Alternative Energy, Hybrid and Electric Vehicle Programs in TARDEC Tactical Wheeled Vehicles Conference
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Operational Energy:
“energy required for training, moving, and sustaining military forces and weapons platforms for military operations.”

Pursue Operational Energy Efficiency by targeting the Army’s Energy Security Goals

- Increased Use of Renewable / Alternative Energy
- Assured Access to Sufficient Energy Supplies
- Reduced Adverse Impacts on the Environment
- Increased Energy Efficiency Across Platforms and Facilities
- Reduced Energy Consumption

Operational Energy: "energy required for training, moving, and sustaining military forces and weapons platforms for military operations.”

2010 QDR
Army Power and Energy

**OPERATIONAL ENERGY**

Integrated Approach to Meet Army Energy Security Goals

- **ESG 1:** Reduced Energy Consumption
- **ESG 2:** Increased Energy Efficiency
- **ESG 3:** Increased Use of Renewable & Alternative Energy
- **ESG 4:** Assured Access to Sufficient Energy Supplies
- **ESG 5:** Reduced Adverse Impacts on the Environment

- Give Soldiers and leaders capability to manage energy status, resources and performance
- Significantly reduce energy footprint
- Provide flexibility and resiliency by developing alternatives and adaptable capabilities
Ground Vehicle Technical Challenge

**Mobility & Energy Efficiency**

- **Vehicle Dynamics**
  - Newton-Euler Equations of Motion
  - \[ Mq + C\dot{q} = \mathbf{Q} \]
  - \( C(q, t) = 0 \)
  - Solve for vehicle mobility and component loads

- Hi-Energy, Hi-Density Energy Storage

- Comprehensive Thermal Management of Propulsion & Cabin

- High Power Density, Low Heat Rejection & Fuel Efficient Engines

**Occupant Centric Survivability**

- Active Protection Systems

- Holistic Occupant Centric Protection

- Affordable, Multi-hit Ceramic Armor

- Fire and Toxic Fume Resistant Materials

**Performance & Reliability**

- Robust Multi-Disciplinary Optimization

\[
\int_S \mathbf{f}(x,t)dV = \int_{x_{min}}^{x_{max}} \frac{\partial \mathbf{f}(x,t)}{\partial t} dV + \int_{S_{min}}^{S_{max}} \mathbf{f}(x,t) \cdot \mathbf{n} dS
\]
Technology Enabled Capability Demonstrations

**Force Protection – Soldier and Small Unit**

**Problem Statement:** The spectrum of threats encountered by soldiers in small units is varied and complex, current equipment, clothing, and other protective measures do not provide adequate protection without adding significant mobility challenges.

**Challenge:** The lack of protective gear and equipment to deal with the various threats.

**What:** Develop a new protective gear and equipment.

**When:** Immediate.

**Human – Medical Assessment and Treatment**

**Problem Statement:** Traumatic brain injury (TBI) continues to be a significant issue for soldiers in the field. The severity of TBI can range from mild to severe, affecting soldiers' ability to continue duty.

**Challenge:** Developing a system to quickly assess and treat soldiers with TBI.

**What:** A new medical assessment tool.

**When:** Immediate.

**Challenge Boundary Conditions:**

- Who: Medical personnel.
- What: Immediate assessment.
- When: Immediate.
- Where: Field.

**Obstacles:**

- Time constraints.
- Availability of medical personnel.

**Objectives:**

- Develop a system to quickly assess and treat soldiers with TBI.
- Increase the survival rate of soldiers with severe TBI.

**Technology Enabled Capability Demonstrations**

**Force Protection – Occupant Centric Platform**

**Problem Statement:** Designing vehicles to protect soldiers from various threats, including indirect fires and indirect threats.

**Challenge:** Developing a new vehicle design that provides maximum protection.

**What:** A new vehicle design.

**When:** Immediate.

**Human – Individual Training to Tactical Tasks**

**Problem Statement:** The soldier today has a larger number and more complex weapons, protective systems and communications systems, which makes them more complex to train and maintain.

**Challenge:** Developing a new training system that integrates all the necessary tools and support.

**What:** A new training system.

**When:** Immediate.

**Challenge Boundary Conditions:**

- Who: All soldiers.
- What: Integrated training.
- When: Immediate.
- Where: Field.

**Obstacles:**

- Limited resources.
- Space constraints.

**Objectives:**

- Develop a system that integrates all necessary tools and support.
- Increase the efficiency of training.

**Technology Enabled Capability Demonstrations**

**Force Protection – Basing**

**Problem Statement:** It takes too long and too much manpower to deploy, set up, protect, sustain, and remove Combat Outposts (COPs) and Patrol Bases (P'a).

**Challenge:** Developing a new system that allows for quicker and more efficient deployment and sustainment.

**What:** A new deployment system.

**When:** Immediate.

**Challenge Boundary Conditions:**

- Who: All soldiers and support personnel.
- What: Efficient deployment.
- When: Immediate.
- Where: Field.

**Obstacles:**

- Limited resources.
- Space constraints.

**Objectives:**

- Develop a system that allows for quicker and more efficient deployment.
- Increase the efficiency of sustainment.

**Technology Enabled Capability Demonstrations**

**Surprise/Tactical Intelligence – Actionable Intelligence**

**Problem Statement:** The small unit has to have the ability to quickly and accurately identify threats and respond to them.

**Challenge:** Developing a new system that allows for quick and accurate identification of threats.

**What:** A new identification system.

**When:** Immediate.

**Challenge Boundary Conditions:**

- Who: All soldiers.
- What: Quick identification.
- When: Immediate.
- Where: Field.

**Obstacles:**

- Limited resources.
- Space constraints.

**Objectives:**

- Develop a system that allows for quick and accurate identification of threats.
- Increase the efficiency of response.

**Technology Enabled Capability Demonstrations**

**Sustainability/Logistics – Transport, Distribute & Dispose**

**Problem Statement:** The Army needs improved capability to tactically transport and deliver consumables to Forward Operating Bases (FOBs) and smaller satellite bases in remote, dispersed, austere locations with reduced supplier and equipment risk, including improved efficient and safe methods for disposing waste.

**Challenge:** Developing a new transport system that allows for efficient and safe disposal of waste.

**What:** A new transport system.

**When:** Immediate.

**Challenge Boundary Conditions:**

- Who: All soldiers.
- What: Efficient transport.
- When: Immediate.
- Where: Field.

**Obstacles:**

- Limited resources.
- Space constraints.

**Objectives:**

- Develop a system that allows for efficient and safe disposal of waste.
- Increase the efficiency of transportation.

**Technology Enabled Capability Demonstrations**

**Ready this time**

**Deferred to next cycle**
Force Protection – Occupant Centric Platform
Technology Enabled Capabilities Demonstration (TECD)

New design philosophy that considers the Soldier first and builds the vehicle to surround and support the Soldier and their mission.

- Reduce casualties by 50% across each mission role with scalable protection levels to defeat a wide range of threats
- Enhance fielded mobility performance
- Maintain freedom of action during full spectrum operations.

Occupant Centric Survivability for Military Ground Vehicle Design:
- Publish an overarching Military Standard (MIL-STD)
- Publish technical specifications
- Update and develop component and sub-system Test Operations Procedures (TOPS/ITOPS)

Occupant Centric Concept Demonstrator:
A physical realization of the new Occupant Centric design philosophy

Current Platform Demonstrator
A unique occupant protection suite of technologies specific to the platform given its design constraints

Weight Reduction:
Weight neutral at threshold and 25% weight reduction at objective

Maneuverability and Mobility:
Maintain fielded mobility performance
Ground Vehicle Power and Energy Technology Taxonomy

**Power Generation**
- Diesel Engines
- Rotary Engines
- Transmissions
- JP-8 Fuel Cells
- Traction Motors
- Integrated Starter Generator
- Turbine Engines
- Alternators
- Drivelines

**Energy Storage**
- Li-Ion / Ultracap Hybrid Energy Storage
- Capacitors
- Advanced Batteries

**Thermal Mgmt & Power Distribution**
- Radiators
- Microgrids
- Power Controllers for Power Management
- Heat Recovery
- Power Converters/Inverters
- Advanced Electronics Cooling
- Thermal Architecture

**Materials**
- Lightweight Materials
- Thermal Interface Materials
- Wide Band Gap Materials (SiC)
- High Temperature SiC Modules
- Lightweight Structures
- High Temp Inductors

**Fuels & Lubricants**
- Qualifications & Specifications
- Biomass Energy (Renewable)
- Conversion Process
- Single Fuel
Capabilities

• Provides steady state and transient (mission profile based) testing
• Ability to test current and emerging classes of ground vehicles
• 32,000 ft² of laboratory space
• Environmental chamber able to test between -60° to 160° F with winds up to 60 mph
• Provides 10 dynamometers to allow testing of up to 5 axle wheeled vehicles

Grand Opening April 11, 2012

Certified LEED Silver in accordance with the USGBC Board
Army and DOE Sign Charter to Achieve Vehicle Power and Energy Efficiency

Advanced Vehicle Power Technology Alliance (AVPTA)

Breaking New Ground

AVPTA will move us toward reducing our reliance on fossil fuels.

Combines the intellect of the DA and the DOE to accelerate energy-related R&D initiatives.

- Partnership with true collaboration to enhance national energy security
- Demonstrate federal government leadership
- Provide shared capabilities and access to resources
- Accelerate technology development
- Drive innovation
- Increase the value of research investments
- Address national energy needs
### Technical areas for joint activity:

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<td>• High density, energy efficient powertrain</td>
<td>• Reduce weight to improve performance</td>
<td>• Cost Improved efficiency, manage heat generation</td>
<td>• Standardization &amp; security</td>
<td>• Efficiency improvements</td>
<td>• Assessment/Design Trades</td>
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<td>• Extreme gains in engine efficiency</td>
<td>• Cost reduction for consumer market</td>
<td>• Efficiency gains through waste heat recovery</td>
<td>• Efficiency gains through advanced oil formulations</td>
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**Driving results through collaboration**
It’s All About the Warfighter

TARDEC’s Ground Vehicle Gateway
https://tardec.groundvehiclegateway.com