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Technology Evaluation and Integration for Heavy Tactical Vehicles

Project Summary Presentation
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Project Objectives

• Provide engineering support to the US Army, Program Manager for the Fielding of Heavy Tactical Vehicles (PM-HTV).

• PM-HTV is in the process of upgrades to the HEMTT production vehicle so as to increase vehicle reliability and safety, and reduce life cycle costs.

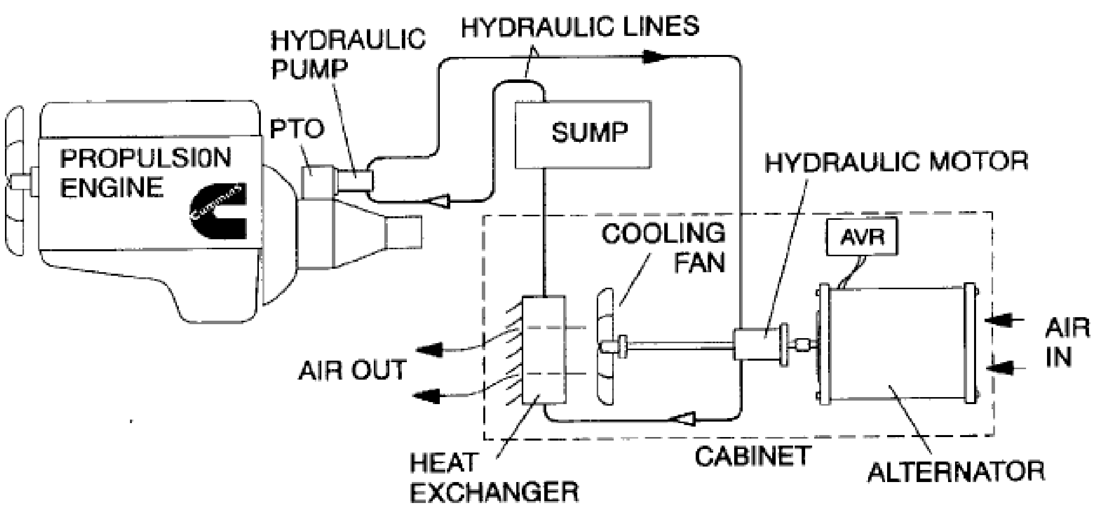
- Vehicle upgrades may include the addition of ***electrical power management, vehicle sensor integration and monitoring, and driver-assist equipment***.
- In order to illuminate what this means in terms of future engineering changes this effort will conduct engineering, integration, test and evaluation of these systems.
- Though these efforts and experience PM HTV will have an engineering foundation, set of performance data, and a technical data package to decide and carry on with implementation.
    - All deliverables are government owned.

• One of the main outcomes of this effort will be the delivery of a demonstration HEMTT A2 vehicle equipped with these systems for user evaluation and assessment.

Modular Hydraulic Power Generator

- Popular in fire/rescue and other industries since mid-1990s
- Completely integrated solutions available from 6-30kW
- Significant existing industry base:
  - Harrison Hydra-Gen
  - Cummins Onan
  - Hart-A-Gen Systems
  - Nartron Smart Power

Hydraulic operational schematic



- Benefits:
  - Allows flexibility of placement
  - Not subjected to engine compartment temperatures
  - Low cost APU capability
  - Reliable operation, minimal maintenance required
  - Multipurpose hydraulics: Power Steering, Winches, Power generation

Modular Hydraulic Powered Generator

- Approach: Repurpose the hydraulic drive for the winch
- Assembled and installed a bolt-on module
- Uses a hydraulically powered motor to drive a generator
- Existing alternator and this supplemental unit handle high power loads in place of large (>400A) belt driven system.

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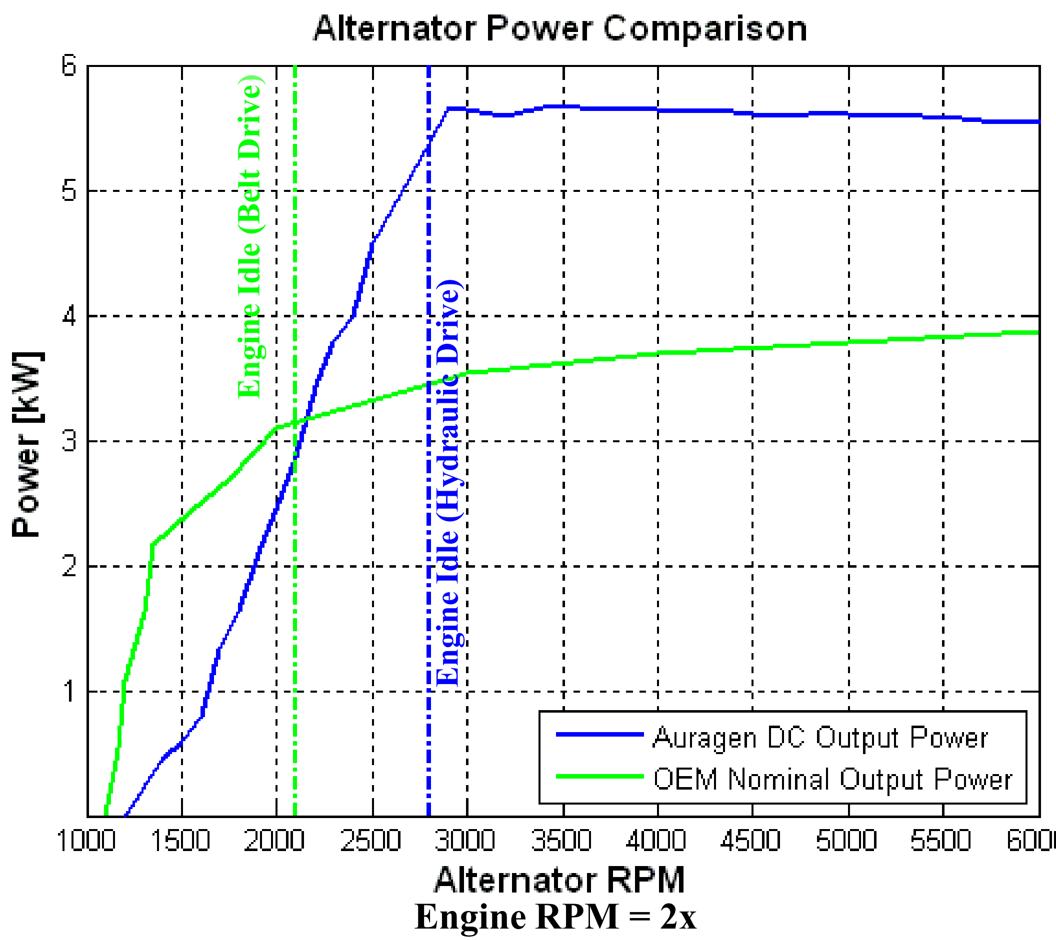
Key Findings- Modular Hydraulic Powered Generator

- Hydraulic powered alternator proved functional

- Provided higher, constant 5.6kw power output across wider engine speed ranges over current OEM equipment
- Need to add a flow control, by-pass feature to account for the effects of possible engine over-speed



Issues Supporting the Need for Primary Power Management

- Reliable engine starting after long term storage
  - AGM Battery loss on vehicles aboard Pre-Pro Ships (USNS Pomeroy)
  - War Reserve, National Guard, etc. with long periods of inactivity
- Higher total power needed for high electrical demands (e.g. A/C, C4ISR, CREW, IED countermeasures, lighting)
- Longer operation during 'silent watch'
- Reduced logistics burden
- Lower lifecycle costs
- Simplified maintenance and diagnostics

Battery Graveyard, Kuwait

Approach: Primary Power Management System (PPMS)

PENNSTATE 1855 ARL

A common vehicle power & energy architecture across platforms

- Employs a split energy storage system to optimize energy delivery

Evaluated the utility of a planetary gear starters

Accepts modular external charging sources (e.g. BB-2590, Solar, etc).

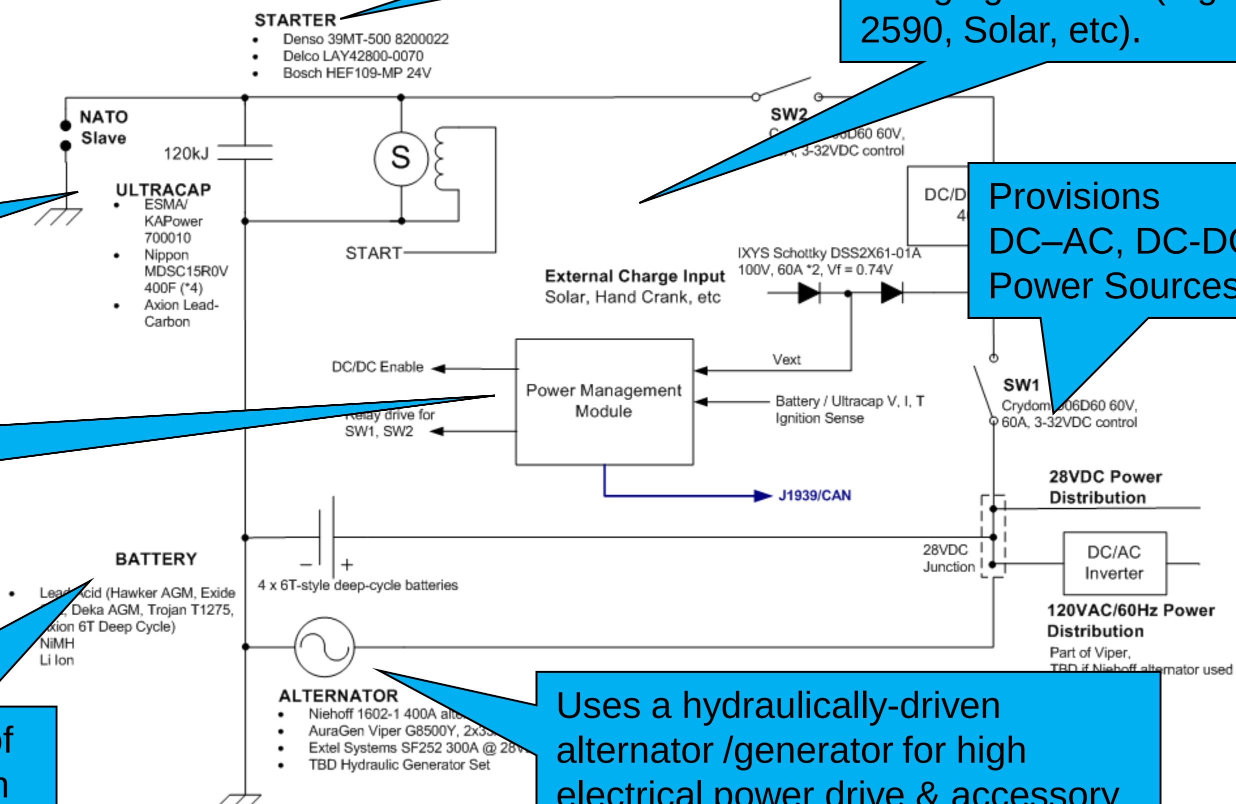
Uses ultracapacitor for vehicle starting

Provisions DC–AC, DC-DC Power Sources

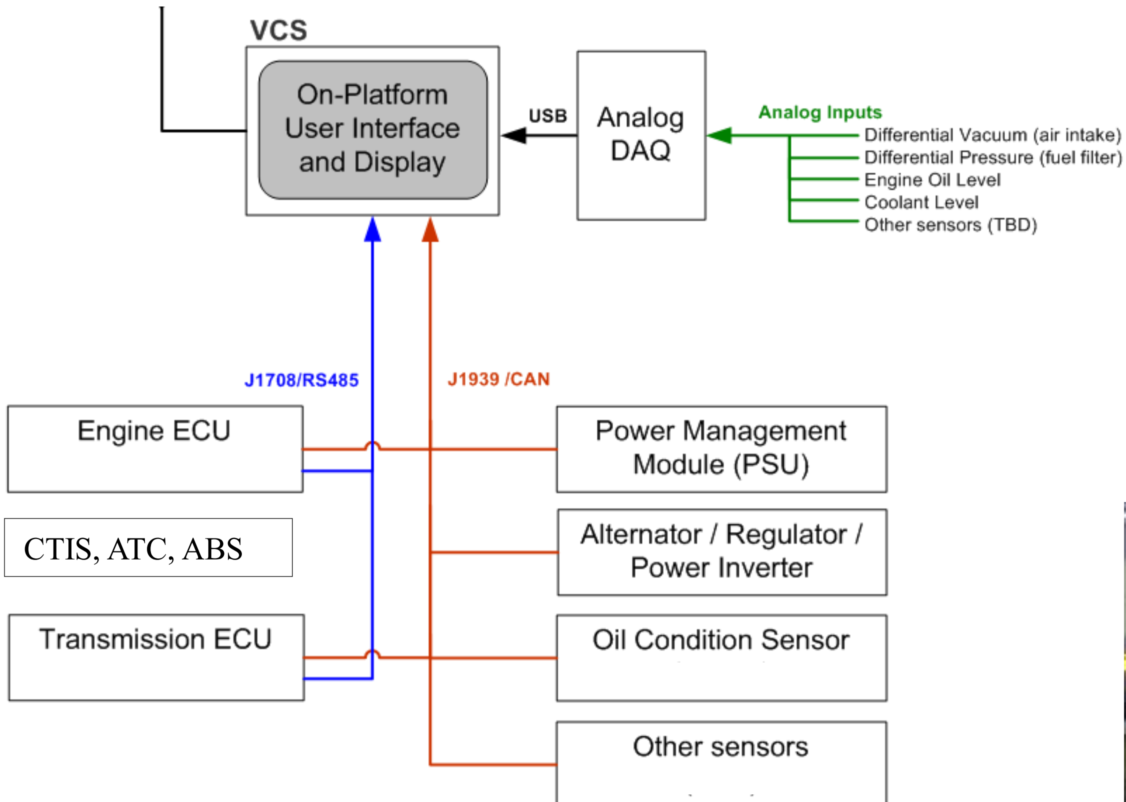
Integrates power management & control

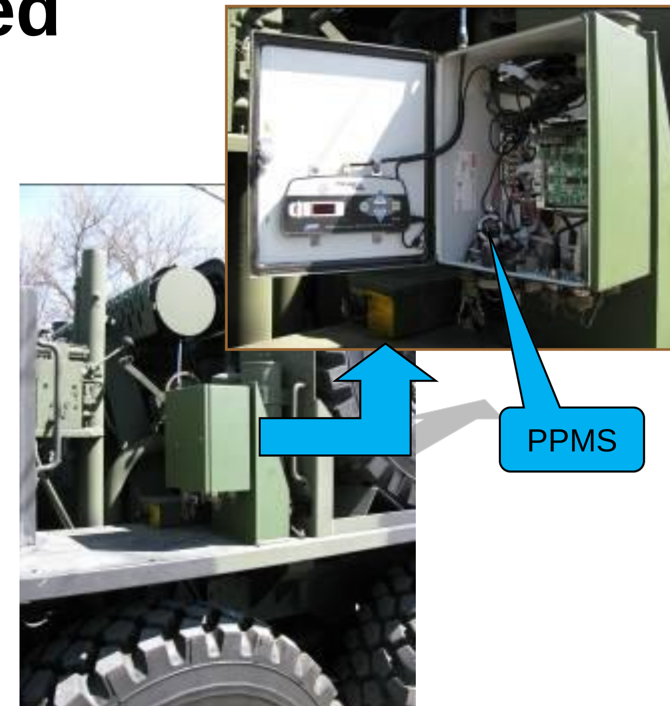
Accommodates variety of batteries to meet mission requirements

Uses a hydraulically-driven alternator /generator for high electrical power drive & accessory loads



Primary Power Management System Built & Tested





Scalable across TWV's

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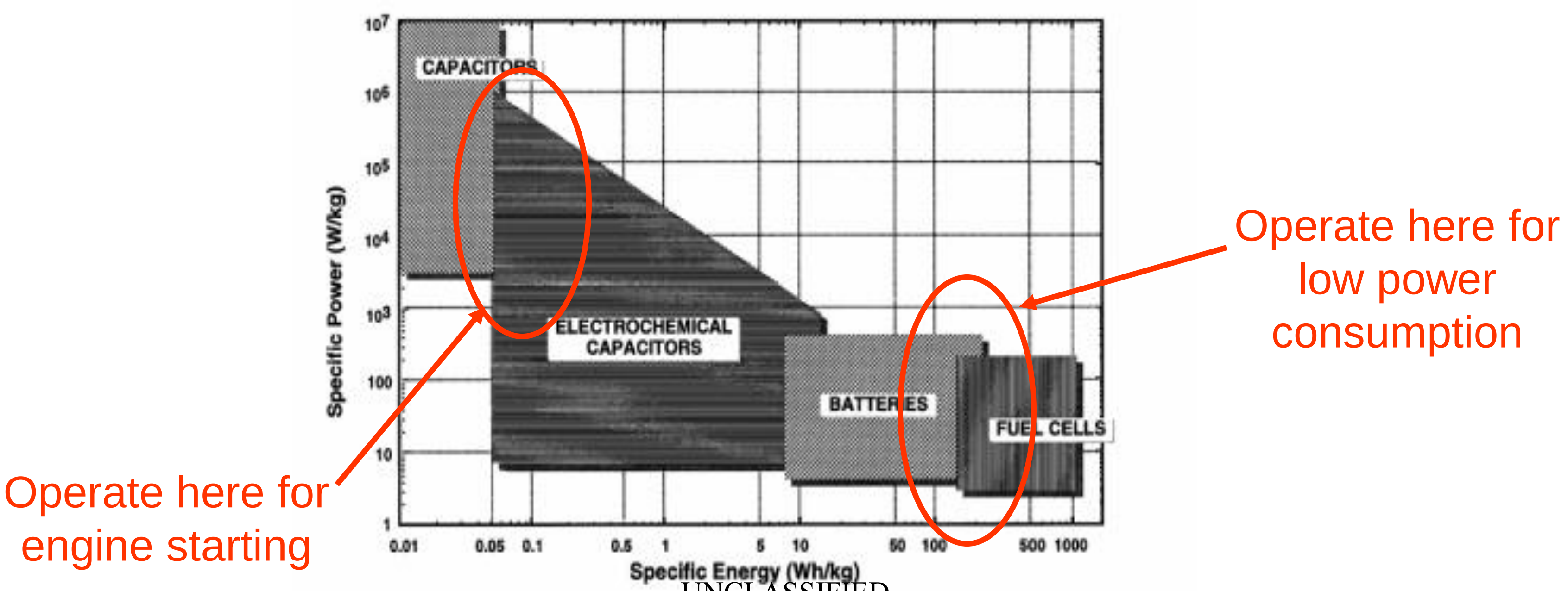
PPMS Split Energy Storage System Design Benefits

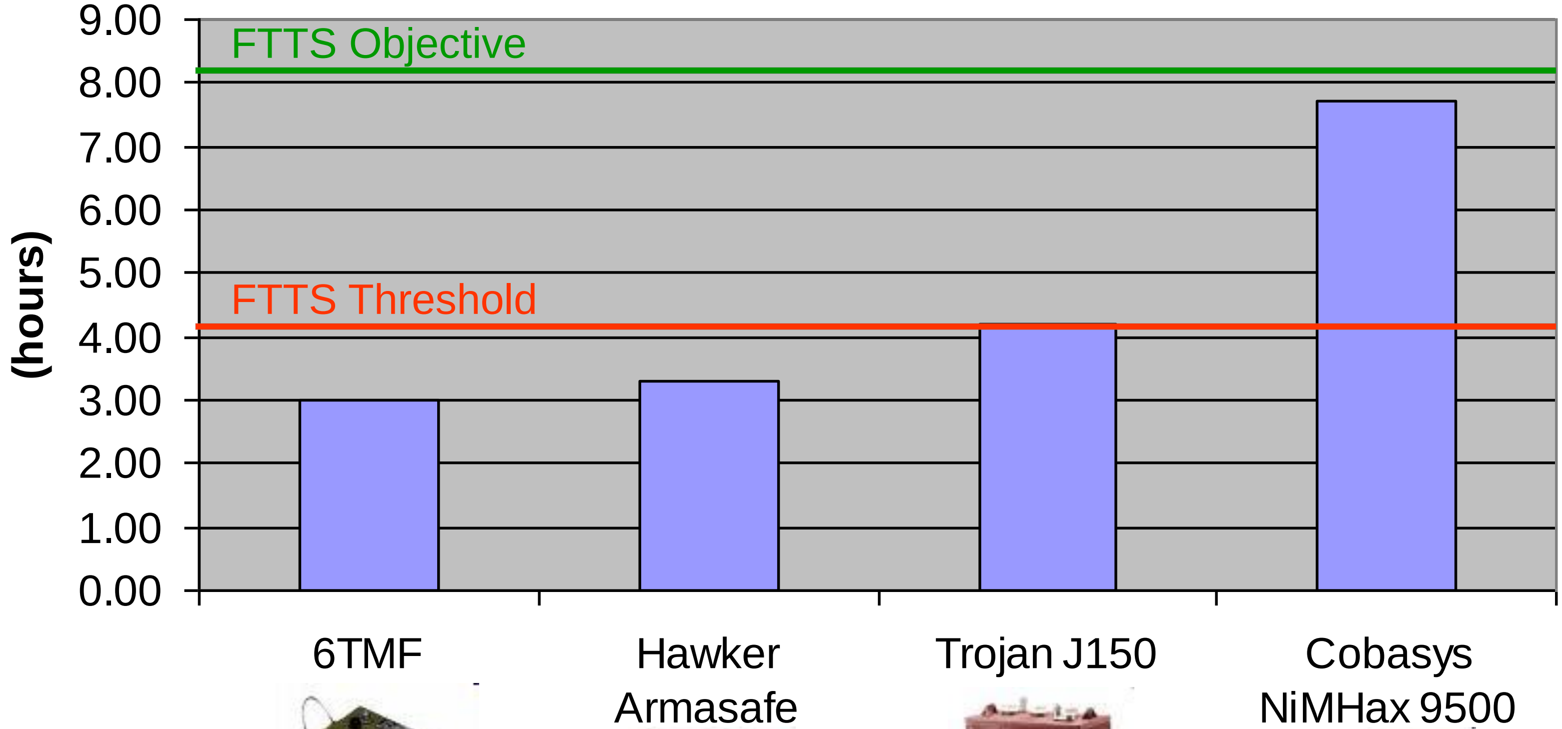
- Utilize ultracapacitors for engine starting
- Use the appropriate battery technology for specific mission requirements
- Meets the needs of the two different vehicle energy/power requirements
    - One for starting, other for low power, long duration
- No battery exists that can be optimized for both functions



Results- Energy Storage for Silent Watch and Life Cycle Costs

Silent Watch Runtime vs. FTTS Requirements

Runtime estimates based on 60A @ 24VDC, with battery pack = size/weight of (4) 6TMF batteries; *assumes no energy required for engine start at conclusion of silent watch*

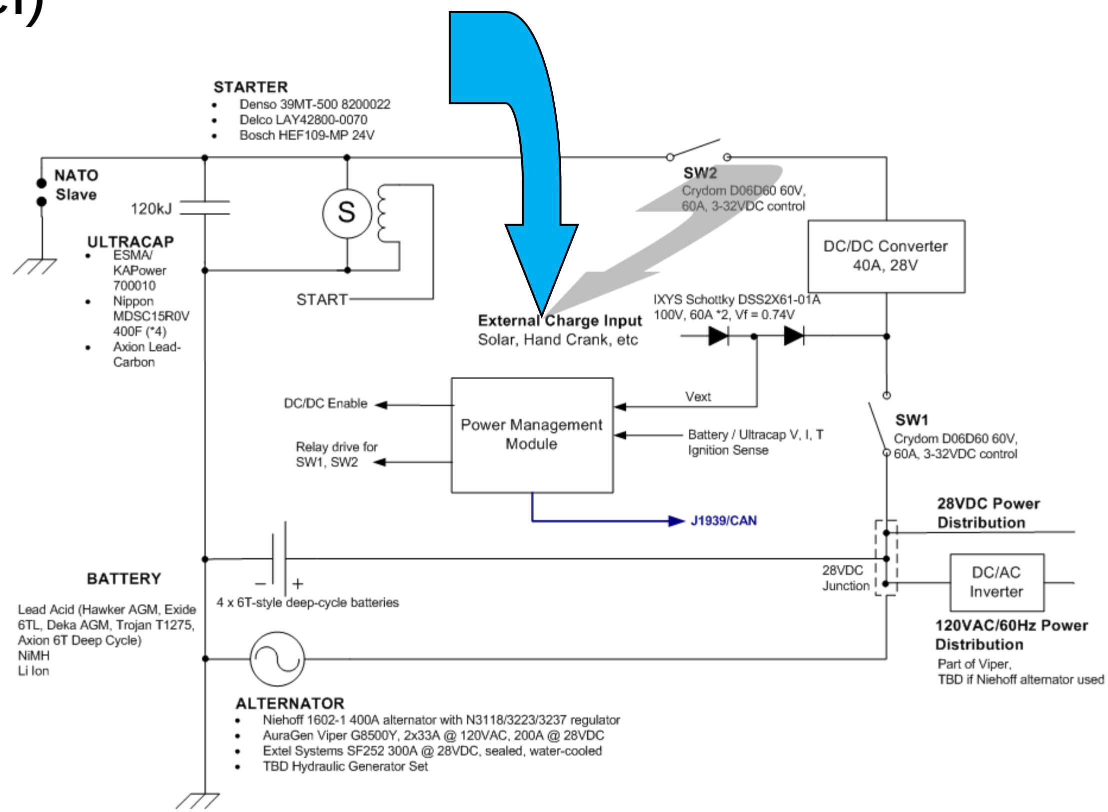


Total Life Cycle Costs	**$17,280**	**$20,900**	**$8,960**	**$36,000**

Lifecycle costs based on 25 year vehicle lifetime with two high intensity conflicts and 6000 charge/discharge cycles.

Recharge of Hybrid Starting System with External Source

- PPMS and hybrid starting system accommodates multiple, new external charging sources (e.g. BB2590, hand-crank, solar panel)



- BB2590 External Recharge
- 126 sec's from dead to start; 6-7 charges from one BB2590 Battery

PPMS Key Findings

Findings:

- Hybrid starting system proved functional
- Works with wide range of batteries
- Ultracapacitors can restart vehicle many 1000's of times
- Hydraulic powered alternator proved functional
- Ultracapacitor recharge control system proven using BB 2590, can also use BB390 NiMH, etc.

Impact:

- Life cycle cost reduction, reliability, improved performance in 'silent watch' runtime, modularity, applicability across family of TWV's

PPMS Path Forward

- Better integrate and package the power and energy control system into the demonstrator vehicle with Vehicle Information Backbone (TRL-8)
- Perform electrical noise characterization and testing
  - Similar to a Mil. Std. 810 characterization, but short of certification)
- Conduct System Integration Test
- Update cost benefit analysis
- Complete performance specification for transition

Collision Detection System for Military Convoy Vehicles Operating CONUS

Problem: We have no acceptable fielded safety system for run-on crash avoidance

Commercial RADAR systems are ineffective in tough terrain, environmental conditions, and with moving obstacles. Further, cost is too high to field on all vehicles.

Objective: Assemble and package a modular collision avoidance system that could be used in vehicles operating CONUS.

Technical Approach:

- Compare instantaneous GPS positions between vehicles and inertial sensor data to compute inter-vehicle closing distance & stopping time.
- Provide audible/visual alert to driver inside their reaction time window.
- Use COTS components integrated into a modular package for allocation to vehicles on an as needed basis.

*TACOM Safety Office Report

Collision Detection System-Description

As-Built Prototype System for Test & Evaluation

•GPS and inertial sensors on each vehicle

•Wireless communication between vehicles

•Use of Netbook PC's

Approach

•Share precise separation distance between vehicles

•Combine separation data and rate of closure to determine warning

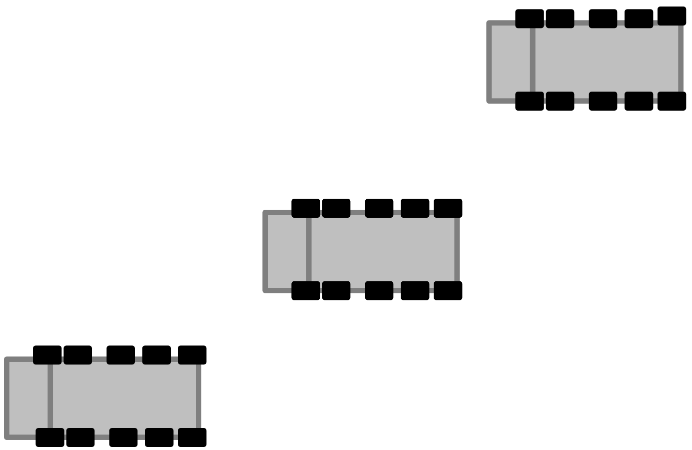
•Present audible and visual driver alert

System Testing

- 2 and 3-vehicle testing conducted at Penn State test track
- 3-vehicle convoy testing conducted on PLS's at Yuma Proving Ground

Example- Yuma Hard Brake, Emergency Stop Test

- Three vehicle convoy, staggered in three parallel lanes on runway
- Accelerate to 30 MPH
- Vehicle 1 brakes suddenly, Vehicles 2 & 3 respond to Vehicle 1's brake-lights *with deliberate 1 sec reaction delay time*
- System records vehicle positions as well as velocities and generates warning parameters indicated on a driver display to alert of a possible collision



Collision Avoidance Testing
Hard Brake / Emergency Stop

Immediate End of Test- all vehicles braked to a stop

Vehicle 2 “overran” Vehicle 1

Vehicle 3 stopped with headway between Vehicle 2

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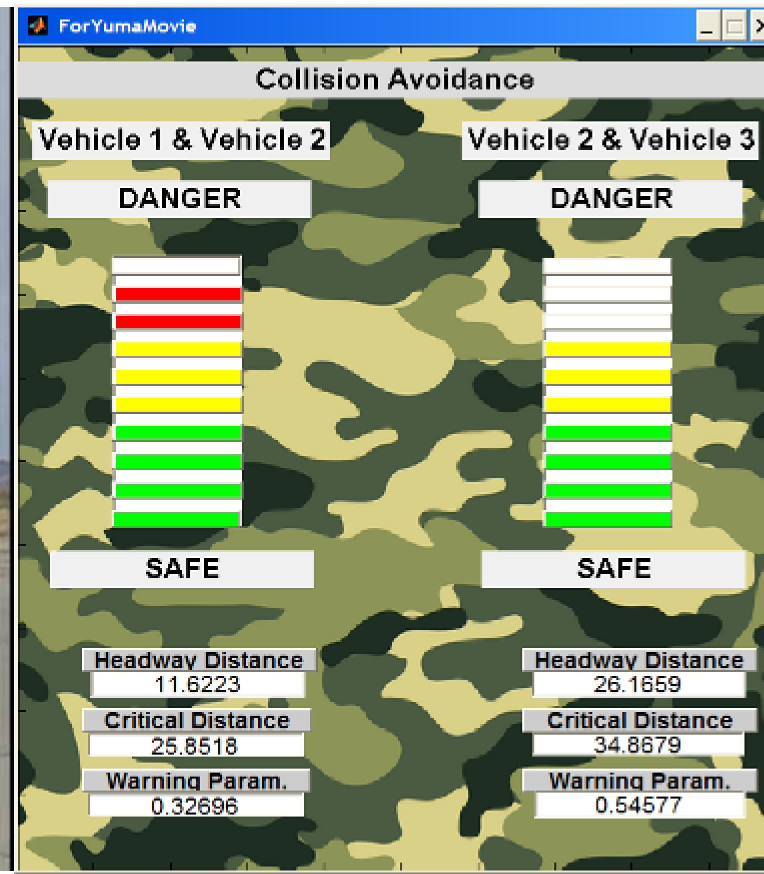
Takeaways:

- Red gives proper indicator of unsafe headway distance
- Need to tailor and adjust thresholds to optimize system performance and driver effectiveness



Collision Detection System- Findings & Next Steps

Key Findings:

- System performance unaffected in visually obscured environment
- Technique of combining GPS with inertial measurement meets the desired performance at lowest cost

Next Steps:

- Move from prototype to field ready package
- Develop capability to localize within the convoy
- Modify the Driver Alert Interface based upon feedback from drivers

On-Vehicle Sensor Integration for Monitoring and Diagnostics

Applied to existing vehicle data sources

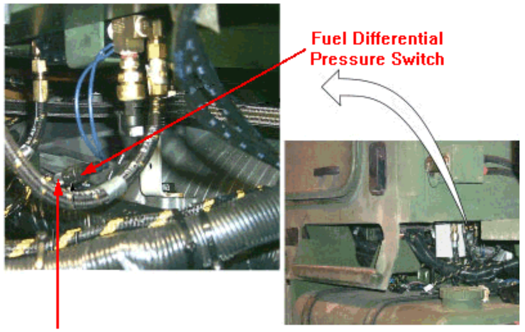
- Integrate Vehicle Computer System (VCS)
- Develop and integrate common CBM graphical user interface
- Open data sources: J1939, J1708
- Proprietary data sources: ADM diagnostic messages, ADM operational parameters

Applied to new sensors

- Engine oil condition analysis
- Engine oil level
- Transmission oil level
- Coolant sensor level
- Hydraulic reservoir oil level
- Fuel level
- Fuel filter condition
- Tire pressure monitoring
- Brake wear monitoring

Applied to power system components

- Alternator: Voltage, Current, and Temperature
- Battery: V, I, T, State of Charge, and State of Health
- Ultracapacitor: V, I, T, and SOC



Automated Reporting Information System- Displays

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History of Penn State Support to PM HTV

11865 Hydraulic System Diagnostics and Condition-Based Maintenance for Heavy Tactical Trucks
20-Aug-2003 – 31 Mar-2004
6 months

11899 Battery Diagnostics/Prognostics for Heavy Tactical Trucks - Preliminary Design and Demonstration System
21-Oct-2003 – 20 Nov-2004
13 months

12368 Demonstration of Hydraulic System Diagnostics and condition Based Maintenance for Heavy Tactical Trucks
8-Jun-04 – 7-Jun-05
13 months

13275 Hydraulic System Diagnostics for the HEMTT A2+Technology Demonstration Vehicle
12-Jul-2005 – 31 Dec-2005
6 months

13792 Hydraulic System Diagnostics for the HEMTT A2+ Technology Demonstration Vehicle FY06
9-Feb-2006 – 8 Aug-2006
7 Month

14982 Production Testing Techniques for Performance Assessment of the Primary Power System for TWV's
Aug- 2007 – 30 Sept 2008
12 months

16136 Advanced Technology Evaluation and Integration for Heavy Tactical Vehicles
24-Sep-2008 – 23 Mar-2010
18 months

Supporting Vehicle Test Beds


Hydraulic Powered Alternator Assembly

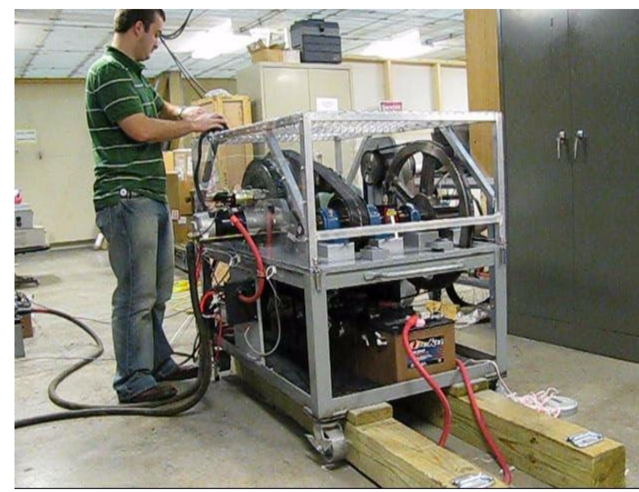

Advanced Technology Demonstrator (GFE HEMTT)

Automated Reporting Information System and Model


Battery & Ultracapacitor Environmental Test Bench

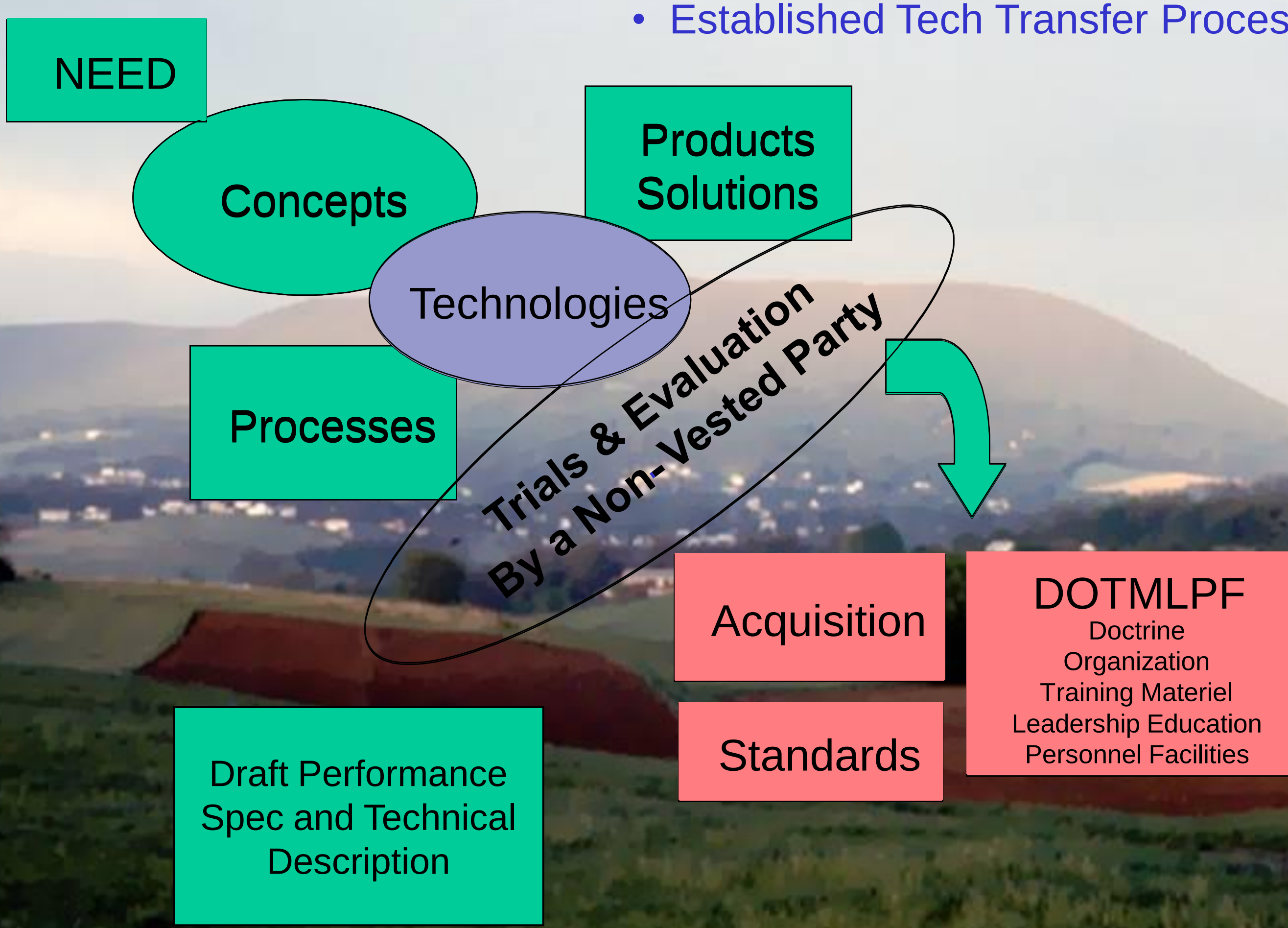

Collision Avoidance Test System


Ground Vehicle Alternator Test Bed


Hardware-in-the-Loop Test Bench (engine, starter, alternator)

Our Role, Process and Value to PM Tactical Vehicles

- Engineering of Embedded Diagnostics and Prognostics
- Architecture Design for Logistics/Command-Control Systems
- Full Time Dedicated Science & Engineering Staff
- US Citizens, Cleared for DoD
- Established Tech Transfer Processes



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