U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

TARDEC Technical Overview Briefings
21st Century Truck Partnership
Partners Meeting Plenary Session

U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

Analytics (Modeling & Simulation) Overview
21st Century Truck Partnership
Partners Meeting Plenary Session

Philip Smith

Associate Director

U.S. ARMY RDECOM GROUND VEHICLE SYSTEMS

ANALYTICS: PHYSICS BASED M&S

Mobility & Dynamics

- Vehicle Dynamics Performance Analysis
- Ride & Shock quality
- Lateral Stability
- Soft Soil Performance

Structural Analysis & Light Weighting

- Durability Assessment
- Structural Integrity Analysis
- Composite Material Analysis
- Light Weighting: Topology optimization and parametric optimization

Survivability & Protection - Crash, Blast & Restraints

- Occupant protection and restraint system analysis in crash and blast
- Structural material/design analysis for improved energy management and survivability

Vehicle Performance & Trade Space JOEI

- Dash Speed
- Speed on Grade
- Step Climb
- Drawbar Pull
- Fuel Economy
- Range
- Cooling
- Platform Sustainment and Fleet Optimization
- Condition Based Maintenance analysis, diagnostic & prognostic algorithm development

Fluid & Thermal Cooling/Swim/Fire Suppression

- Under hood cooling
- HVAC
- AFES Simulation
- Thermal Signature
- Swim
- Bridge flow forces

Analytical Development & Data Science

- Custom Software/Application Development
- TVEC Quantitative Data Analysis
- System level data analysis and data mining
- Machine Learning and Optimization algorithm development

Computer Aided Engineering Analysis Provided Across the System Life Cycle

Technology Focus Area: Analytics (Modeling & Simulation)

Top Technical Challenges

Technical Challenge 1:

1. **Gap:** Automated Computational Fluid Dynamics/Finite Element Analysis (CFD/FEA) Processing is required for Design Optimization and Reduced Order Modeling.
2. **Barrier:** Current CFD/FEA Modeling & Simulation (M&S) require a high level of expert analyst interaction, and therefore do not lend themselves easily to batch processing by optimization tools. Enhancements are needed to enable automated generation of new geometry, meshing, running, and post processing of models by optimization tools to facilitate FEA/CFD's inclusion in Multi-disciplinary Design Optimization exercises.
3. **Resolution Timing:** Real-time, near-term and continuing improvement desired for support enhancement of TARDEC's Digital/Physical Thread process.

Technical Challenge 2:

1. **Gap:** More comprehensive duty-cycle-based dynamic data is needed to ensure robust design.
2. **Barrier:** On-road loads, accelerations, etc. are well known throughout the automotive industry, but off-road vehicle data is less well known. The result is the application of 'rules of thumb' design guidelines rather than actual duty-cycle data which results in sub-optimized designs.
3. **Resolution Timing:** Real-time, near-term and continuing improvement desired for support enhancement of TARDEC's Digital/Physical Thread process.

U.S. ARMY RDECOM
GROUND VEHICLE SYSTEMS

U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

Powertrain Overview
21st Century Truck Partnership
Partners Meeting Plenary Session

John Tasdemir

Team Leader, Powertrain

Ground Vehicle Power & Mobility (GVPM)

The Powertrain Team is the Army's lead for research, development and integration of powertrain systems focusing on: Engines, Transmissions, Thermal, Electrification, Control Systems, and Combat/ Tactical propulsion systems by working directly with Program Executive Offices, Industry and Academia to increase overall power density by increasing fuel efficiency and reducing thermal burden.

The Powertrain Team integrates advanced/alternative propulsion systems to enable leap ahead capabilities for military vehicles.

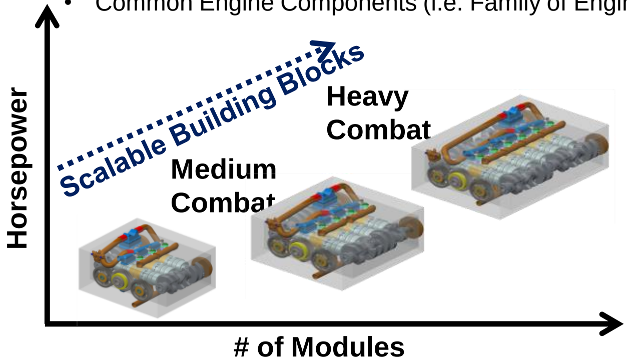
UNCLASSIFIED: Distribution Statement A. Approved for public release; distribution is unlimited.

U.S. ARMY RDECOM GROUND VEHICLE SYSTEMS

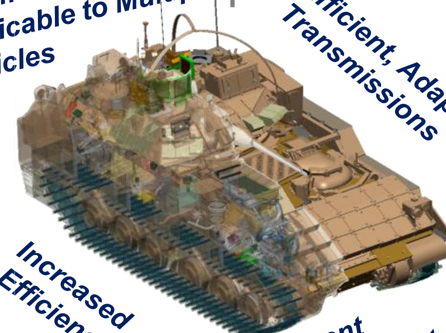
Advanced Powertrain Technologies

Family of Power Dense, Common, Modular Engines

- Increased Power Density
- Increased Efficiency (> 48%)
- Decreased Heat Rejection (≤ 20 BTU/hp-min)
- Common Engine Components (i.e. Family of Engines)



Common Engine Applicable to Multiple Vehicles



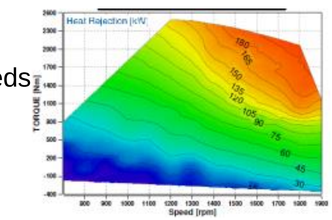
Efficient, Adaptable Transmissions

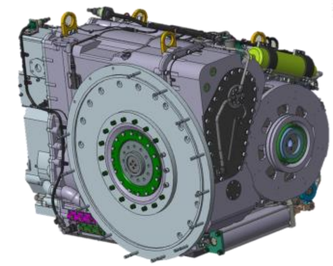
Increased Efficiency

Intelligent Power Management

Family of Adaptable, Military Specific Transmissions

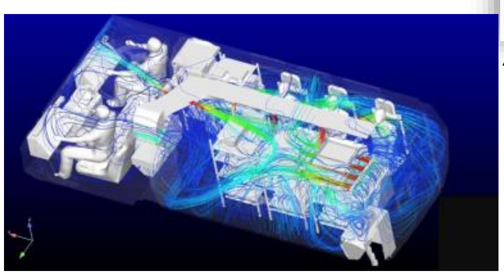
- Advanced Multi-Speed Transmissions
- Adaptable to a wide range of engine input speeds
- Flexible design configuration and packaging
- High efficiency geared steering system
- > 90% efficiency in all gears

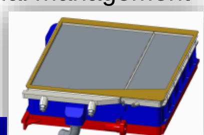




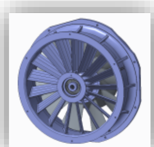
Efficient Thermal Management

- Improved vehicle efficiencies
- Increase Propulsion Power Density, more sprocket power
- Develop and integrate high efficiency components
- Increased fidelity of system level thermal management analysis and optimization





Advanced Heat Exchanger Pack

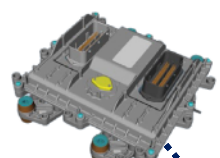


Advanced Fan

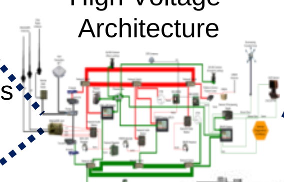
Electrical Fan Drive

Controls Development & Vehicle Electrification Architectures

- Developing a controller with industry partner that will meet future research needs by using the state of the art components, incorporating greatly increased processing power, and supporting multiple new communication protocols
- Increased onboard vehicle power and



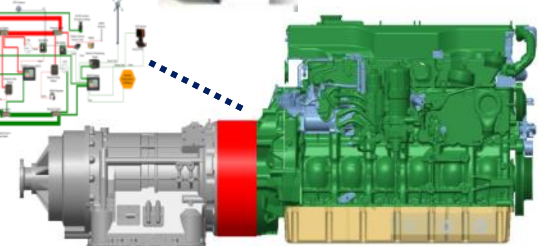
Optimized Powertrain Controls



High Voltage Architecture

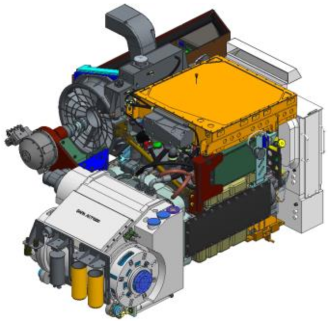
Advanced Modular Battery

Power Electronics DC-DC, Export Power



Integrated Starter Generator

OPSEC1344



Technology Focus Area: Powertrain

"Top Three" Technical Challenges

Technical Challenge 1: Thermal Management

1. **Gap**: Advanced Low Heat Rejection Powertrain Technologies are necessary to minimize vehicle cooling systems to increase mechanical and electrical efficiency.
2. **Barrier**: The Army has a completely different operating field in comparison to the commercial industry, so it is crucial to further optimize the entire powertrain to improve the thermal efficiency & reduce the amount of heat rejection. This concern is compounded by the use of ballistic grills which further inhibit air flow through the vehicle's engine cooling system.
3. **Resolution Timing**: The development and prototype demonstration by FY20 of the Advanced Powertrain Technologies will demonstrate the 20-25% reduction (kW/kW) of the thermal burden.

Technical Challenge 2: Power Density & Efficiency

1. **Gap**: High Efficient, Compact Technologies that lead to Power Dense Powertrain architectures are necessary to provide more power at the sprocket/wheel to exceed mobility requirements
2. **Barrier**: The Commercial Sector is focused on meeting EPA standards for consumer applications that have defined operating conditions that are not applicable to the Global reach of Military operations
3. **Resolution Timing**: The development and prototype demonstration by FY20 of the Advanced Powertrain Technologies will demonstrate the 1.5 -2 X increase in installed sprocket power/powertrain volume.

Technical Challenge 3: Durability & Reliability

1. **Gap**: The Army needs to increase the durability of powertrain technologies in high ambient conditions and operations at transient conditions that are not compatible to commercial environments
2. **Barrier**: The Military Operating Conditions and Vehicle Life Cycle demands over 20 years demand new and unique subcomponents over commercially available technologies
3. **Resolution Timing**: The development and demonstration by FY23 of the Advanced Powertrain Technologies will demonstrate the durability and reliability within military vehicle operations.

U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

Powertrain Electrification Overview
21st Century Truck Partnership
Partners Meeting Plenary Session

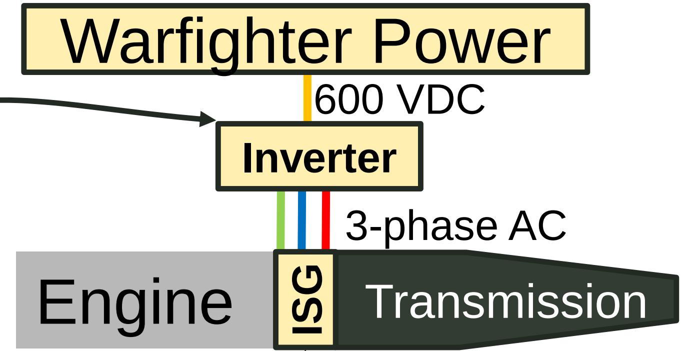
Kevin Boice

Electrical Engineer - Technical Lead

Ground Vehicle Power & Mobility (GVPM)

The Powertrain Electrification Team leads research, development, integration and testing of electrified powertrain components, sub-systems, and systems.

Its mission is to provide the Warfighter electrical power/mobility systems to enable future warfighting capabilities such as directed energy weapons, silent mobility high power jamming, radar, vehicle-to-grid, and advanced armor systems.



Technology Focus Area: Powertrain Electrification – Combat Platforms "Top Three" Technical Challenges

Technical Challenge 1: Electronics Power Density

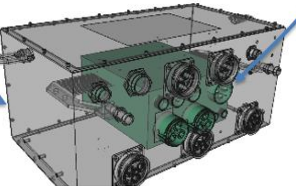
1. Gap – Available power electronics power density does not package within combat platforms (~ 3kWL)
2. Barrier – Need 12kW/L power density - necessitates wide band gap - not commercially available
3. Resolution Timing - Silicon Carbide Inverter MAR 19 TRL5 & SEP 19 TRL6 Generator and Inverter

120 kW @ 85C

200 kW @ 105C

Technical Challenge 2: High Temperature Electronics

1. Gap – Available power electronics coolant temperature is not supportable – 85C
2. Barrier – Need 105 C coolant (same as engine) – necessitates wide band gap - not commercially available
3. Resolution Timing - Silicon Carbide Inverter MAR 19 TRL5 & Generator and Inverter SEP 19 TRL6

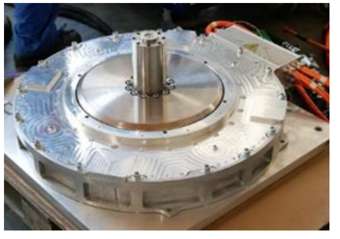


Package Comparison

Technical Challenge 3 High Temperature Integrated Starter Generators (ISG)

1. Gap – Available rotating equipment rated coolant temperature is not supportable – 85C
2. Barrier – Need 105 C coolant (same as engine) – need custom design for high temperature - 105C
3. Resolution Timing – Advanced Generator MAR 19 TRL5 & Generator and Inverter SEP 19 TRL6

ISG



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GROUND VEHICLE SYSTEMS

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Powertrain Electrification Overview
21st Century Truck Partnership
Partners Meeting Plenary Session

Laurence M. Toomey, Ph.D.

Energy Storage Supervisory Team Lead

Ground Vehicle Power & Mobility (GVPM)

The Energy Storage Team is the single point of accountability to provide full service lifecycle engineering and integration support (cradle-to-grave) for Energy Storage systems for Army Ground vehicle platforms.

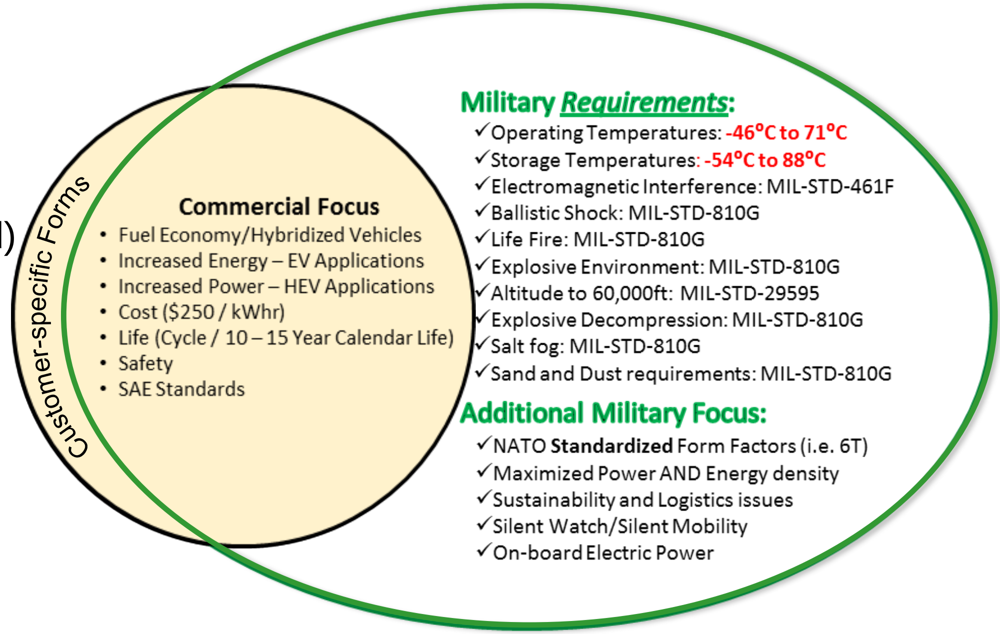
Additionally, the Energy Storage team is responsible for developing and maturing advanced energy storage technologies to enable new capabilities on vehicle platforms.

Strategic Purpose:

- **Leverage commercial automotive advances in Lithium-ion based anode, cathode, electrolyte and separator battery materials to electrode, cell and military-specific pack designs to:**
  - **Significantly increase energy density vs. traditional lead acid battery baseline from 36 Whr/kg to > 160 Whr/kg while increasing power density by > 50%**
  - **Increase operating temperature range for the Li-ion batteries from (-20^{o}C to +50^{o}C) to (-46^{o}C to +71^{o}C)**
  - **Develop common military battery solutions (i.e., 6T form factor to facilitate transition to current force and future force platforms. Current focus has been on low voltage (24V) 6T form factor batteries, but this approach will be applied as work is started on high voltage efforts (300 – 600V)**
  - **Enable future electrification of military ground vehicles to enable silent mobility and advanced e-based weapons and systems.**

U.S. ARMY RDECOM GROUND VEHICLE SYSTEMS

Technology Focus Area: Energy Storage "Top Three" Technical Challenges



Technical Challenge 1: Delivering reliable (militarized) battery solutions in standardized military form factors (logistics/sustainability/compatibility)

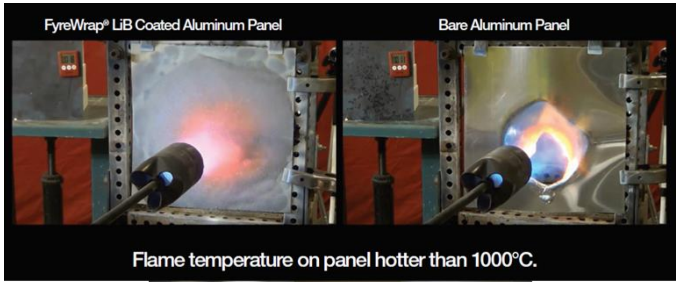
1. Gap: Commercial battery solutions do not meet military requirements/form factors.
2. Barrier: Military requirements/form factors require investment.
3. Resolution Timing: Low Voltage (LV) FY19 (Li-ion 6T); High voltage (HV) FY23-24

Technical Challenge 2: Installed Energy Density AND Recharge Infrastructure to support All Electric platforms

1. Gap: The size and terrain that our platform must navigate require as much as 11.5kWhr/mile for propulsion. Such a platform would need an ESS that has a usable energy of ~3.4MWhr for a 300 mile range and would need a recharge infrastructure that can supply as much as 13MW.
2. Barrier: Current battery technologies are not capable of meeting these metrics. There is no mobile charging capability that meet these recharge requirements.
3. Resolution Timing: FY24 – to facilitate full EV military platforms

Technical Challenge 3: Safety

1. Gap: Military applications introduce unique abuse threats (ballistic/IED/shock&vib) as well as are subjected to rigorous Navy safety testing
2. Barrier: Cell chemistry/battery designs to improve safety, Materials and integration strategies to mitigate risks and M&S tools.
3. Resolution Timing: LV FY19 (Li-ion 6T) / HV 23-24



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Powertrain Electrification Overview
21st Century Truck Partnership
Partners Meeting Plenary Session

Kevin Centeck

Fuel Cell Technologies Supervisory Team Lead

Ground Vehicle Power & Mobility (GVPM)

The Fuel Cell Technologies team leads research, development, integration, and testing of fuel cell power systems into Army Ground vehicle platforms.

Additionally, the Fuel Cell Technologies team is responsible for the research on production, distribution, and storage of hydrogen on the battlefield.

U.S. ARMY RDECOM GROUND VEHICLE SYSTEMS

Technology Focus Area: Fuel Cell Technologies
"Top Three" Technical Challenges

Technical Challenge 1: Hydrogen Production, Distribution, and Storage

1. **Gap: Hydrogen is not available as a logistics fuel.**
2. **Barrier: Commercial technologies support domestic infrastructure; not easily transportable.**
3. **Resolution Timing: Niche Applications FY20 (JP-8 Reforming); Large H2 Quantities (Cryogenic FY23-24)**

Technical Challenge 2: Installed Hydrogen Storage Density On-board Fuel Cell Vehicle

1. **Gap: Hydrogen storage efficiencies are too low to meet heavy vehicle range requirements.**
2. **Barrier: Commercial compressed hydrogen storage methods are high TRL, but won't meet requirements, commercial automotive not investing heavily in high storage densities. Cryo-compressed hydrogen storage need additional maturation and testing.**
3. **Resolution Timing: FY24 – Cryo-compressed hydrogen storage in a combat vehicle**

Technical Challenge 3: Fuel Cell Power System Cooling

1. **Gap: Fuel cell power systems require additional radiator volume due to having a lower operating temperature.**
2. **Barrier: Combining multiple fuel cell power system together for a combat vehicle powertrain will require a large radiator unless higher coolant temperatures can be used.**
3. **Resolution Timing: FY24 combat vehicle demo**

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GROUND VEHICLE SYSTEMS

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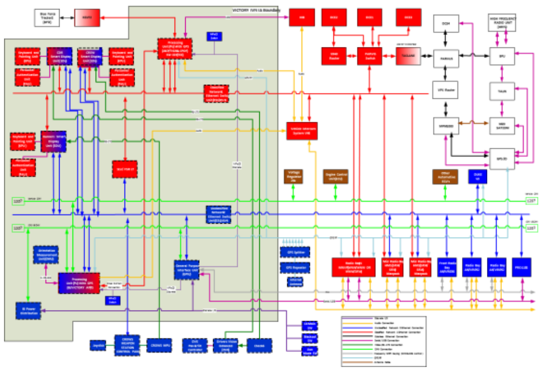
Vehicle Electronics and Architecture Overview
21st Century Truck Partnership
Partners Meeting Plenary Session

George Hamilton

Deputy Associate Director

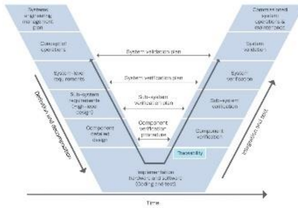
ENABLING CAPABILITY FOR CURRENT & FUTURE MILITARY VEHICLES

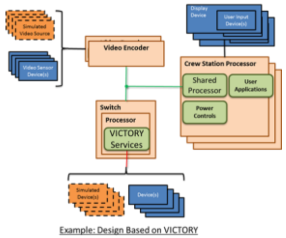
C4ISR Integration



Electrical Power Distribution & Management

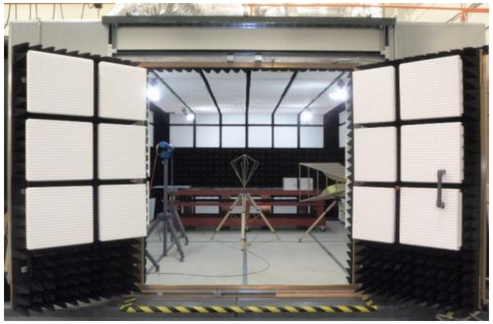
Engineering Services



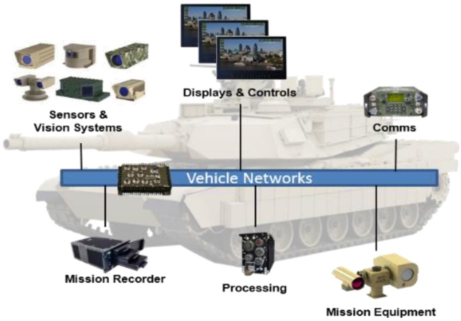


VEA

EMI Analysis & Test



Vetronics



Systems Integration Laboratories (SILs)

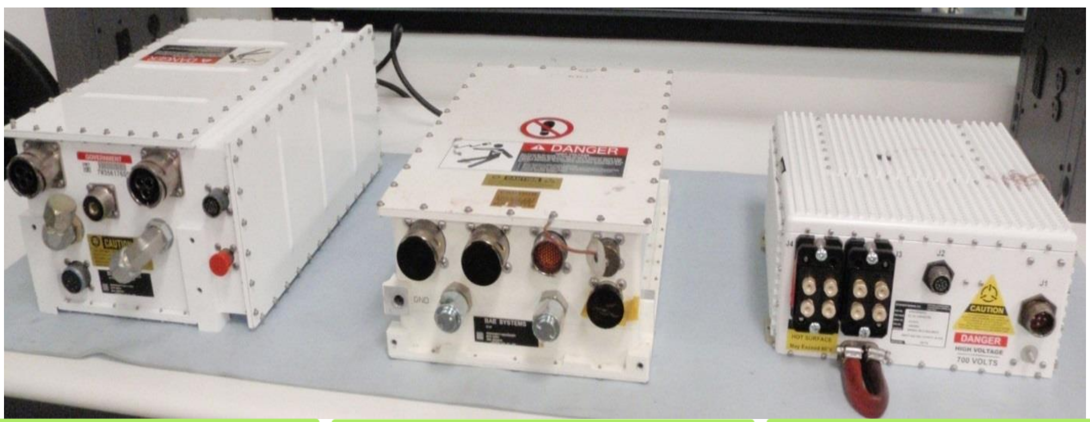
U.S. ARMY RDECOM GROUND VEHICLE SYSTEMS

NGCVEPA CONSTRAINING REQUIREMENTS:

- Provide 45kW @ 28 VDC -> MIL-STD-1275E
- Provide 200kW @ 600 VDC -> MIL-PRF-GCS600A
- Silent Watch: 4 kW for 4 hours to vehicle Low Voltage loads with the main engine off
- Import/Export 30kW @ 208 VAC
  - 10kW 110VAC
  - 20kW 220VAC
- Utilize the SAE-J1772 connector for exporting/importing High Voltage DC power
- Power electronics liquid cooling temp @ 105C
- Automated power management with anti-idling
- Meet the requirements contained within ATPD-2404, MIL-STD-461, MIL-STD-810

WIDE BANDGAP (WBG) SEMICONDUCTORS

- Silicon Carbide (SiC) demonstrated
  - Faster switching
  - Higher operating temperatures
  - Higher efficiency operation
  - 80% reduction in volume
  - 60% reduction in weight



BAE IRAD (10 kW)

Year: 2008
Weight: 35.6 kg
Volume: 2,072 in^3
Power Den: 4.8 W/in^3

BAE PIM LRIP (10 kW)

Year: 2011
Weight: 27.15 kg
Volume: 1,517 in^3
Power Den: 6.6 W/in^3

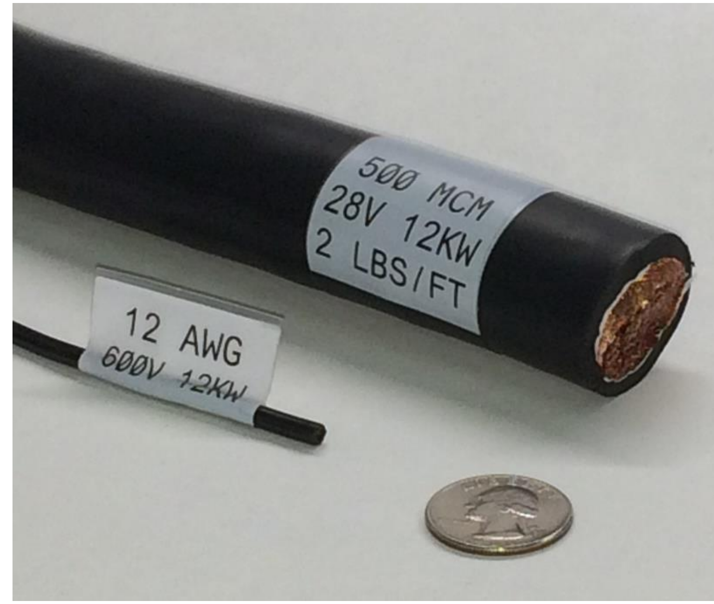
GE SiC (15 kW)

Year: 2014
Weight: 17.26 kg
Volume: 1,075 in^3
Power Den: 14 W/in^3

GE SiC (20 kW Uni)

Year: 2018
Weight: 21.77 kg
Volume: 588 in^3
Power Den: 34 W/in^3

Technology Focus Area: Vehicle Electronics Open Architecture



"Top Three" Technical Challenges

Boundaries for open architecture

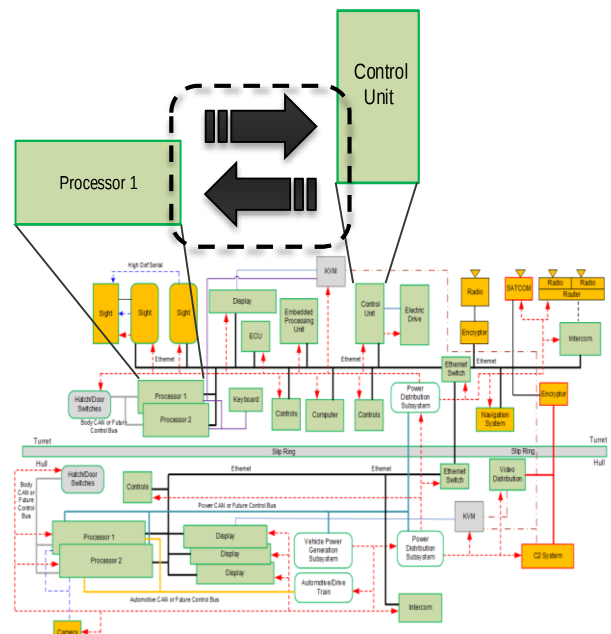
1. Definition for hardware and software interfaces to maximize commonality
2. No central authority to enforce, maintain, or update interfaces
3. Ongoing

SiC Power Electronics

1. Small Mil-Rugged Power Electronics
2. Availability and cost of power switching devices
3. TRL 6

MIL-Rugged Technology Affordability

1. Cost goals
2. Low Volume for Mil Rugged Electronics
3. Program Dependent



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Ground Vehicle Robotics Overview
21st Century Truck Partnership
Partners Meeting Plenary Session

Bernard Theisen

Program Manager

GROUND VEHICLE ROBOTICS

MISSION:
GVR is responsible to Develop, Experiment, Demonstrate, and Transition Autonomy-enabled Ground System Capabilities and Technologies to Meet and Shape Army Requirements

VISION:
To be the Army's first choice for technology and engineering expertise for all robotics and autonomous ground vehicle systems – today and tomorrow.

OPSEC1344

Robotic Technical Challenges

Perception (Autonomous Maneuver):

- Organic sensing and computational algorithms required for understanding the local environment

Intelligence:

- Vehicle Intelligence, planning infrastructure for unmanned system to plan, execute, and replan as required to conduct military missions
- Tactical Behavior, ability for an unmanned system to emulate basic military tasks and skills
- Collaboration, ability to conduct coordinated (peer to peer) activities among teams of unmanned or mixed manned and unmanned systems
- Mission Specific Behavior, tactical behavior related to implementation of a specific mission package

Command & Control:

- Operator Control Interface, direct supervision of one or more unmanned systems
- Battle Command Integration, incorporation of unmanned systems into the overall force command and control structure

Safety:

- Autonomous Vehicle safety, safely operate unmanned vehicles among people and other vehicles
- Autonomous Weapon safety, safe remote operation of lethal and non-lethal weapon

Platform:

- Mobility innovations for unmanned system specific platform developments

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GROUND VEHICLE SYSTEMS

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Ground Systems Cyber Engineering Overview
21st Century Truck Partnership
Partners Meeting Plenary Session

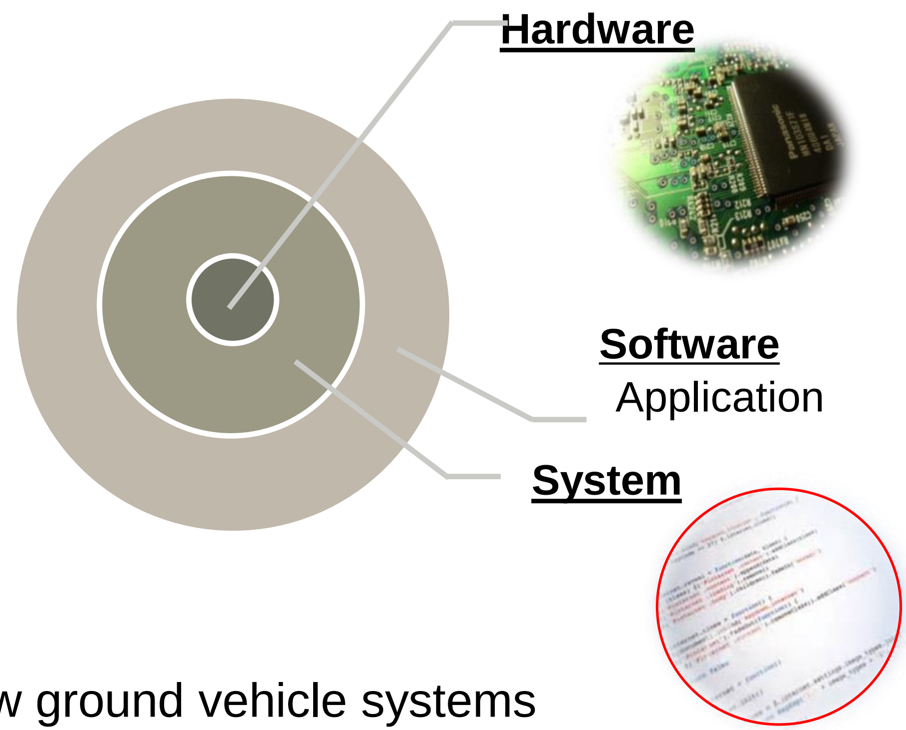
Jeffrey Jaczkowski

Associate Director

GROUND SYSTEMS CYBER ENGINEERING

Ground System Cyber Engineering team is responsible for identifying cyber vulnerabilities and adaptively securing joint service ground vehicles, watercraft and support systems by engineering resilient cyber solutions.

Securing the System Architecture



Priorities

#1 Ensure cyber resiliency for new ground vehicle systems

#2 Mitigate critical vulnerabilities in fielded systems

Baking security into the vehicle architecture will significantly reduce the cyber attack surface.

Technology Focus Area: Vehicle Cybersecurity

"Top Three" Technical Challenges

Technical Challenge 1: Resilience in Deterministic Vehicle Architectures

1. Gap: Lack the ability to defend against unauthorized control or service denial
2. Barrier: Ground systems are highly complex integrated system-of-systems with distributed computer units, wide variances in vehicle iterations, inter-system data communication channels, and vehicle electronic architectures. As such, these platforms are vulnerable to cyber-attack from multiple vectors and multi-faceted approaches.
3. Resolution Timing: 3-5 years

Technical Challenge 2: Device Security

1. Gap: Lack the ability to harden against reverse engineering, tampering, or unauthorized updates to hardware and software
2. Barrier: Vehicle system, subsystem and component level supply chain is global and diverse.
3. Resolution Timing: 2-4 years

Technical Challenge 3: Quantification of Vehicle Cybersecurity Capabilities

1. Gap: Lack a robust evaluation methodology for vehicle cybersecurity that allows for standardized comparison across heterogeneous systems.
2. Barrier: Diversity of cybersecurity ecosystem and wide variety of lenses to assess and/or cybersecurity posture.
3. Resolution Timing: 1-2 years

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GROUND VEHICLE SYSTEMS

U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

Ground Vehicle Survivability & Protection Overview
21st Century Truck Partnership
Partners Meeting Plenary Session

Gale Litrichin

Assistant Associate Director

Ground Vehicle Survivability & Protection (GVSP) is responsible for the development of design requirements and technologies for use in U.S. Army Ground System Vehicles (GSVs) to reduce potential impact injuries and mitigate fatalities resulting from underbody blast, crash and rollover events.

Technology Focus Area: Occupant Protection

"Top Three" Technical Challenges

Technical Challenge 1: Vehicle Crash and Rollover Standard

1. Gap: Automotive safety standards are the required demonstration of crash and rollover protection, and those standards exempt vehicles over 10,000 lbs from conducting crash and rollover testing. JTAPIC injury data shows that injuries occur from crash and rollover incidents during both combat and non-combat times.
2. Barrier: Potential for (3) standards: (1) light combat/tactical vehicle, (2) medium combat/tactical vehicle, (3) heavy combat/tactical vehicle, Seat direction will effect standard: driver and commander will face forward, crew seats are bucket or bench; front and side seating, Determine appropriate injury criteria to be utilized
3. Resolution Timing: FY23

Technical Challenge 2: Multi-Axis Protection with Warrior Injury Assessment Manikin (WIAMan) and achieve response data that is below those injury criteria/thresholds

1. Gap: Research current ground vehicle interiors to understand gaps for optimization of interior features for solider accommodation and protection. The WIAMan is more biofidelic in UBB than the currently used Hybrid III Anthropomorphic Test Device. FY20 will be the first opportunity to begin testing vehicle technologies with the new injury criteria associated with the WIAMan. The resulting data from the WIAMan could change the design characteristics of seats, flooring, and restraints to better protect the mounted Warfighter.
2. Barrier: Define and develop requirements and use cases from research and collaboration, develop performance specifications. Seats, restraints, and flooring need to be tested with WIAMan and re-designed if failing the new injury criteria.
3. Resolution Timing: FY23. Testing must take place during the technology development and subsystem testing, but must take place after injury criteria are released in FY20. The final Title 10 Live Fire Test and Evaluation Under Body Blast tests should also be completed with WIAMan.

Technical Challenge 3: Vibration Comfort, Vision and Motion effects of long term usage on occupant

1. Gap: understand current influence vibration has on occupant injury and Soldier endurance and performance
2. Barrier: Define and develop requirements and use cases from research and collaboration, develop performance specifications
3. Resolution Timing: FY23

U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

Product Lifecycle Engineering (PLE) Overview
21st Century Truck Partnership
Partners Meeting Plenary Session

Ravi Thyagarajan, Ph. D.

Senior Technical Expert

U.S. ARMY RDECOM GROUND VEHICLE SYSTEMS

Product Lifecycle Engineering (PLE)

provides a diverse set of essential support services and subject matter expertise across the entire DoD Acquisition Lifecycle to both internal and external TARDEC customers for all ground vehicle systems including:

- Materials
- Computer Aided Design
- Obsolescence Management
- Configuration Management
- Standardization
- Reverse Engineering
- Tires/HVAC/Electrical

PLE Materials Tech Areas

Materials Application and Integration
- Evaluation of lightweight materials & technologies
- Design analysis and optimization for weight reduction

Joining Technologies
- Welding, Adhesives, Bolted Joints
- Develop requirements for acquisition
- Evaluate OEM welding process
- Weld crack analysis
- Resolve field issues

Additive Manufacturing
- Direct Metal Deposition for reclaiming and repairing of worn and damaged parts
- Support reverse engineering of parts

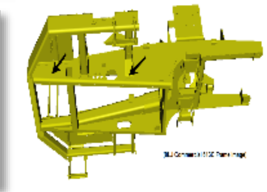
Coatings & Corrosion
- Develop Corrosion Prevention Control requirements for acquisition
- Evaluate, test, and develop solutions for corrosion/coatings issues
- Evaluation of the fielded fleet for corrosion.

Materials Characterization & Failure Analysis
- Failure analysis and characterization of Metallic and Non-metallic materials.
- Materials substitution/replacement
- Testing and qualification of elastomeric materials for track and road wheels

Environmental Management
- Prepare environmental documents (NEPA and PESHE)
- Eliminate/reduce hazardous materials
- Execute environmental policy and regulations

Coatings & Corrosion

Coatings Selection



Design Changes for Corrosion Prevention

Environmental

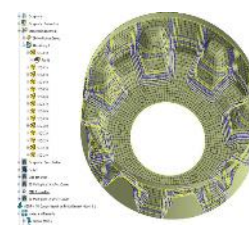
Environmental Assessments

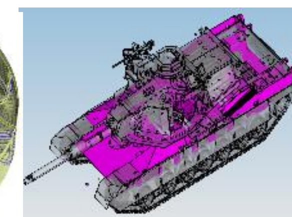
Elimination of hazardous materials

Materials Char. & Failure Analysis

Failure Analysis of components

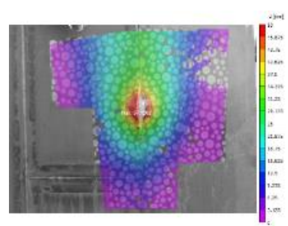
Materials Application & Integration

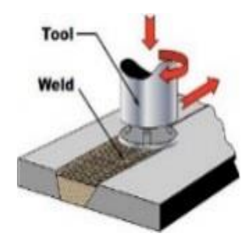




Design Analysis for Weight Reduction

Joining Technologies





Friction Stir Welding

Additive Manufacturing

Direct Metal Deposition for Worn Parts

TARDEC's Light-Weighting Campaign focuses on the following primary programs:

1. **Lightweight Materials (FeMnAl)**
2. **Design Optimization (Running Gear)**
3. **Additive Manufacturing**
4. **Ground Vehicle Loads Acquisition**
5. **Multi-material Joining (Friction Stir Welding)**
6. **Operational Metrics**

Technology Focus Area: PLE/Materials

"Top Three" Technical Challenges

Lightweight Materials

1. Gap: The pace of discovery of advanced lightweight materials that can meet very high strain rate loading performance (blast/ballistics) is slow
2. Barrier: No silver bullet, R&D is on an evolutionary rate of progress, plateaued out
3. Timing: Continuous need

Multi-material Joining Methods

1. Gap: To use the right material at the right location for the right purpose, need advanced methods that can efficiently join different materials (steel, Aluminum, magnesium) and withstand high loading rates
2. Barrier: Auto and other commercial industries use thicknesses much less (mm) than military (inch), so limited research
3. Timing: Continuous need

Undercoating Corrosion Detection

1. Gap: Corrosion under military ground vehicle coatings is difficult to detect until it is too late and significant structural damage has already happened
2. Barrier: Laboratory techniques exist, but not a portable field device. Also Modeling and Simulation methods to predict invisible corrosion are not readily available.
3. Timing: ASAP

End of TARDEC Overview Briefings

Questions and/or Comments?