



Ground Vehicle Power and Mobility Overview

30 May 07



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Report Documentation Page

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Organizational Thrust Areas

Technology Thrusts:

Prime Power

- Engines
- Power Trains
- Hybrid Electric and Energy Storage
- Drive Components (motors, generators)
- Power Electronics

Non – Primary Power

- APU's, On Board Power Generation)
- Fuel Cells

Energy Storage

Power and Thermal Management

System Assessments

- Hybrid Electric Vehicle Assessments

Track and Suspension

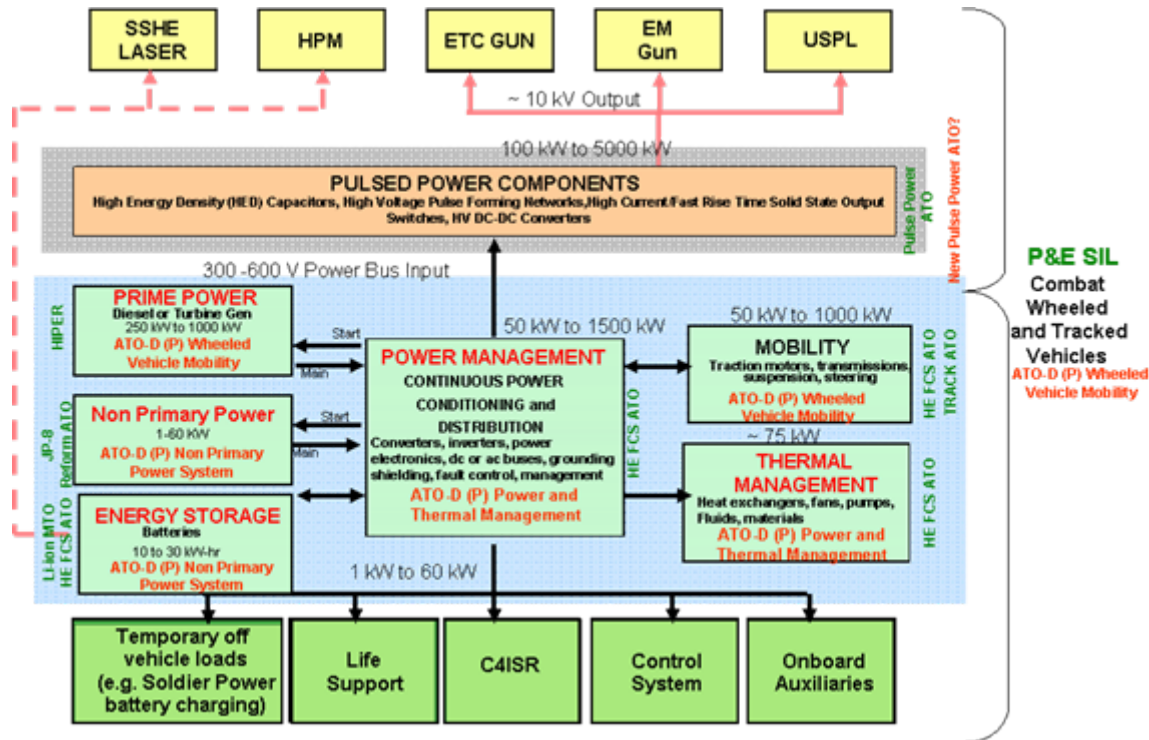
- Lightweight track
- Elastomer Research
- Advanced suspension

Capabilities Thrust:

Modeling and Simulation

Testing, Evaluation and Assessment

- Propulsion Laboratory** - Engine, Transmission, Air Filtration, Thermal and Vehicle testing, evaluation and assessments
- Future Power and Energy Laboratory
- Power and Energy SIL
- Power Management SIL
- Track and Suspension Laboratory





Ground Vehicle Power and Mobility FY08 Proposed ATO Collaboration Strategy

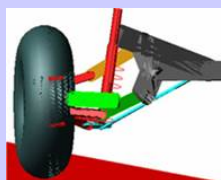


Existing ATOs and Programs

New ATO-D Proposed for FY08

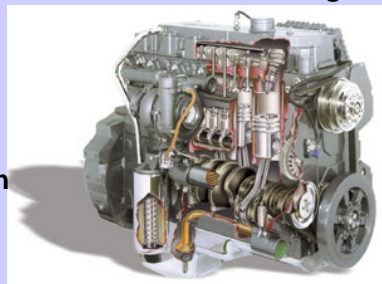
Tactical Vehicle Power and Mobility

Adv. TRACK ATO



Advanced Suspension

Militarized Commercial Engines



Advanced Hybrid Electric Components



HIPER

HE FCS ATO

Advanced Chemistry Batteries for HEV

Primary Power Generation Sources and HEV Components

Intelligent Power and Thermal Management Strategies and Controls



Power & Energy SIL
Common M&S System Model
HEV Mission Profile Analysis

Power and Thermal Management

Potential Applications

APS

C4ISR

Environmental Controls

Propulsion Systems

Radios

Radars

P&TM* Technology



* Power and Thermal Management

Potential Platforms



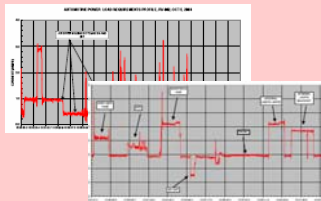
Intelligent Power and Thermal Management Strategies and Controls

Non-primary Power Generation and Energy Storage Sources

Li-ion MTO



Advanced Batteries



Silent Watch Load Profile M&S



Power Dense Quiet Power Generation



JP-8 Reformation ATO

Non-primary Power System

Prime Power Technology

Problem:

Current high power commercial engines are not compact enough for future manned combat ground platforms. Future ground combat vehicles will require lighter and more efficient engines that occupy less space. Current state of the art engines require significant development operate on one fuel forward in order to meet future tactical vehicle power and mobility needs.

Challenges:

Diesel combustion is rate limited due to physical burn time.
Restrictive volume and weight constraints for propulsion system
Engine thermal management
Lack of combustion optimization strategy for JP-8 military version of an emission compliant commercial engine.

Key Goals:

50% improvement in combat engine power density
30% improvement in combat propulsion system power density
30% improvement in combat engine specific heat rejection
30% reduction in combat engine weight
20% improvement in tactical engine thermal efficiency
20% improvement in tactical engine specific heat rejection

Key Efforts:

Opposed Piston Opposed Cylinder Engine
High Speed Combustion
Two Stage Controlled Turbocharger/Engine Development
Wheeled Vehicle Engine Development and Optimization

Customer:

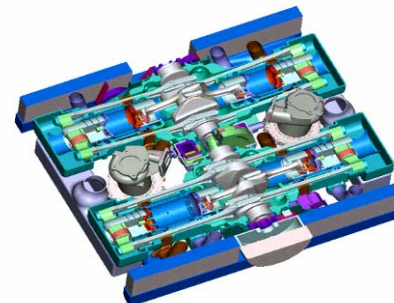
PM FCS MGVBCT
PM HBCT
PEO CS/CSS



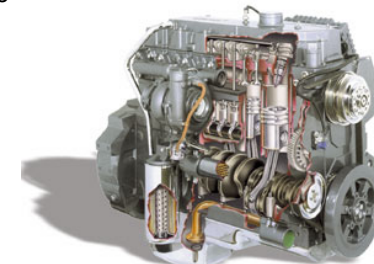
Cylinder/Injector
Geometry for Air
Utilization



Advanced High
Pressure Fuel
Injection Systems



OPOC 2-Stroke
Diesel Engine Tech



Tactical Vehicle Engine
Dev and Optimization

Hybrid Electric Technology

Problem:

Hybrid electric systems for combat and tactical vehicles do not currently meet mobility requirements within the specified space and weight constraints. The State Of the Art power electronics operate at low temperatures resulting in large cooling system which also requires a significant amount of power from the prime mover. This also results in oversizing the engine/generator for making up the power budget loss to the cooling system

Challenges:

There are trade offs between power and torque for rotating machines. It is difficult to produce high power and high torque density from the same motor/generator. Similarly, there is a trade off between power and energy for the energy storage system. The challenge is to increase power and torque densities for traction applications and also to advance the battery systems to increase power and energy from the same source. Compact high frequency and high temperature power electronics are still in development

Key Goals:

10 kW/l and 90 N-m/l for traction motors

120 W-hr/kg and 8kW/kg for safe and reliable Li-Ion batteries

Reduce the hybrid electric drive train for combat vehicle by half its current size and weight

Key Efforts:

SIL for FCS and Wheeled vehicles

SiC MOSFET

Defect free Si/C materials

Three DC-DC converters

Integrated Thermal Module

SiC power steering motor drive

High power density traction motor

Hybrid HMMWV fuel economy test

Customer:

PM FCS MGVBCT

PM HBCT

CS/CSS –FTTS and JLTV



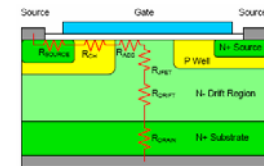
High power Li-Ion Cell



Traction Motor



Combat and Wheeled vehicle SIL



SiC MOSFET

Non-primary Power System Technology

Problem:

Current lead-acid batteries store insufficient energy to meet Warfighter requirements for ground combat vehicle silent watch (main engine off) which range from several hours for JLTV to 24 hours for Abrams. Silent watch missions are interrupted because main engines must be re-started to recharge batteries, causing excessive fuel use, acoustic and thermal signatures.

Challenges:

Traditionally power generation (engine-generators) technologies have low power densities and high acoustic signatures. Fuel cells are not ready for combat vehicles: Hydrogen fuel is not logistically practical; JP-8 fuel reforming is developmental, and fuel cell power units need maturation for the battlefield.

Current silent watch power requirements create unrealistic targets and need to be validated through M&S.

Key Goals:

40 W/kg NPS system level specific power
50 W/L NPS system level power density

- Undetectable at 100m in accordance with MIL-STD-1474D
- Run continuously on 3000 ppm sulfur JP-8

Key Efforts:

D.TAR.2008.02 Non-primary Power System ATO

Power Generation Efforts

R.LG.2006.03 JP-8 Reformer for Fuel Cells ATO

Reformer Risk Mitigation Efforts

Fuel Cell Risk Mitigation Efforts

JP-8 DeS Risk Mitigation Efforts

In-house efforts – NPS technology evaluation, Fuel cell evaluation and integration lab

Customers:

PM HBCT, PM SBCT, PM FTS, PM FCS (BCT)

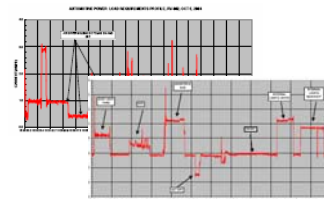
Rotary Engine APU



SOFC APU



OPOC APU



*Non-propulsion
Load Analysis*

*(CA)-Congressional Add

Energy Storage Technology

Problem:

High power Li-Ion battery pack production for FCS combat hybrid electric vehicles is costly
Li-Ion batteries for HEV dash mobility, silent watch, and pulse power for electric weapons and survivability needs to be safer and more reliable

Challenges:

Understanding the thermal runaway process and its control in all sealed cells
Cell & system design optimization – power vs. energy trade-off
Manufacturing process development and cost control
Thermal Management
Cell & system safety & reliability
Power Conditioning & Integration with DC/DC Conversion
System Control & Cell Management – Battery Management System
Alternative electrochemical improvements

Key Goals:

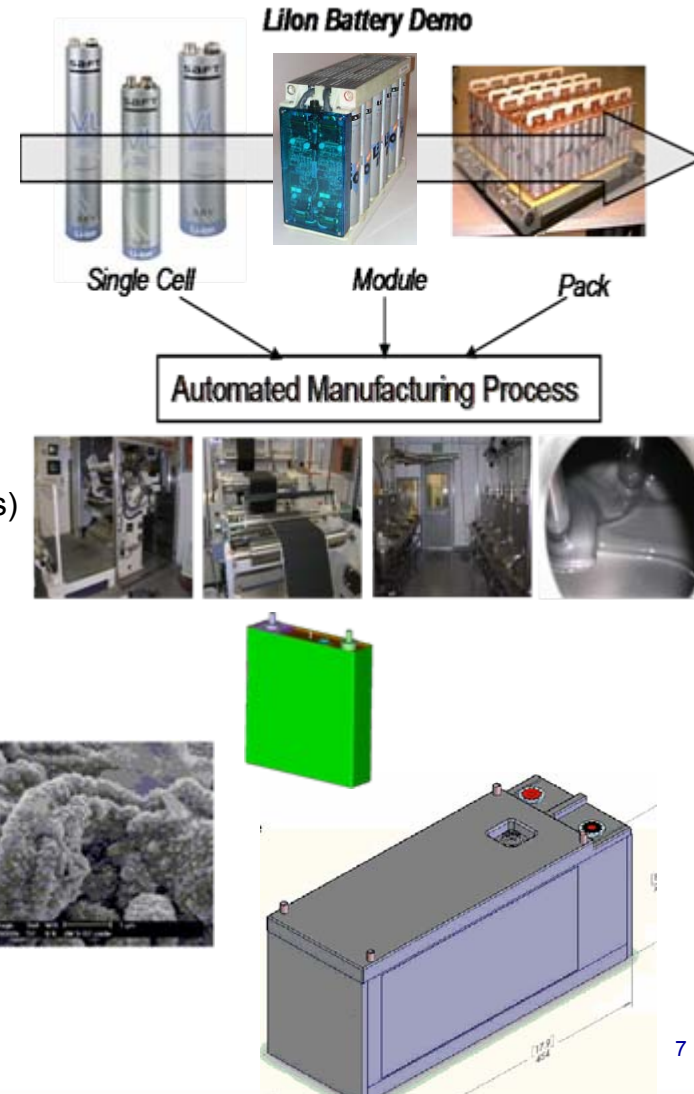
70% improvement in power density, 30% improvement in energy density
50% improvement in cost, 50% reduction in labor hours (automated manuf. Process)

Key Efforts:

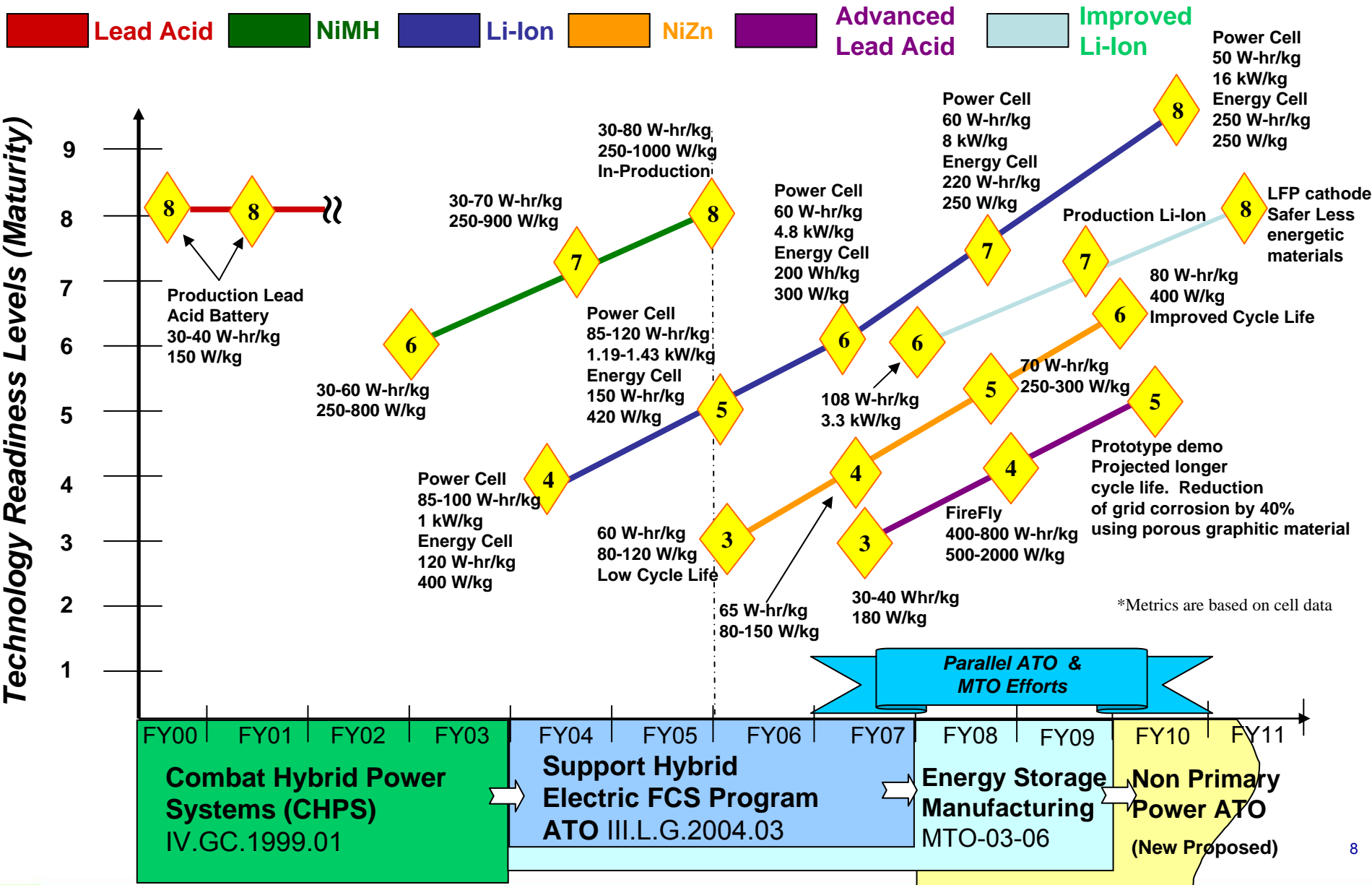
High Power, High Energy Li-Ion Battery MANTECH Program
Li-Ion Phosphate (LFP) Cathode Materials
Large Format Li-Ion Prismatic Cells and Modules with Integrated Liquid Cooling
Integrated Prototype Vehicle using Li-Ion Batteries
Battery Architecture using a Hybrid Energy Module
Thermal Runaway
Research Calorimeter
Module Test Rig
Battery Characterization

Customer:

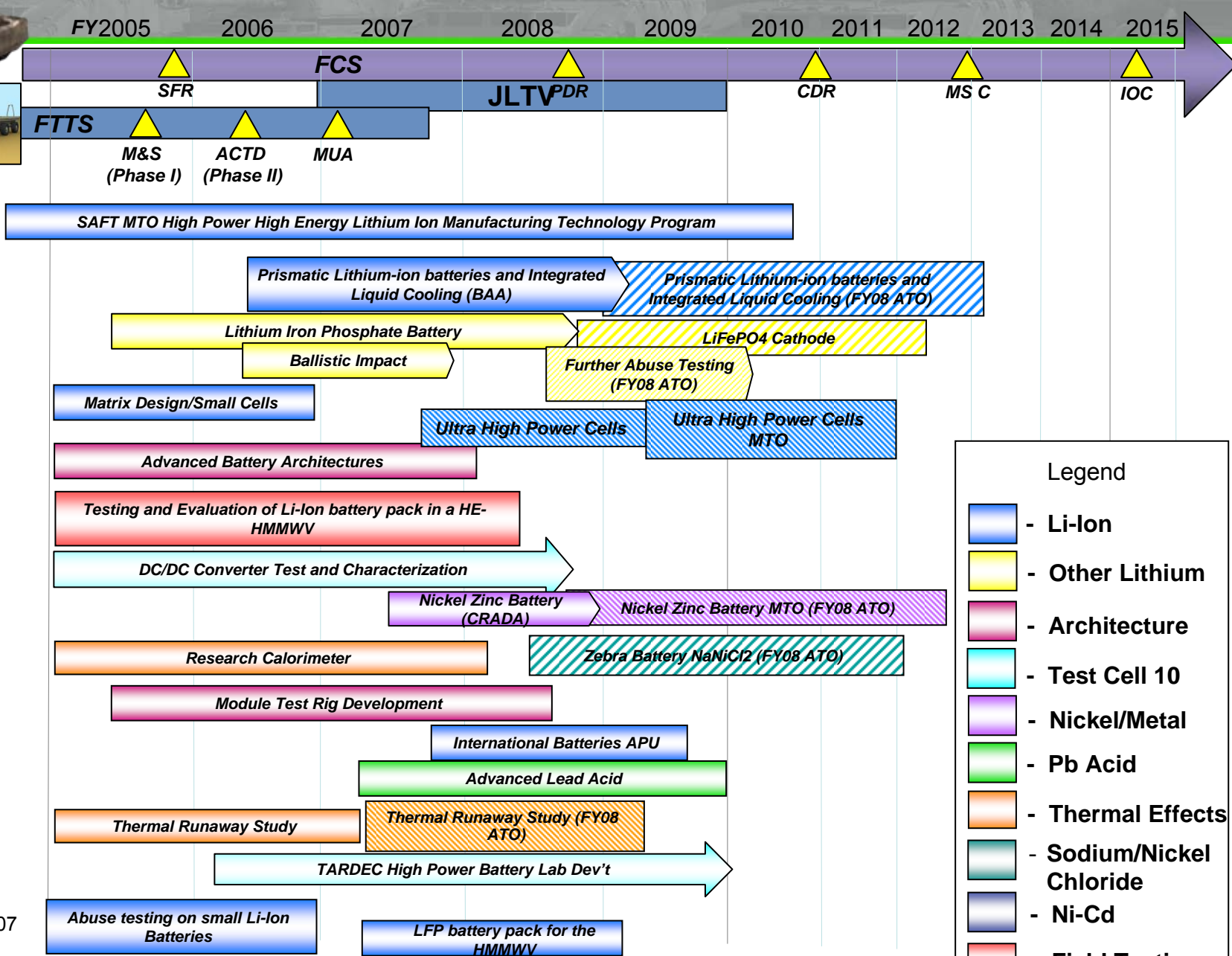
PM FCS MGV BCT
PM JLTV
PM FTTS



TARDEC Battery Roadmap



TARDEC Battery Roadmap






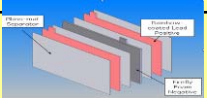


23 May 2007



TARDEC Battery Projects



Programs		FY07 Goals
6.2 Combat Vehicle & Automotive Technology Projects		
Experimentation and Ballistic Testing of Li-Ion and NiMH Batteries		To identify potential vulnerabilities resulting from ballistic impacts to high power density batteries 
Li-Ion Battery Electrochemical Research		Electrolyte research
6.3 Combat Vehicle & Automotive Advanced Technology		
Li-Ion Battery Pack for Hybrid Electric HMMWV using NCA cells		Integrate a Li-Ion battery pack in a HE-HMMWV for testing and evaluation 
Prismatic Li-Ion Cells with Integrated Liquid Cooling		Develop large format prismatic Li-Ion batteries and implement liquid cooling to manage the heat transfer 
MTO		
Li-Ion Battery Manufacturing Technology Objective		Automate the manufacturing process of Li-Ion batteries and improve safety and performance 
Congressional		
HE-HMMWV Battery Pack using LFP cells		Integrate a LFP pack into a HE-HMMWV to assess small format 26650 cells 
Battery Test Rig		Test rig with integrated research calorimeter to allow local testing of battery modules
3D Advanced Battery Technology		To proof out a design potential and prototype a 3D graphite/lead grid prototype for evaluation and test
Battery Charging Technology		Develop an intelligent battery charging system for tactical vehicles 

Power Management Technology

Problem:

Current and future force electrical power demands exceed their power generation and energy storage capabilities. Advanced power generation (fuel cells) and storage systems (Lithium-ion batteries) depend on sophisticated control methodologies for safe operation. Limited fuel availability in the field. Increasing the number and size of electrical loads on a vehicular platform increases the amount of heat generated. There is no automated way to recover from faults and induced faults (i.e. Sympathetic tripping, chain tripping of loads.) Today's vehicular electrical architectures contain vehicle-unique electrical components which increase the logistics burden.

Challenges:

Vehicle size and weight limitations constrain power generation and storage capacity. Ability to accurately monitor and control the power distribution to react to fluctuating loads and sources in real time has not been developed. Lack of an open architecture for Electrical Power Architecture. Off-board power requirements are not fully defined.

Key Goals:

Manage power generation, energy storage, and power control/distribution components in order to maximize efficiency, increase reliability, reduce crew burden, and ensure propulsion and ancillary systems receive their required power based on crew (or robotic) input, mission derived priorities, system health, and/or tactical environment. Extend Power Mgmt Standard (FCS adopted) to include thermal mgmt. Develop Adaptive Power Mgmt for robotic platforms.

Key Efforts:

Power & Thermal Mgmt ATO; PEO GCS CMPS effort. Advanced Interconnects/Cable Systems; Cognitive Power Mgmt. Electrical Power Architecture SIL; Lightweight Adaptive Control Network. Point of Use/Load Switching/Conversion; Power/Thermal Standard. SBIR: Advanced 42-volt Technologies, Vehicle Networking; Virtual SIL, Intelligent Power Control and Prognostics Harness.

Customer:

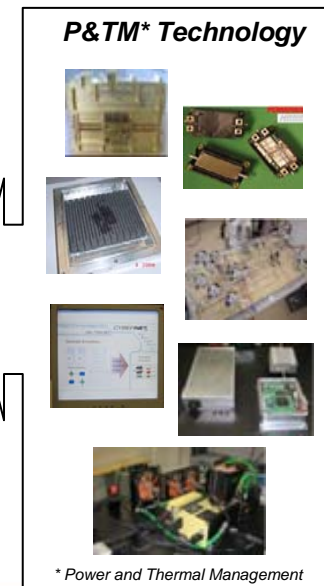
PEO GCS, PM-FCS, PM-JLTV, HEV EA ATO, TWVS ATO, NPS ATO



Software Standard Flex cable/PCU integration

Potential Applications

- APS
- C4ISR
- Environmental Controls
- Propulsion Systems
- Radios
- Radars



Potential Platforms



Thermal Management Technology

Problem:

Current cooling systems have insufficient capacities for projected heat rejecting requirements.
Increases in electrical power demand proportionately increase cooling system volume and weight requirements.
Thermal degradation inevitably results in reductions of component life and reliability.
Lack of intelligent control strategies for military ground vehicle thermal management systems.
Debris and contamination cause damage to vehicle powertrain components resulting in increased service requirements.

Challenges:

Insufficient data exists on the efficiency benefits of integrating emerging technologies into ground vehicle power electronics.
Available vehicular space claims limit heat rejection infrastructure.
Improvement in capabilities/capacities for filtration (liquid and air) without increasing the system physical size.

Key Goals:

Increase coolant temperature into power electronics from 65C (baseline) to 80C (threshold), 100C (objective).
Increase heat flux from 89 W/cm² (baseline) to 350 W/cm² (threshold), 400 W/cm² (objective).
2X improvement in service life for air filtration scavenging blower motor.
3X improvement in dust loading capacity and 5X improvement on water removal capability for fuel filter.
Integrated monitoring system within oil filter for condition based service intervals.

Key Efforts:

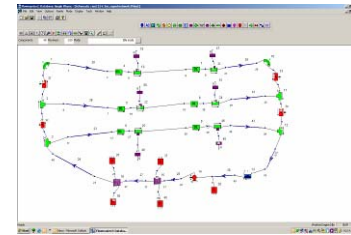
Power and Thermal Management Technologies ATO-[R]
Advanced Inverter Cooling Demonstration
Army Research Laboratory's (ARL) work on:
 SiC, high-temperature components
 Low-Loss, Nanocrystalline Magnetic Materials
 Ceramic, Micro-Channel Heat Exchanger Development
Self Contained Two-Phase Thermal Management System SBIR

Customers:

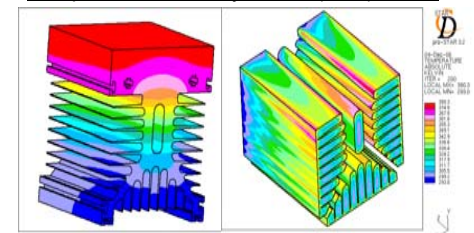
PM HBCT
PM SBCT
PM JLTV
PM FCS
PM LTV

- Advanced Cooling Technologies, Shock Tolerant Capillary Two-Phase Loops SBIR
- Thermal Design/Signature Management Tools SBIR
- Liquid & Air Filtration efforts, multiple phase I & II SBIRS
 - Dynamic Air Engineering Scavenging Fan Blower Motor.
 - Real Time Engine Oil Monitoring.
 - Cross Flow Membrane Fuel Filter.
 - Dynamic Air Engineering, High Temperature Cooling Fans.
- Oak Ridge National Laboratory's (ORNL) work on:
 - Graphite Foam
 - CFD Modeling
 - Neutron Imaging
 - Rotating Heat Exchanger

Analogous flow network model



Computational fluid Dynamics (CFD) model



Temperature distributions

HEVEA PROGRAM

Problem:

No holistic approach to define, evaluate, and substantiate TWV mobility requirements and specifications.

No standard Hybrid Electric Vehicle Test Methodology for TWV.

TWV duty cycles not well defined/understood; enhancing difficulty in assessing advantages and disadvantages of hybrid propulsion systems.

Challenges:

Accepted industry practices (SAE) for testing are not developed to be replicated in traditional military settings.

No industry standard advancing propulsion systems, specifications including requirements.

Key Goals:

Data and analyses to support PEO CS/CSS information requirements for JLTV MS B

M&S capability to provide a tool to predict hybrid electric drive cycle performance and fuel economy. – VPSET

HEV test methodology/Test Operating Procedure (TOP) using accepted industry practices and DOE processes. – Draft TOP validation testing ongoing.

Key Efforts: GVSL Execution of Experiments/Support - DCS

Electrical Power Architecture SIL Upgrade/Support and Thermal Management

M&S vehicle propulsion systems analysis and tool

Vehicle Testing

Customer:

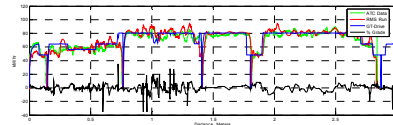
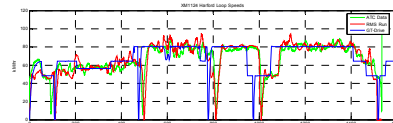
PM JCSS, PM JLTV

WV Class	Vehicle	Fuel Consumption Tests										Performance Characterization Tests																	
		C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36	C37	C38	C39	C40	
L	HM9WV M1113	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
L	HM9WV M1152 Up-Armored	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
L	HM9WV XM1124	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
L	BMV N GOR S	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
M	PPTS UN AM General																												
M	PPTS UN International MG																												
M	PPTS UN Lockheed Martin																												
M	EMTV 2-ST Engine MT078																												
M	EMTV 2-ST EMTV M1078 LMTV																												
M	HEMTV A2 OTC																												
M	HEMTV A2																												
M	HEMTV A2 Up-Armored																												
M	EMTV CVT Amvee Holdings, 2-ST LMTV																												
M	EMTV M1084 MTV																												
M	EMTV HEV/BEV Systems M1086																												
M	PPTS MSV Amvee Holdings																												

Note: All pairings are part of this study, other than those designated "NA"

Key: C = Testing Completed
PC = Partially Complete
NA = Not Applicable

Notations: (1) = Gap in data; may do additional testing
v = Graphical model completed, and included
* = Updated from previous reporting period



Track Technology

Problem:

Future combat vehicles desire lightweight track with no degradation in robustness or field supportability.
Current lightweight track durability threshold at 25 ton GVW vehicles.
Current lightweight track prone to AP mine blast damage.
Elastomer components are track system life limiter of legacy track fleet.

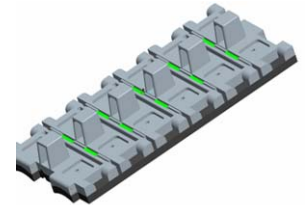


Challenges:

Light weight track systems challenged with higher stresses / less mass which limits durability / AP mine survivability.
Natural rubber elastomers rapidly degrade under high stress / high temperature conditions

Key Goals:

40% reduction in weight
50% improvement in elastomer durability



Key Efforts:

Segmented Band Track - ATO-D
Hybrid Steel Track – ATO-D
Elastomer Research Program – ATO-D
Segmented Steel Track – Congressional Add
Component Maturation Program – CMP Risk Reduction Funding

Customers:

PM FCS MGVBCT
PM HBCT



Suspension Technology

Problem:

Army Tactical and Combat vehicles require superior performance for battlefield dominance.
Up-Armoring of existing vehicle fleet challenging stock suspension components.
Developmental suspension systems maturation oversold.

Challenges:

Suspension components more complex with adaptive control.
Suspension components must be extremely robust, passive default required.
To save volume, suspension components placed outside armor protection and vulnerable to damage.

Key Goals:

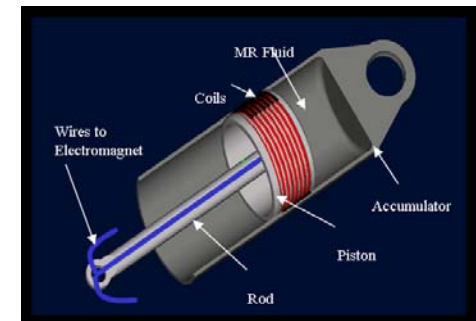
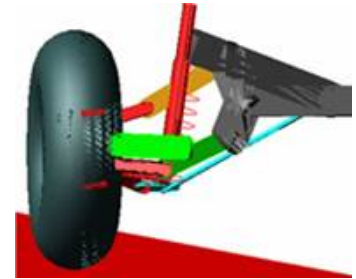
50% improvement in ride quality
50% improvement in vehicle stability

Key Efforts:

MR Suspension on Stryker – Maturation & Test, Wheeled Vehicle Power and Mobility – Proposed ATO-D
MR Suspension on Stryker - Proof of Principal Demonstration, SBIR Phase II Effort
Modular Suspension Development – Advanced Lightweight Track ATO-D
Compressible MR Fluid Development – Congressional Add
MR Suspension for Tracked Vehicle – SBIR Phase I Effort

Customers:

PM Stryker
PM FCS MGV



Modeling and Simulation Efforts

Problem:

Science and Technology programs, as well as Technology Insertion into fielded systems, requires accurate component and system level modeling and simulation efforts to support decision making.

The M&S community, and decision makers, need to be attentive to the correct level of fidelity and robustness required in models to identify the effects of emerging technologies on system performance.

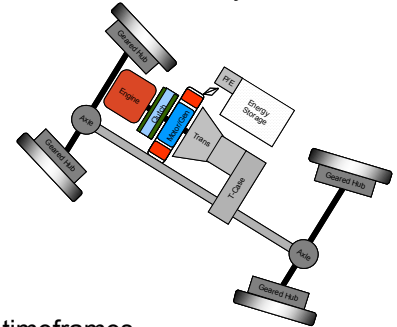
Challenges:

Access to OEM and supplier data for model development is often difficult to obtain.

Access to performance data to use for model validation is often non-existent or costly to obtain.

Expected vehicle system usage is often unclear, making merits of future technology difficult to evaluate.

Complexities of current and future vehicle systems require multidisciplinary knowledge to support system level M&S.



Key Goals:

Develop and maintain a database of valid system level models of current fleet to support “what-if” studies within short timeframes.

Develop in-house expertise and processes to advance M&S capabilities pertaining to mobility and power system analyses.

Key Efforts:

SBIRs:

Cybernet - Vehicle/Virtual System Integration Laboratory (VSIL) for testing vehicle design prior to committing to a hardware prototype. Acquisition tradeoff studies.

PCKA - software infrastructure enabling distributed system level M&S, implementing compatibility between different simulation tools as well as protecting vendor proprietary data.

Programs:

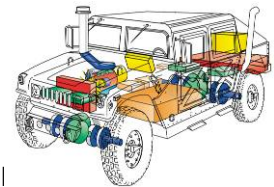
HEVEA – Drive cycle development for fuel economy evaluation, on-board data acquisition for TWV usage histories.

P&E HSIL – M&S support for SIL operation, control system development and test management, power system modeling.

In House:

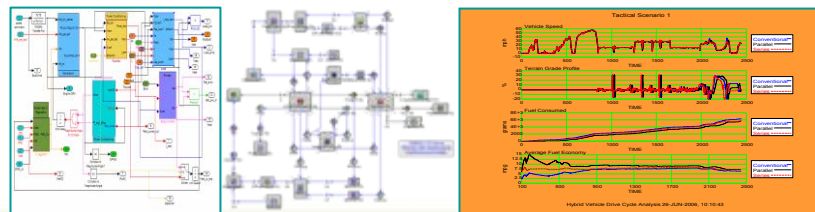
Duty Cycle Experiments – Driver-in-the-Loop, ride motion simulators

Database development – Stryker, HMMWV (M1113, M1114, XM1124), MTV (2.5-ton, 5.0-ton, Hybrid [BAE], CVT), FTTS UV, Abrams, Bradley,



Customer:

S&T Programs, PEO, ONR



Mobility Facilities

Mobility Facilities

- **Propulsion Test Laboratory**
- **Power and Energy System Integration Laboratory (SIL)**
- **Track and Suspension Laboratory**
- **Power Management System Integration Laboratory (SIL)**

Propulsion Test Laboratory

10 Test Cells which include

- 6 “engine” test cells used for performance, endurance, transmission or drive train testing
- 3 vehicle test cells designed for steady-state tests to 44000 ft-lbs per side as well as transient tests and a Power & Inertia Simulator (PAISI)
- Most contain portable dynamometers with absorption capability of 100-3000 horsepower

Test Cell #9 can simulate desert heat, wind and solar conditions at full load

- Ambient temperature control to 160°F
- Wind speeds up to 20mph in eight possible directions
- Two 2500 Hp dynamometers

Test Cell #10 can test batteries, power electronics and motors to 6000rpm

Air Flow Lab has air cleaner and radiator testing capability

Power and Energy SIL



Schedule:

MILESTONES (FY)	04	05	06	07
Collaborate with enabling tech development	P&E Tech Base			
CHPS Baseline Facility	5 Facility Available			
Expanded P&E SIL Capability	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>Vol 3.8 m³ 2800 kg</p> <p>Ground Breaking</p> </div> <div style="text-align: center;"> <p>HERMIT Available</p> </div> </div>			
- Building Expansion				
- HERMIT Integration				
- HERMIT Dev & Validation				
			HERMIT Available	Vol 3m ³ 2100 kg

Purpose:

- Integrate and evaluate power and energy technologies and subsystems from advanced tech base programs in a user-like lab environment.

Product:

- Compact integrated system that will provide efficient spin-out power and energy generation and management, including pulse power. Enables “Form, Fit, and Function” testing of power and energy technologies.

Payoff:

- Comprehensive power distribution and control capability in a real vehicle environment.
- Compact lightweight power and energy system with enhanced deployability through reduced volume and weight.
- Lowers technical risk for both technology developer and vehicle integrator.

New Power and Energy Lab

Design/Build request RFP being developed

Improved/Introduced Laboratories:

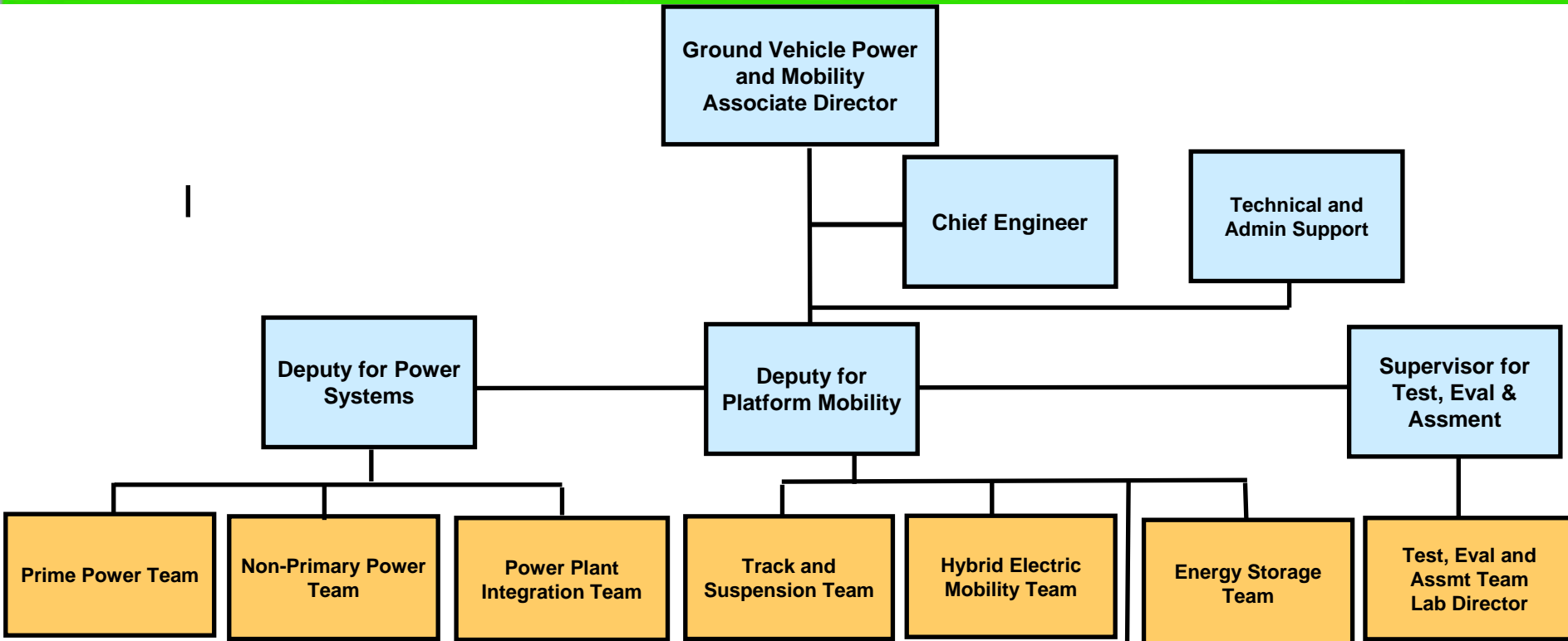
- Power and Energy Laboratory
 - New Capability for hydrogen/JP-8 fuel cell reformation testing
 - Improved alternator and starter testing capability by 20% over current capabilities
 - New Capability to test hydraulic systems
 - New Capability for air conditioning component testing
 - New Capability for capacitor DC life testing
 - New Capability Pulse formed Network system integration and testing
 - Improved capability to test large motors and power electronics by 2x current capability
- Airflow and Thermal laboratory
 - Improved air flow capability by 3x current capability
 - Improved thermal capabilities by 3x current capability
- Multipurpose Room
 - New Capability: Multi Wheeled vehicle testing with environmental capability from -60°F to 160°F
 - New Capability: Hybrid Electric Vehicle System Evaluation

Push for “GREEN”

- TARDEC is guiding the design to maximize energy conservation and use of alternative energies, materials, and other aspects of building design
- Goal is to attain Leadership in Energy and Environmental Design (LEED) gold/platinum certifications

Back up

Organizational Overview



Resources (Facilities, Capabilities, Expertise)

Building 212

- Vehicle, Engine, transmission, APU, batteries, generators, and motor testing
- Environmental heat management chamber and lab
- Steady state and transient test cells and labs

Building 7

- Air flow and coolant test cells and lab
- Fuel Cell/Battery testing capability

Building 215

- Track pad abrasive testing capability
- Track blowout testing capability
- Track pin deflection machine

Personnel

- 72 Engineers
- 13 Technicians
- 11 contract Engineers and Technicians

Modeling and Simulation Team

Applicable S&T programs to Robotic Vehicles

Mobility Power & Energy Thrust Areas

Power Systems
Engine
Fuel Cells
Air, Thermal and Power Management
Power Trains
Non – Primary Power Systems
(APU's, On Board Power Generation)

Platform Mobility
Hybrid Electric Drive Components
Power Electronics
Energy Storage
Lightweight track
Elastomer Research
Advanced suspension
Modeling and Simulation

Testing, Evaluation and Assessment
Propulsion Lab, Air and Cooling Lab
(Future Power and Energy Lab)
Vehicle Testing and Experiments

Key Platforms

PM FCS

Robotic

PEO-GCS

PEO-CS/CSS

Key Power & Energy Technologies for Robotics

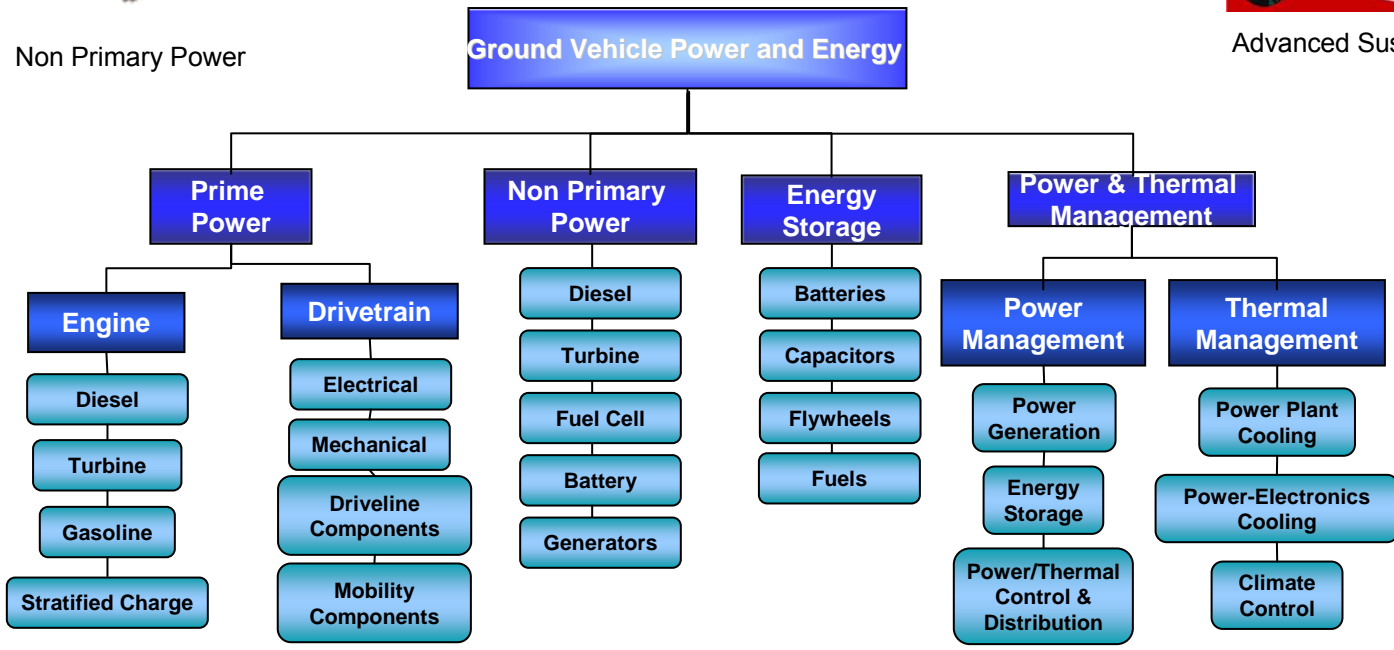
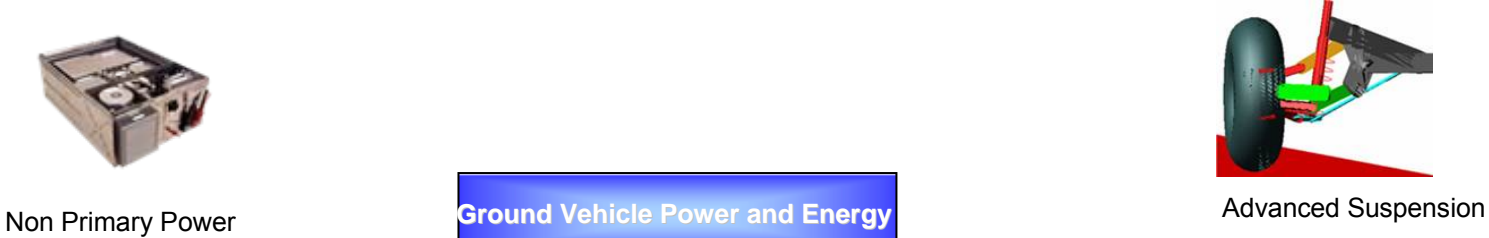
PEM, SOFC Fuel Cells
System and Component Thermal Management
Power monitoring, improved diagnostics,
fault management,
automatic/semi automatic load control,
Auxiliary Power to include
small IC engine, small generators

Drive Motors/Generators
Converters/Inverters
Advanced Batteries
(Li-ion, Ni-mh)
Capacitors

Band Track
Hybrid Steel Track
MR Suspension
Semi Active Suspension

Mobility M&S
Laboratory and vehicle
Evaluation and testing

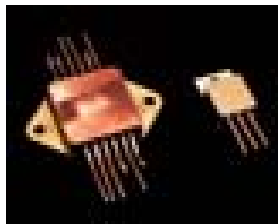
Requirements - Functional Decomposition



JP8 Reformer



Hybrid Components



Energy Storage



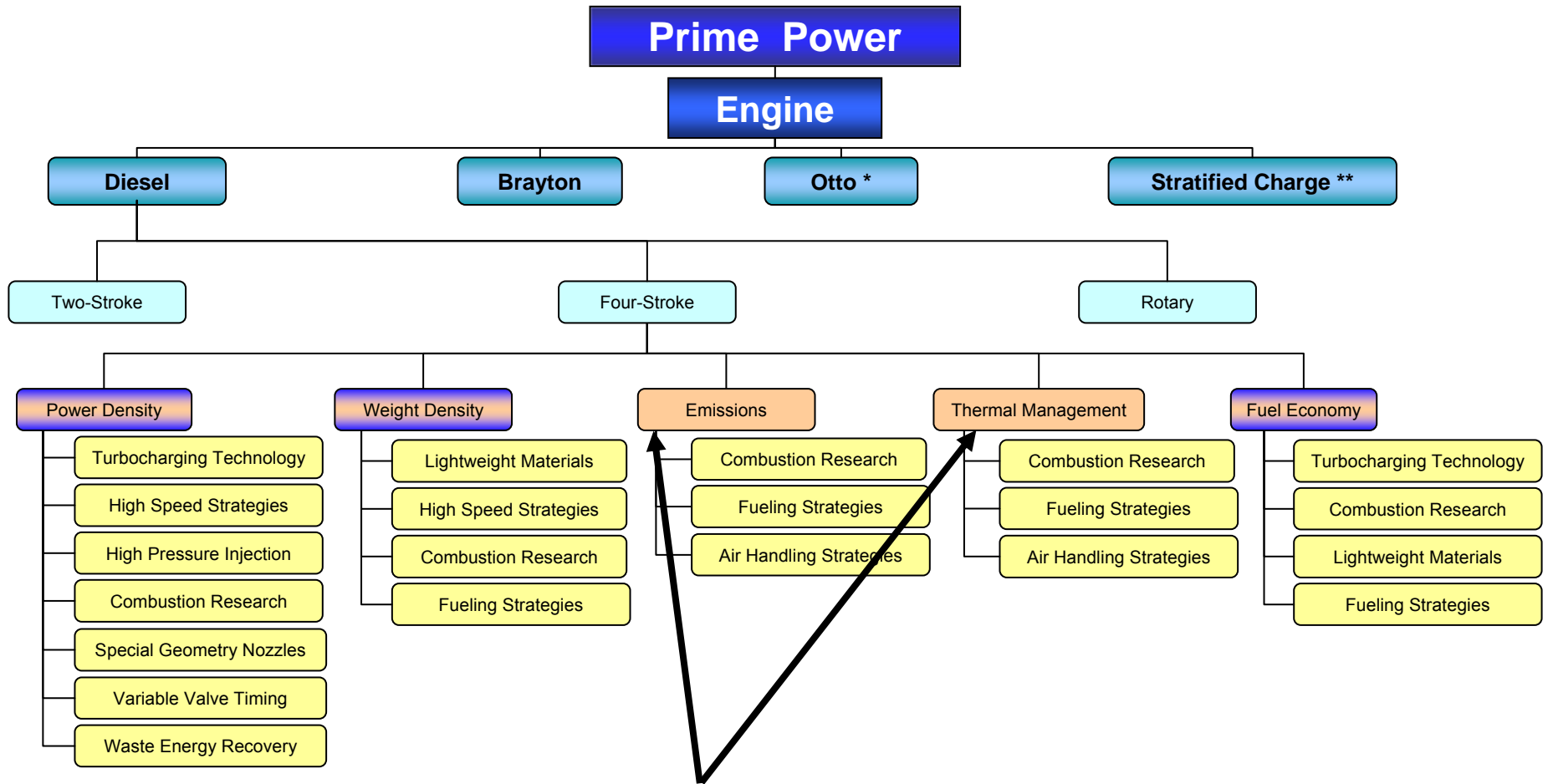
Power Dense Quiet Power Generation



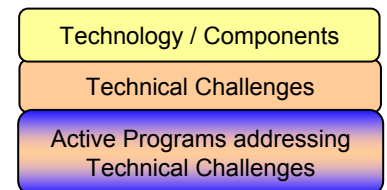
Militarized Commercial Engines



Requirements - Functional Decomposition



Technology Driven
Gap Analysis



Current Power and Energy Programs

Primary Power



S&T Programs – FY07

High Performance Engine (HIPER)
Hybrid Electric (HE) for Future Combat Systems (FCS)
Advanced Lightweight Track
Automotive Research Center
Ceramic Metal Matrix Composites
Segmented Steel Track
Lightweight Roadwheels

Advanced drivetrains for enhanced mobility
PEM Fuel Cells for Medium Duty Vehicles
Next Generation Non-Tactical Vehicle Power
Hydraulic Hybrid Research (HAMMER)
Low Temperature Vehicle Research
Compressible Magneto Rheological Fluids

Non-Primary Power



JP8 Reformation
Development of Logistical Fuel Processor
Defense Transportation Energy Research
Plasma JP-8 Reformer
Solid Oxide Fuel Cell Materials
Fuel Cell Ground Support Equipment
Rotary APU

Energy Storage

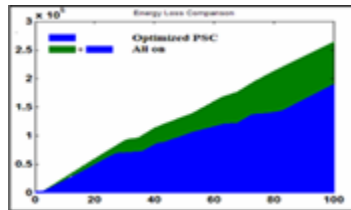


Experimentation and Ballistic Testing of Li-ion and Ni-Mh Batteries
Li-ion Battery Pack for Hybrid Electric -HMMWV
Prismatic Li-ion Cells with Integrated Liquid Cooling
Li-ion Battery Manufacturing Technology Objective
Li-ion Battery Electrochemical Research
Pulse Power Components
HMMWV Battery Pack
Battery Test Rig

3-D Advanced Battery Technology
Battery Charging Technology
Solid Hydrogen Storage
Military Fuel Research Program
Advanced Microgrid Liquid Fueler
Transportable Synthetic Fuel Manufacturing Modules
Fire Resistant Fuels

Current Power and Energy Programs

Power Management



Thermal Management



System Assessments



6.1 / 6.2 / 6.3

Congressional

S&T Programs – FY07

Cognitive Power Thermal Management Algorithms

Electrical Power Architecture (EPA) SIL

Foam Heat Exchanger

Integrated Heat Sink Micro-Channel

Use of Graphite Foam as a Cold Plate for Heavy Hybrid Propulsion Systems

Advanced Inverter Cooling Demonstration

Advanced Thermal Management Controls

Power and Energy System Integration Labs (SIL)

Hybrid Electric Vehicle Evaluation & Assessment (HEV EA)

21st Century Base

HMMWV Hybrid Technology Conversion Kits

Maturation and User Evaluation of Hybrid Electric XM1124 HMMWV's