Alternative Energy, Hybrid and Electric Vehicle Programs in TARDEC

Tactical Wheeled Vehicles Conference

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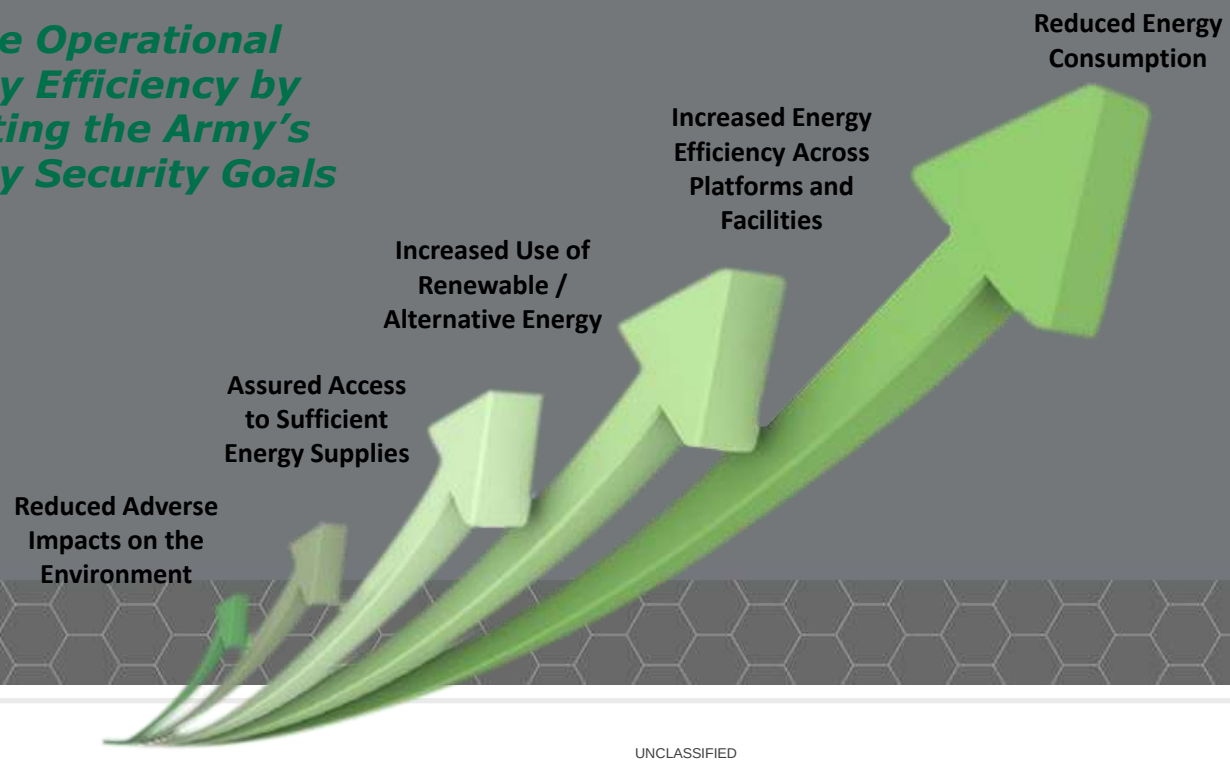
S&T Vectors for Improving Operational Energy Efficiency

Operational Energy:

"energy required for training, moving, and sustaining military forces and weapons platforms for military operations."

2010 QDR

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



Army Power and Energy

Basing

- Installation
- Contingency

Soldier

Vehicles

- Tactical
- Non Tactical

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

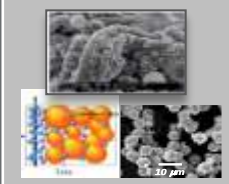
Vehicle Dynamics

Newton-Euler Equations of Motion

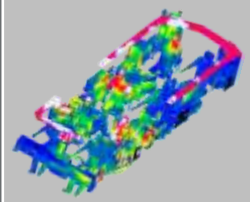
$$\left.\begin{aligned}\mathbf{M}\ddot{\mathbf{q}}+\mathbf{C}_{\mathbf{q}}^{T}\boldsymbol{\lambda}=\mathbf{Q}\\ \mathbf{C}(\mathbf{q},t)=\mathbf{0}\end{aligned}\right\}$$

Solve for vehicle mobility and component loads

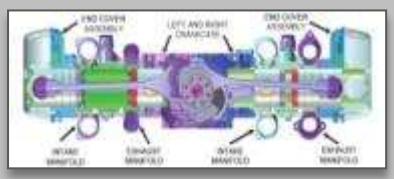
$$\begin{bmatrix}\mathbf{M} & \mathbf{C}_{\mathbf{q}}^{T}\\ \mathbf{C}_{\mathbf{q}} & \mathbf{0}\end{bmatrix}\begin{bmatrix}\ddot{\mathbf{q}}\\ \boldsymbol{\lambda}\end{bmatrix}=\begin{bmatrix}\mathbf{Q}_{e}+\mathbf{Q}_{v}\\ \mathbf{Q}_{d}\end{bmatrix}$$



Hi-Energy, Hi-Density Energy Storage



Comprehensive Thermal Management of Propulsion & Cabin



High Power Density, Low Heat Rejection & Fuel Efficient Engines

Performance & Reliability

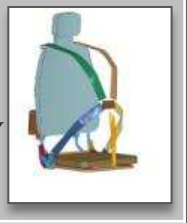
Robust Multi-Disciplinary Optimization

Occupant Centric Survivability

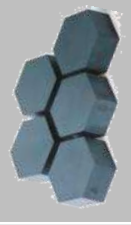
Active Protection Systems

Holistic Occupant Centric Protection

$$\frac{d}{dt}\int_{Vt} f(x,t)dV=\int_{Vc=Vt}\frac{\partial f(x,t)}{\partial t}dV+\int_{Sc=St} f(x,t)\bullet ndS$$



Affordable, Multi-hit Ceramic Armor



Fire and Toxic Fume Resistant Materials

Technology Enabled Capability Demonstrations

Ready this time

Deferred to next cycle

Force Protection – Soldier and Small Unit

1.b

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.

Force Protection – Occupant Centric Platform

1.c

Problem Statement: We design vehicles to put Soldiers in rather than designing vehicles around Soldiers. Increasing protection levels of the platforms impacts interior volumes reducing mobility, maneuverability, and freedom of movement for occupants and leads to heavier platforms.

Challenge: Formulate a S&T program to make

Overburdened – Physical Burden

2.a

Problem Statement: Soldiers in Small Units (squads/fire teams/crews) are physically overburdened, often carrying up to 130lbs; this degrades performance and may result in immediate, as well as, long term consequences.

Challenge: Formulate a S&T program to significantly reduce the weight and volume of all items that

Surprise/Tactical Intelligence – Mission Command

3.a

Problem Statement: The Small Unit lacks tools and ability to execute mission command on the move (air or ground) to synchronize action, seize the initiative and maintain situational awareness.

Challenge: Formulate a S&T program to provide an

Human – Medical Assessment and Treatment

7.d

Problem Statement: Traumatic brain injury (TBI) continues to be a significant issue due to IEDs and other hazards. The Army medical community is not able to promptly assess, diagnose, treat and rehabilitate Soldiers who have been exposed to ballistic and blast events or other insults.

Challenge: Formulate a S&T program to rapidly conduct in-the-field screening, assessment and mitigating treatment to improve short and long term adverse outcomes of mTBI and TBI.

Challenge Boundary Conditions:
Who: Individual Soldier and combat medic

What: Selected Operational Mission Scenarios

How: Measure the number of Soldiers correctly identified and diagnosed with mTBI/TBI without significant false positives; reduce number of evacuations due to suspected against 2011 baseline

Objectives:
Near term (FY17): Develop tools that accurately and objectively assess Soldiers with mild to moderate TBI in less than 1 hour following Soldier's return to COP/FO without increasing personnel or administrative burden.

Force Protection - Basing

1.a

Problem Statement: It takes too long and too much manpower to deploy, set up, protect, sustain and relocate Combat Outposts (COPs) and Patrol Bases (PBs).

Challenge: Formul
percentage of Soldi
and protect against
indirect fires, air de
austere, restricted t

Challenge Boundary C
Who: Focus on Cond
Afghanistan-like condi

What: Representative
that it takes 60-90 da
assets (i.e., 70% not a

How: Measure impac
time

Human – Individual Training to Tactical Tasks

7.b

Problem Statement: The Soldier today has a larger number and more complex weapons, protective systems and communications devices with which to perform more complex missions. The Army needs a highly adaptable, versatile, easy-to-access learner –centric system of training skills and tasks that is tailored to the individual's developmental needs through timing, content, delivery, and duration.

Challenge: Formulat
mechanisms which c
track Soldier learning
feedback, select appr
seek out information
needs, and provide in

Challenge Boundary C
Who: Selected specific
weapon operations)

What: Baseline of FY

How: Measures of So
proficiency; determine
training/retraining.

Surprise/Tactical Intelligence – Actionable Intelligence

3.b

Problem Statement: Small Units do not have capability to send/receive critical tactical intelligence; the tools or training to help them recognize/identify friends or foes, to know where IEDs are, to see inside buildings and around corners or over hills; or awareness of cultural patterns that might indicate imminent danger.

Challenge: Formulat
Small Units with tool
collect, process, expl
support situational a
without adding more
increasing weight or

Challenge Boundary Co
Who: Small Units oper
Afghanistan-like condit

What: Goal is to provid
operational picture in re
in a given AO with 90%
probability of determini

How: Measure reducti
encounters, reduction in
(friendly/non-combatan

Sustainability/Logistics – Basing

4.a

Problem Statement: The Army needs improved capability to enable sustainment independency"-"self-sufficiency"-and to reduce sustainment demands at expeditionary basing levels. It is too costly, too unpredictable, and too labor intensive for a Small Unit to carry all required consumables to last for weeks or months at a COP/PB, storage facilities and systems do not meet needs of these small bases, and resupply efforts are highly ung

Challenge: Formulate
self-sufficiency, redu
reduce waste at COP
to sustain the Small U
mission at lower cost
without adversely imp
Soldier availability.

Challenge Boundary Co
Who: Small Units in Afg

What: Identify tools, tac
demand reduction.

How: Measure demands
generated and/or waste
of food; time to resupp

Sustainability/Logistics – Transport, Distribute & Dispose

4.b

Problem Statement: The Army needs improved capability to tactically transport and reliably 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: Formulate a S&T program to leverage all available conveyance modes to ensure supply delivery, to increase the reliability and timeliness of supplies delivery, and to be able to predict when and where all classes of supplies will be needed. In addition, the program will devise methods to reduce waste and use it to provide power.

Challenge Boundary Conditions:
Who: For Forward Operating Bases with applications to expeditionary bases (Small Units in COPs and PBs)

What: Rapidly deliver significant quantities (volume, weight, etc) of supplies. Air drop and convoy operations –develop ability to conduct rapid movement of emergency, planned, or critical logistics support that enables precise delivery of supplies and repair parts to forward battlefield locations, medical evacuation operations and relief operations

How: Representative 2011 Afghanistan-like environment baseline

Objectives:
Near term (FY17): Develop tools that efficiently manage, track, redirect, account for and distribute supplies to support forced entry, early entry, and non-contiguous operations

Force Protection – Occupant Centric Platform
Technology Enabled Capabilities Demonstration (TECD)

Pre-conceptual configuration

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

Ground Vehicle Power and Energy Technology

Power Generation


Diesel Engines


Rotary Engines

Transmissions



JP-8 Fuel Cells


Traction Motors

Integrated Starter Generator

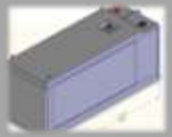


Turbine Engines

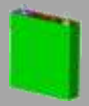

Alternators

Drivelines


Energy Storage


Li-Ion / Ultracap Hybrid Energy Storage


Capacitors




Advanced Batteries

Thermal Mgmt & Power Distribution


Radiators

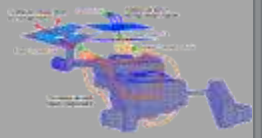

Microgrids


Power Controllers for Power Management


Heat Recovery


Power Converters/Inverters


Advanced Electronics Cooling


Thermal Architecture

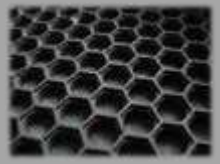
Materials


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)

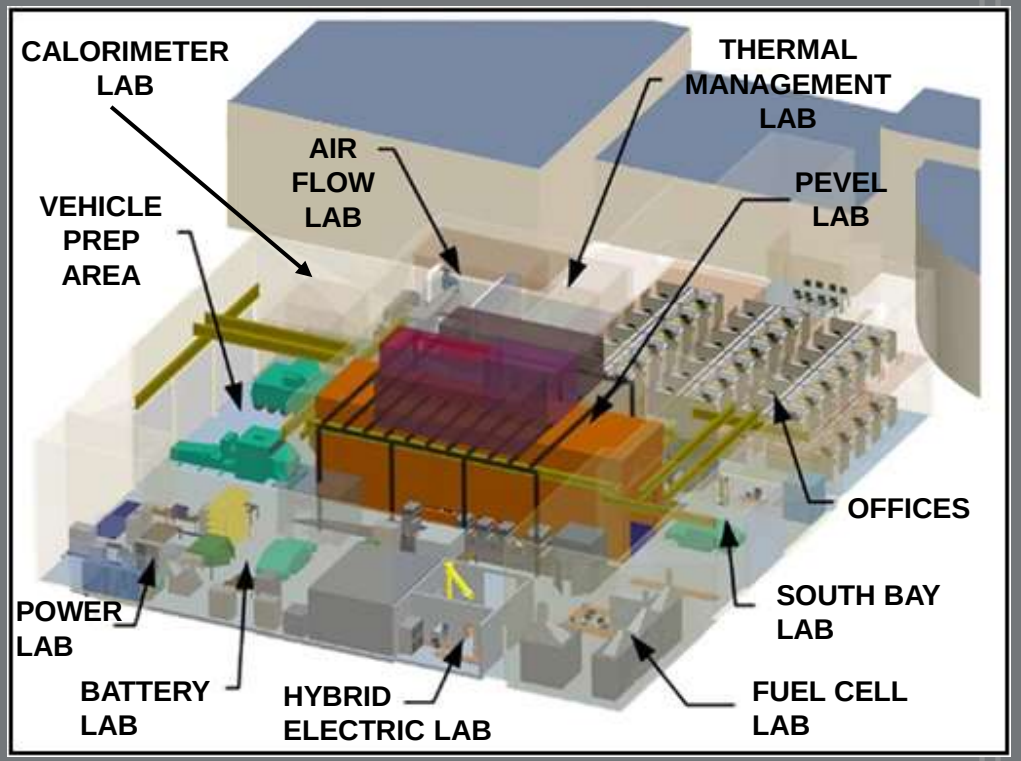

Conversion Process


Single Fuel

Ground Systems Power and Energy Laboratory

Capabilities

- Provides steady state and transient (mission profile based) testing
- Ability to test current and emerging classes of ground vehicles
- 32,000 ft^2 of laboratory space
- Environmental chamber able to test between -60^o to 160^o 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

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.

Advanced Vehicle Power Technology Alliance (AVPTA)

Breaking New Ground

22 July, 2010

18 July, 2011

- 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

Achieving Common Goals in Joint Technology Areas

Advanced Combustion Engines and Transmissions	Lightweight Structures and Materials	Energy Recovery and Thermal Management	Alternative Fuels and Lubricants	Hybrid Power Systems	Analytical Tools
Technical areas for joint activity:					
• High density, energy efficient powertrain • Extreme gains in engine efficiency	• Reduce weight to improve performance • Cost reduction for consumer market	• Cost Improved efficiency, manage heat generation • Efficiency gains through waste heat recovery	• Standardization & security • Efficiency gains through advanced oil formulations	• Efficiency improvements	• Assessment/ Design Trades

Driving results through collaboration

It's All About the Warfighter

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