



Advanced Vehicle Power Technology Alliance (AVPTA) Overview Briefing to USCAR

3 June 2014

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Report Documentation Page

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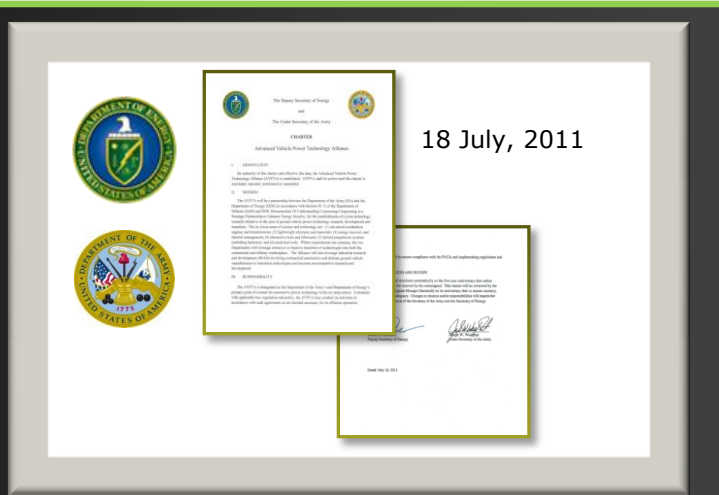
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14. ABSTRACT Purpose: An Advanced Vehicle Power Technology Alliance was formed to address critical ground vehicle challenges across the vehicle spectrum from lightweight platforms through super-heavy systems in efficient power and energy systems. Emphasis: During the first nine (9) months of the Alliance, primary emphasis was placed on start-up administration issues including initial project selection and associated funding allocation. Throughout the past six (6) months, primary emphasis has been on project status, execution and reporting; and identification of future Jointly Solicited project opportunities.					
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Significant Activities Chronology



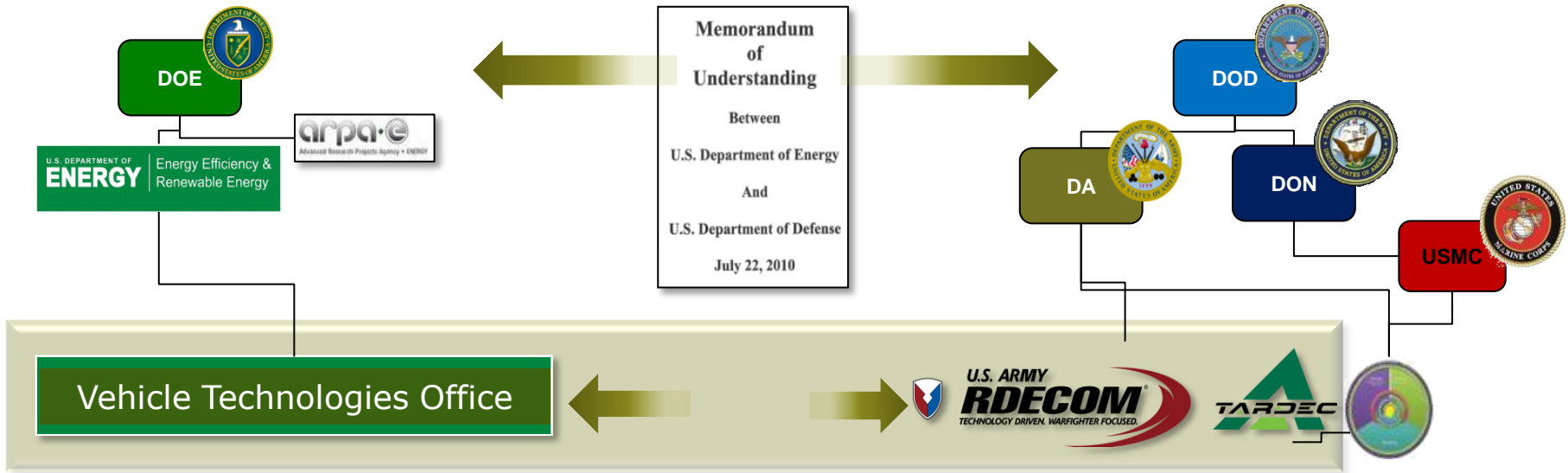
- MOU between DOD and DOE signed - 22 July 2010
- Charter Signed - 18 July 2011
- Workshop to identify areas of mutual technical interest - 18-19 July 2011
- Workshop Summary Report published - 5 Oct 2011
- Agreement to Jointly Fund Projects Dec 2011
- First Quarterly leadership meeting – 10 Jan 2012
- DOE-VTOs FY13 Funding Opportunities Announcement (FOA) containing three candidate AVPTA-related Areas of (Mutual Technical) Interest (AOIs) – Feb 2013
- FY13 FOA source selections publicly announced – Sep 2013
- FY14 FOA publicly announced containing seven candidate AVPTA joint-solicitation (AOIs) – Jan 2014
- **Directors' FY14 new start projects selection meeting – 1 July 2014**

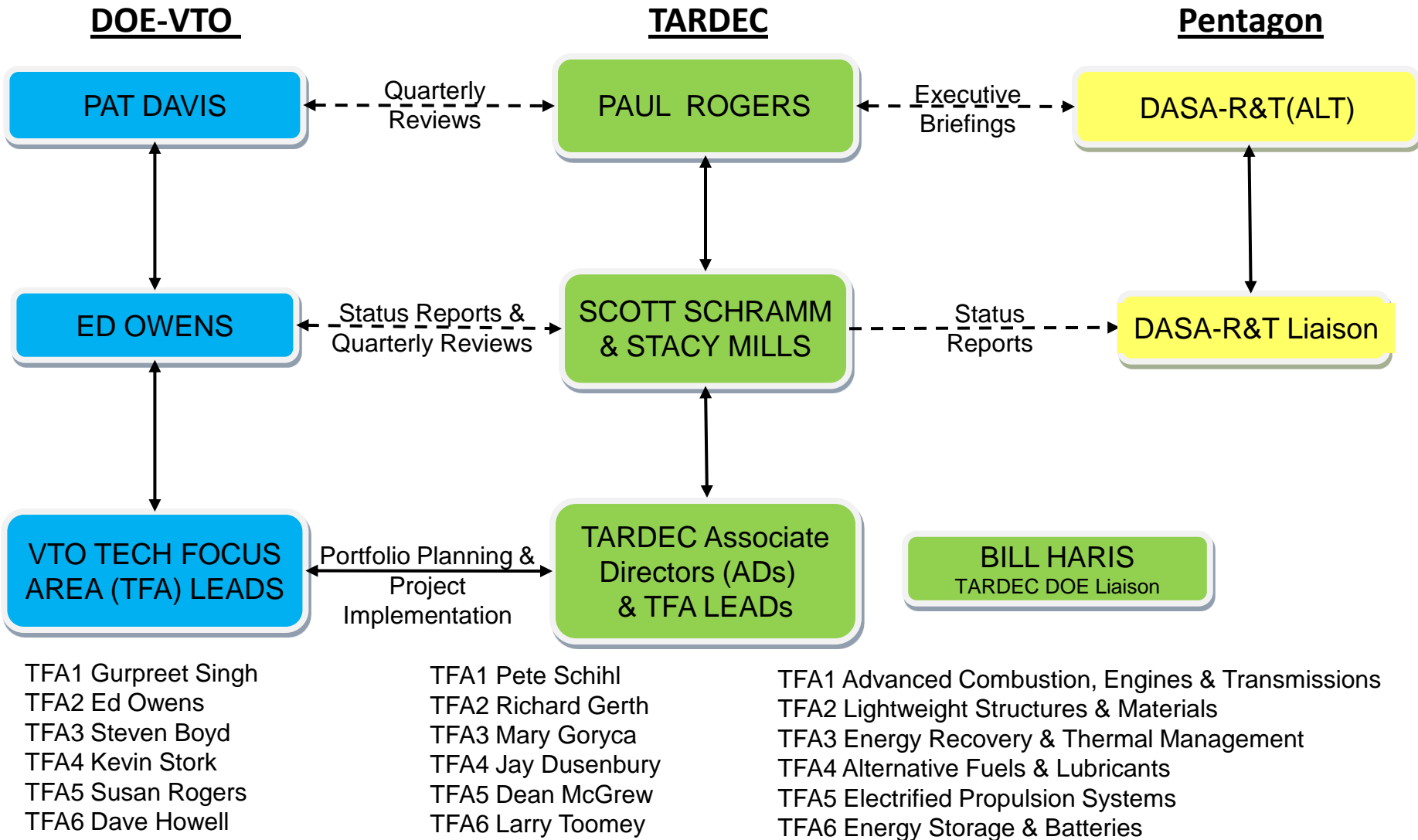
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Organizational Construct







Joint Technology Areas



Advanced Combustion, Engines & Transmissions	Lightweight Structures & Materials	Energy Recovery & Thermal Management	Alternative Fuels & Lubricants	Electrified Propulsion Systems	Energy Storage & Batteries
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Technical areas for joint activity:

- High density, energy efficient powertrain
- Extreme gains in engine efficiency
- ❖ Ignition Models for Heavy Hydrocarbon Fuels

- Reduce weight to improve performance
- Cost reduction for consumer market
- ❖ Lightweight Vehicle Structures
- ❖ Multi-Material Joining
- ❖ Dissimilar Material Joining

- Cost Improved efficiency, manage heat generation
- Efficiency gains through waste heat recovery
- ❖ Thermoelectric Enabled Engine

- Standardization & security
- Efficiency gains through advanced oil formulations
- ❖ Fuel Bulk Modulus
- ❖ Lubricant Formulations to Enhance Fuel Efficiency

- Operational Energy Efficiency improvements
- ❖ Non-Rare Earth Materials for Motors (Integrated Starter/Generator)

- Operational Energy improvements
- ❖ Computer Aided Engineering for Batteries (CAEBAT) Phase II



Driving results through collaboration



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Ongoing Projects

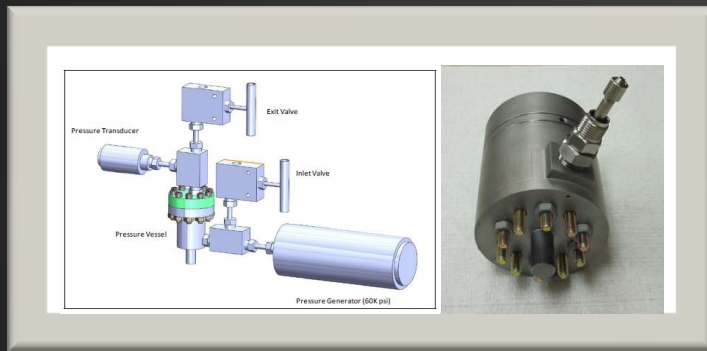


Lightweight Vehicle Structures



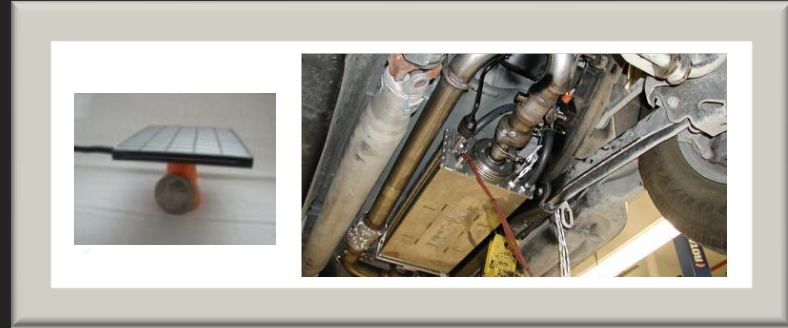
Utilize automotive technology investments in vehicle structure light weighting

Fuel Bulk Modulus



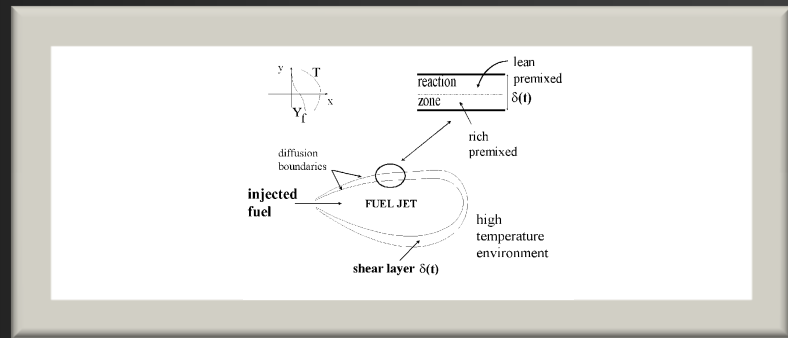
Develop an improved test method to determine the bulk modulus of liquid transportation fuels

Thermoelectric Enabled Engine



Improve platform efficiency by recovering thermal energy from the engine exhaust for military and passenger/commercial vehicles

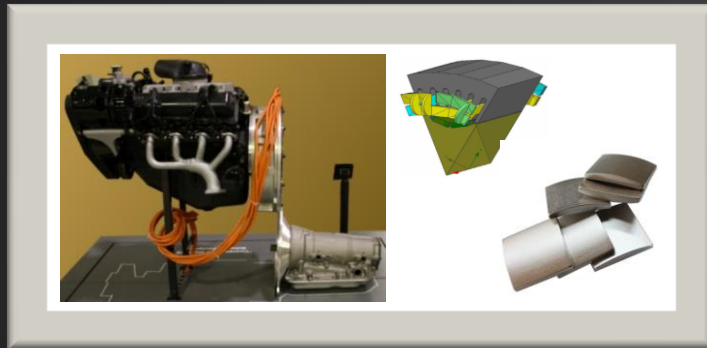
Ignition Models for Heavy Hydrocarbon Fuels



Perform a series of spray visualization experiments for two fuels supplied by each agency



Non-Rare Earth Materials for Motors (Integrated Starter/Generator)



Develop and demonstrate two Integrated Starter/Generators without rare-earth permanent magnets suitable for on-board power generation

Multi-Material Joining



To overcome technology gaps to enable joining of dissimilar materials for both commercial and military ground vehicles



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FY13 New Start Projects & Sources Selected



- “Breakthrough Techniques for Dissimilar Material Joining”
 - Objective: investigate unique concepts for joining materials beyond fusion or friction welding, riveting or ultrasonic techniques.
 - Sources selected:
 - Johns Hopkins University
 - Chrysler Group, LLC
 - Oak Ridge National Lab
 - The Ohio State University
 - Michigan State University

- “Lubricant Formulations to Enhance Fuel Efficiency”
 - Objective: to develop novel lubricant formulations that will improve by at least 2% the fuel efficiency of legacy light- to heavy-duty vehicles.
 - Sources selected:
 - Ford Motor Company
 - Northwestern University
 - Pacific Northwest National Lab
 - Ashland Consumer Markets (Valvoline)

(Continued)



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FY13 New Start Projects & Sources Selected



- “Computer-Aided Engineering for Electric Drive Batteries (CAEBAT) – Phase II”
 - Objective: to develop and validate an electrochemically-thermally coupled large format Li-Ion battery cell and pack model focusing largely on safety/abuse and degradation.
 - Sources selected:
 - Alliance for Sustainable Energy, National Renewable Energy Lab
 - EC Power, LLC
 - Sandia National Lab



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FY14 FOA AOIs Under Review for New Start Project Recommendations



- Beyond Lithium Ion Technologies
- Commercialization of Power Electronics for Electric Traction Drives using Wide Band Gap Semiconductors
- Tire Efficiency
- Multi-Speed Gearbox for Commercial Delivery Medium-Duty Plug-in Electric Drive Vehicles
- Advanced Climate Control Auxiliary Load Reduction
- Powertrain Friction and Wear Reduction



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Directors' Decisions



- Discontinue (Suspend) TFA7: "Analytical Tools"
 - Simulation & Modeling activities embedded within other project scopes-of-work.
- Interest Concurrence in TFA8: "Advanced/Modular Manufacturing"
 - Requires discussion with, and collaboration buy-in by DOE's Advanced Manufacturing Office (AMO)
- Authorization to Immediately Activate TFA9: "Autonomy-enabled Technologies"
 - Next steps:
 - Identify AOI topics/descriptions for FY15 Program-Wide FOA



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Autonomy-enabled Technologies Capabilities



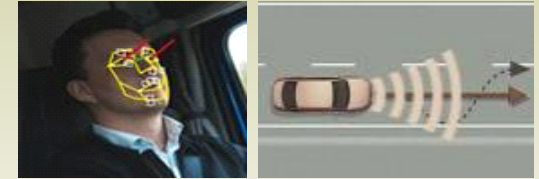
Semi-Autonomous Convoy (Leader/Follower)



Collision Avoidance



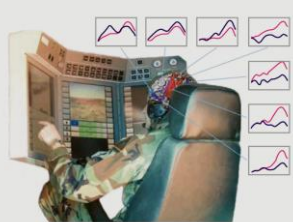
Driver Assist/Driver Monitor



Vehicle Dynamics Management



Intelligent Remote Control/Tele-operation



Prognostics/Diagnostics

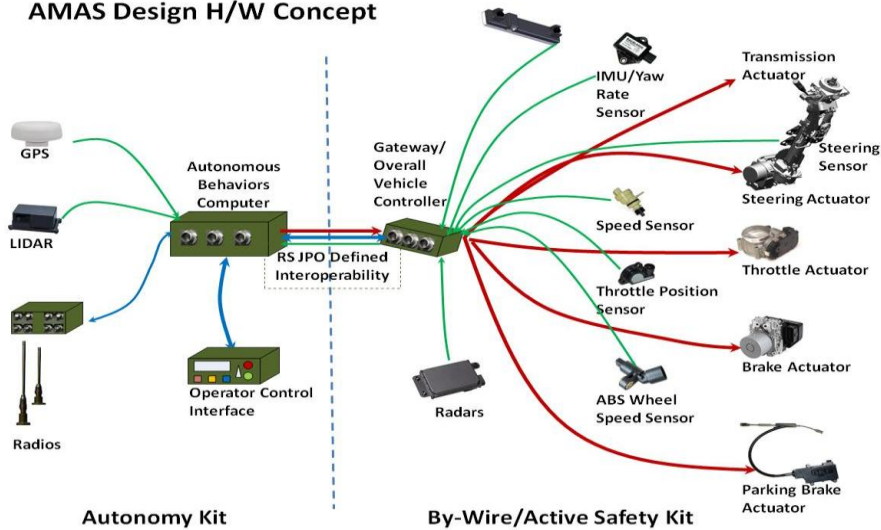




Autonomous Mobility Appliqué System (AMAS)



AMAS Design H/W Concept



Schedule

MILESTONE (FY)	Year One	Year Two
Develop CONOPS/TTP & finalize	[Green bar spanning Year One and Year Two]	
Integrate & Deploy Software/Hardware Components	[Green bar from 5 to 7]	[Green bar from 7 to 7]
Install Integrated System	[Green bar from 5 to 7]	[Green bar from 7 to 7]
Technical Demonstrations	[Green triangle at 7]	[Green triangle at 7]
Operational Demonstration and Assessment	[Green triangle at 7]	[Green triangle at 7]
Operational Utility Assessment Reports	[Green triangle at 7]	[Green triangle at 7]

Purpose:

Provide scalable autonomy onto existing tactical vehicles in a single material solution agnostic of platform. This will be accomplished by integrating 2 kits: (1) a vehicle unique By-Wire Active Safety Kit and (2) a common Autonomy Kit. The By-Wire Active Safety Kit will provide the actuation and an interface for the Autonomy Kit. The Autonomy Kit will be common across the platforms and provide the necessary hardware and software to implement various levels of autonomy. For this JCTD the Autonomy kit, along with the By-Wire/Active Safety Kit will provide scalable autonomy ranging from driver assist technology to automated convoy operations.

Products:

Scalable autonomy in a single material solution agnostic of tactical platform:

Autonomy Kit: Autonomous hardware and sensors.

By-Wire/Active Safety Kit: Vehicle specific devices to retrofit current tactical wheeled vehicles.

Common RS JPO Interoperability Profiles

Common Framework

Payoffs:

- Increased safety, operational efficiency, and effectiveness
 - Improved Situational Awareness
 - Increased Safety (Accidents) and Security
 - Improved operations in no/limited visibility conditions



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Autonomous Mobility Appliqué System (AMAS)



1. What is the problem?

- There are no low-cost, standardized, reliable robotic systems available to provide autonomous operations or other robotic capabilities to the Warfighter.
- Most of the current fielded robotic solutions are built from the ground up with specific sustainment demands not currently available through normal logistic chains.
- Convoys have several needs for improved safe operations and logistical effectiveness, such as improving situational awareness on potential IEDs and other enemy threats, operating in poor weather conditions with limited visibility, and reducing accidents due to fatigue or inattention.

2. What are the barriers to solving this problem?

- Existing platforms are not electronically controllable and require bolt-on actuators that are intrusive and impractical for optionally manned operations.
- Standard, open-architecture solutions for US Army robotics are not yet defined.
- Operating in complex urban environments with minimal operator influence is still in the development stages.

3. How will you overcome those barriers?

- Provide scalable autonomy in a single material solution agnostic of platform. The material solution would provide a Autonomous Mobility Appliqué System (AMAS) comprised of a scalable Autonomy Kit and a Vehicle By-wire kit. The Autonomy kit would provide scalable autonomy ranging from Driver Assist functionality through autonomous behaviors.
- Demonstrate concept on a semi-autonomous convoy application.

4. What is the capability you are developing and where described?

- Platform autonomy in increasing complex environments and mission applications.
- Non-lethal and lethal support capability for mounted forces during operations in terrain ranging from complex urban environments to cross country maneuvers.

Capability	Tasks	Metric	Threshold	Objective
Reliability	System Performance	MTBF	Current Manned System	Improved over Manned
Optionally Manned Vehicle	Unmanned to manned operations mode	Time to Engage and Disengage System	< 1 sec	T=0
FOC 09-04 Operational Tempo	Speed	Kph	Max>40kph Min <5kph	Max>80kph Min<1kph
Joint Land Ops	Lateral Accuracy	Centimeters from lead path	100cm	50cm
Battle space Awareness	Convoy Size	Number of Vehicles	16 Trucks	60 Trucks
FOC 07-01 Protect personnel	Situational Awareness	Sighting increase %	Target sighting increase 10%	Target sighting increase 20%
FOC 07-01 Protect personnel	Emergency braking	Operator Interventions per hour	1	0
By-Wire Control	Drive-By Wire Systems	Systems	DriveTrain, Braking and Steering	All Controllable Systems
Collaborative Operations	Leader / follower swap	Transition time in seconds	Less than 30 seconds	Less than 10 seconds
FOC 09-04 Operational Tempo	Controlling Platform	Distance from Operator	LOS 2 km	NLOS 1 km

6. Transition Milestones

- Demonstrate a TRL 8 capability for the Convoy scenario in FY13.
- Demonstrate optionally manned capabilities of vehicles with multiple levels of autonomy and interoperable autonomy kit in FY12.
- Intermediate products will be available throughout the course of the JCTD and leveraged for fielding.

7. Other Attributes

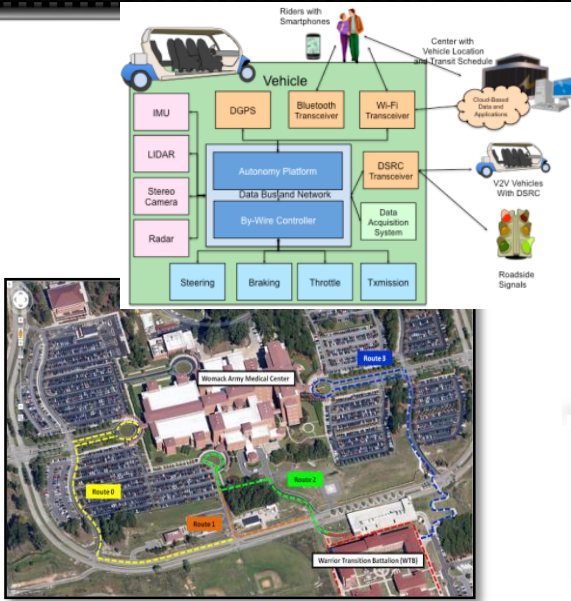
Modeling and Simulation:

- Modeling and simulation will be utilized for the development of perception and control algorithms, for exploration of human-robot interaction.



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Applied Robotics for Installations & Base Operations (ARIBO)



Example platform types



Purpose:

ARIBO provides a method and operational context in which to experiment and demonstrate autonomous vehicle systems in real-world, semi-controlled environments. TARDEC, NASA JSC, and NREL collaborate with input from users at **Ft. Bragg** to design and deploy a safe and reliable autonomous transportation system for wounded warriors. TARDEC is the lead organization.

Products:

- Improved & standardized by-wire control system for neighborhood electric vehicles (NEVs)
- Fleet planning & scheduling system with user interfaces
- Optionally-manned electric vehicles

Payoff:

- Improved technical reliability,
- Data for informed policy decisions and system design,
- Empirical data for business case development and ROI calculations.
- Increased trust & confidence in automated systems

Schedule

MILESTONES	FY13	FY14	FY15	FY16	FY17
Vehicle System Engineering	█				
Planning / Control Sys. Eng.		█			
Site Preparation		█			
Chauffeured Operations			█	◆	
Supervised Operations			█	◆	
Fully-automated Operations				█	◆
Transfer					█

Decision Points to proceed to next stage



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Applied Robotics for Installations & Base Operations (ARIBO)



1. What is the problem?

Robotic systems suffer from low reliability and a lack of trust & confidence on the part of users, non-users, and decision-makers.

2. What are the barriers to solving this problem?

- Lack of a coordinated deployment approach
- Proprietary and piecemeal architecture development
- Prohibitive hardware cost
- Uncertainty over operational impediments
- Reluctance to be an 'early adopter' and adjust status quo behaviour

3. How will you overcome those barriers?

- Partner with other agencies to leverage respective technical strengths and research interests.
- Work closely with Ft. Bragg user community and transportation planners to demonstrate confidence & increase acceptance.
- Define and clearly demonstrate operational efficiencies through use of autonomous systems.
- Demonstrate long-term system reliability.
- Emphasize open architecture and interface standards.

4. What is the capability you are developing?

- Reliable and trusted optionally-manned electric vehicles
- Data-informed decision-making
- Documented process (standards, guidelines, best practices)

5. What is the result/product of this effort?

- Operational autonomous transportation system
- A-kit / B-kit enabled electric vehicles w/ TDP
- Planning and scheduling software
- Empirical data for business case analysis
- Improved behaviour software

6. Quantitative metrics:

Measure	Current*	Effort Objective	TRL or SRL
User acceptance	TBD	90%	N.A.
Classification reliability	90%	99%	6
Operational efficiency	• 13% missed appointments	• 80% reduction	N.A.
Vehicle Costs	• Fuel / energy • Contract drivers • Maintenance	• 75% cost reduction • 100% cost reduction • 45% cost reduction	N.A.

7. How are we leveraging other technology efforts?

- Dismounted Soldier Autonomy Tools (DSAT)
- TBD - Accessible Transportation Technologies Initiative (ATTRI)



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