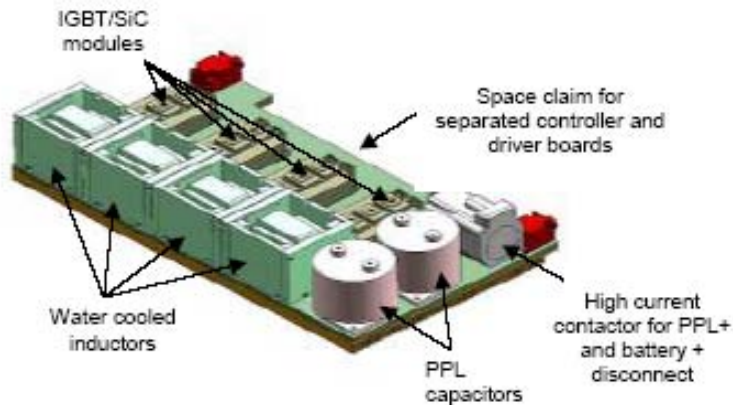
Pulse Power



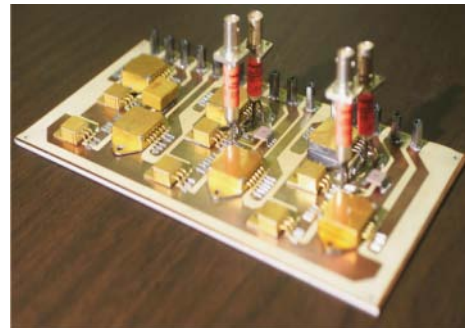
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- Thrust is SiC to overcome:
 - Thermal issues
 - Efficiency
 - Low frequency requiring large capacitors
 - Low power density

Approach: Develop power devices using SiC diodes as an interim step
 Develop All SiC motor drives and DC-DC converters as the device technology matures



100 kW Si/Si-C hybrid DC-DC converter



All-Si-C motor-drive inverter



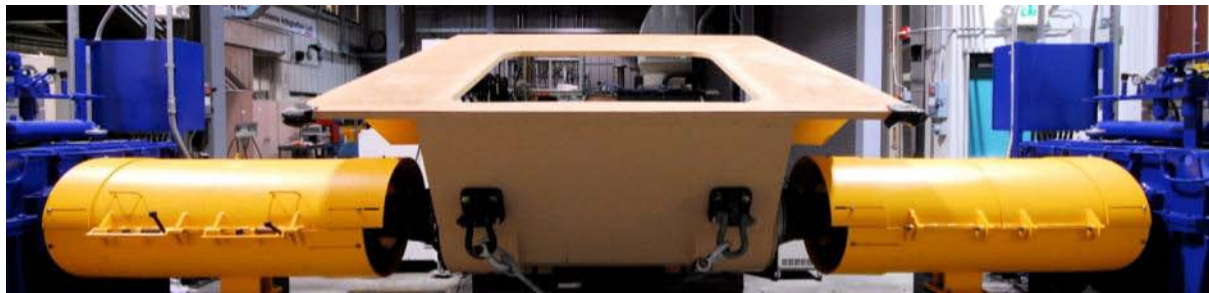
SiC PiN Diode Module

The SIL provides capability to accelerate the integration and maturation of critical FCS MGVS system technologies in order to meet FCS Performance within the weight and volume constraints



System Integration

System integration into vehicle platform



HOTBUCK platform with FCS hardware

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Currently there are no industry or SAE standards for measuring the fuel economy of hybrid vehicles in cross country environments.

Objectives

- Develop HEV Test Operating Procedure (TOP) using accepted industry practices and DOE processes
- Determine the fuel economy benefits of hybrid electric vehicles using quantifiable test data
- Develop and Validate TARDEC M&S models

Testing

9 conventional and 7 hybrid electric vehicles are being tested

A. Conventional:

- 2 - HMMWVs,
- 2 -21/2T LMTVs
- 1 - 5T MTV
- 1 – FMTV CVT
- 2 - HEMTTs
- 1 – UV



HMMWV Series HE



RSTV Series HE

B. Hybrid Electric:

- 1 – HMMWV
- 1 – RSTV
- 1 - UV
- 1 – UV
- 1 – AH/SS MSV
- 1 – FMTV
- 1 – HEMTT A3



Parallel Hybrid MSV



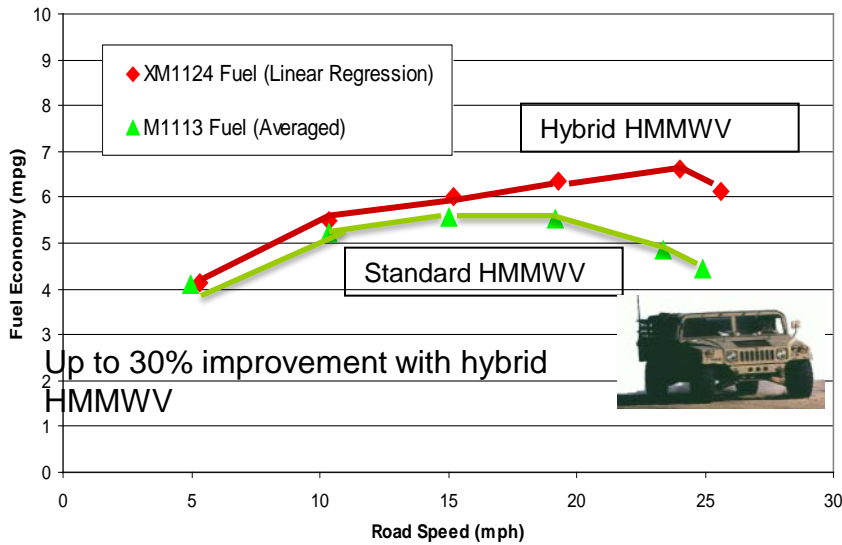
2 Parallel hybrid UVs



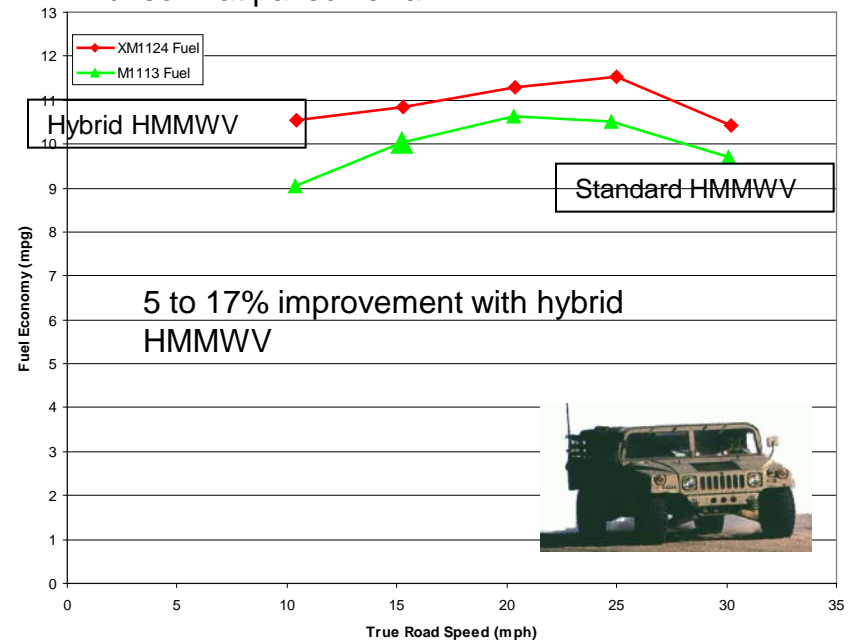
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Fuel Economy varies with terrain & driving conditions

Fuel economy comparison on Churchville hilly Terrain



Fuel economy comparison on Munson flat paved Terrain



- Proven process to launch commercial production, focusing on user needs
- Over 80 national fleets, including DOD, involved in process
- Eight National Meetings of top truck OEMs, suppliers, fleets
- First 24 Pre-Production Trucks tested & fielded w/in 3 Years; million miles of experience; directly led to commercial production launch
- Military receiving first in-use hybrid field data from geographically dispersed nationwide deployment
- Six fleet Working Groups active, new Construction Equip Forum launching
- Three additional pilot deployments ready



HTUF Industry Contact Point for Dual-Use Heavy Hybrid Technologies

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RDECOM

Energy Storage Requirements & Challenges for Ground Vehicles



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Sonya Zanardelli

Energy Storage Team Leader

Ground Vehicle Power & Mobility (GVPM)

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

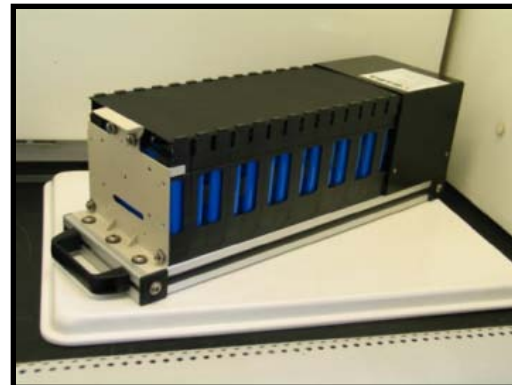
- ***Silent Watch***

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

- 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



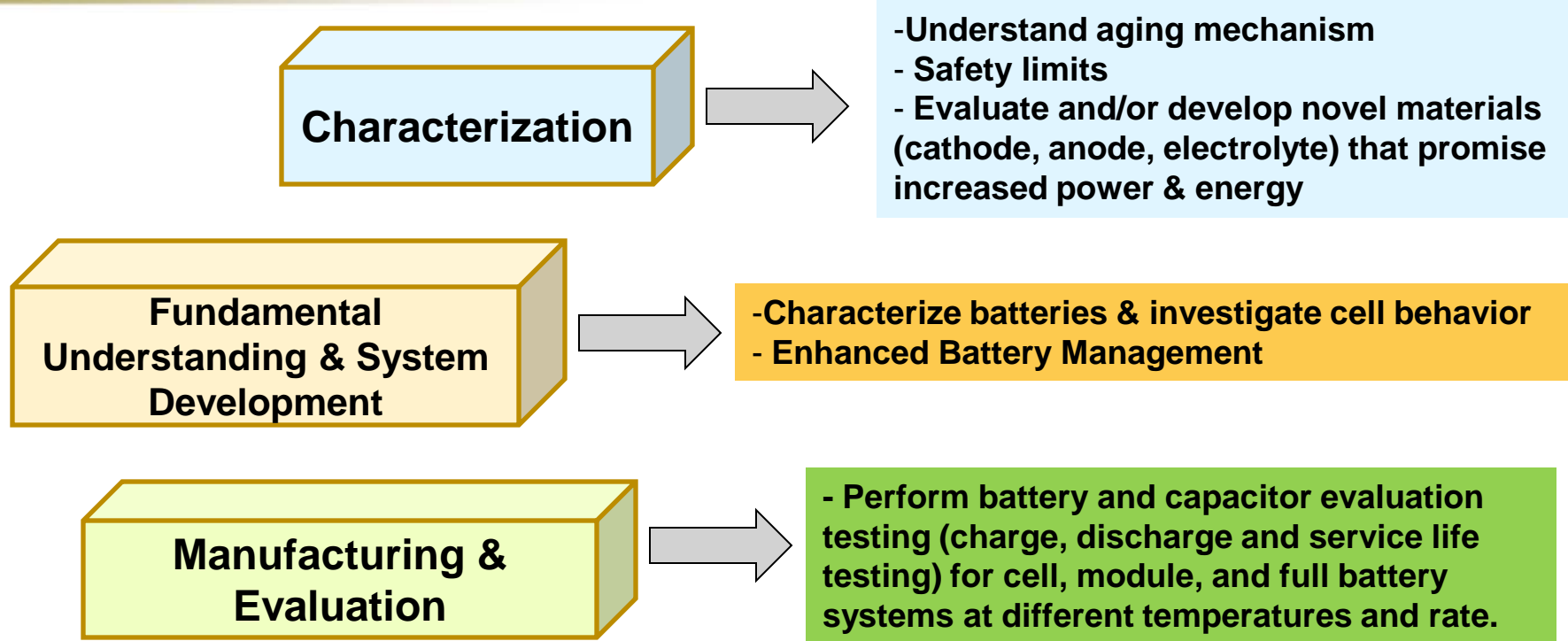
Battery Technology Evaluation Lab



Module Test & Eval



Cell Test & Eval

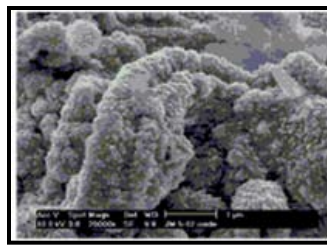


Ongoing R&D:

- 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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