U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

Building a foundation for MUMT

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RDECOM, TARDEC, Ground Vehicle Robotics (GVR)

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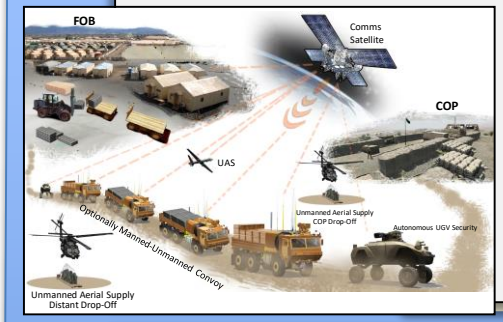
APPROVED FOR PUBLIC RELEASE

BUILDING A FOUNDATION FOR MUMT

Logistic Resupply

Autonomous Ground Resupply



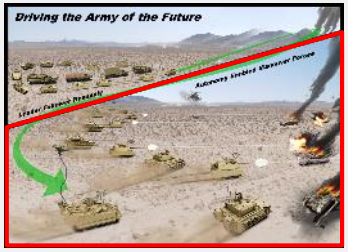
Develop and demonstrate an improved and optimized distribution system that integrates new & emerging technologies across the full spectrum of operational and tactical supply movement operations.

Expedient Leader Follower

Rapidly delivery and issue 70 leader follower enabled PLSs to Soldiers for a one year Operational Technical Demonstration (OTD) starting 4QFY19.

Robotic Combat Vehicles

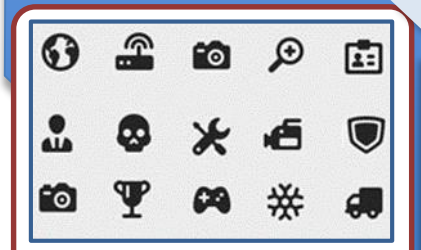
Combat Vehicle Robotics



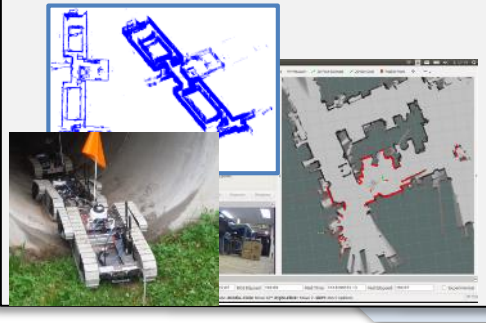
Develop/integrate technologies that enable scalable integration of multi-domain robotic and autonomous system capabilities teamed within Army formations supporting all combat warfighting functions.

Future Manned / Unmanned Teaming Formations

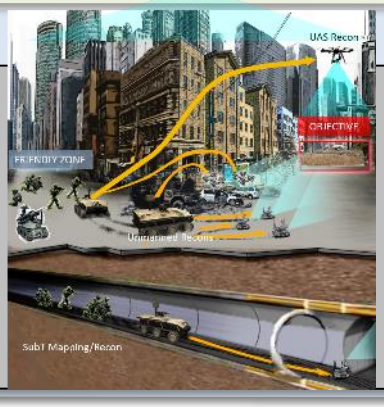
Small Robotics for Urban / Subterranean



Built on Open Autonomy Architecture (AGVRA)



Development of capabilities to support urban and underground operations such as unmanned complex tunnel investigation, CBRNE missions and reconnaissance.



CAPABILITY TO SOLDIERS SOONER

Autonomy Architecture enables getting hardware into Soldier's hands with incremental software capability improvements over time.

Logistic Resupply

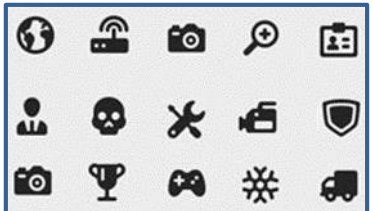
Expedient Leader Follower

Issue two companies (60 PLS Trucks) with Leader Follower capability to soldiers for 12 month operational evaluation.

4QFY19	*3QFY20*	*3QFY22*
Increment I	***Increment II***	***Increment III***
Baseline Architecture Design & Build	**Additional Autonomous Behaviors**	**Advanced Convoy Behaviors**
✓ Modes (Leader Follower, Teleop)	• Modes (Augmented TeleOp, Waypoint)	• Modes (Augmented Waypoint)
✓ Assembly (Manual Line Up Vehicles)	• Assembly (Drive Past and Assemble)	• Assembly (Line Up in Depot)
✓ Formations (Column)	• Formations (Inverted T)	• Formations (Staggered Column)
✓ Reverse (Teleoperation and Manned)	• Trailers (Forward)	• Trailers (Forward & Reverse)
✓ GPS Denied (LOS to Leader)	• Reverse (Retrotraverse)	• Reverse (Retrotraverse)
✓ Turnaround (Vehicle K Turn)	✓ GPS Denied (Comms to Leader)	• GPS Denied (Know AO)
✓ Obstacles (Static & Large Dynamic)	• Turnaround (U Turn)	• Turnaround (U Turn with Obstacles)
✓ Dynamic Rerouting (None)	• Obstacles (Negative)	• Obstacles (Small Dynamic)
✓ AO (Primary & Secondary Roads)	• Dynamic Rerouting (Static Vehicle)	• Dynamic Rerouting (Moving Vehicle)
✓ Operations (Day and Night Driving)	• AO (Open & Rolling Terrain)	• AO (Trails)
• Weather (Light Rain/Snow/Fog)	• Operations (Black Out)	• Operations (PLS OMS/MP)
✓ Safe Harbor (Stop)	• Weather (Moderate Rain/Snow/Fog)	• Weather (Heavy Rain/Snow/Fog)
	• Safe Harbor (Pull Over)	• Safe Harbor (Limited path)

AGVRA

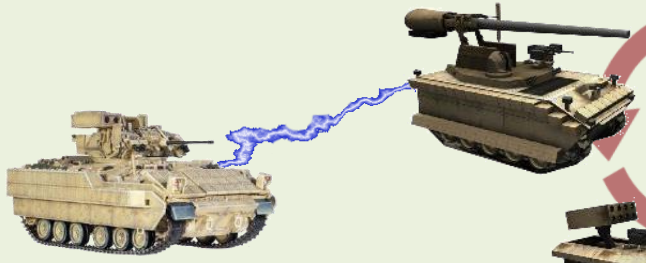
Autonomy Behavior "App Store"



Army does not have to re-buy autonomous similar capability for different platforms

20+ Other Platforms Demonstrated

Baseline capability will be built on for more complex tactical, weaponized systems



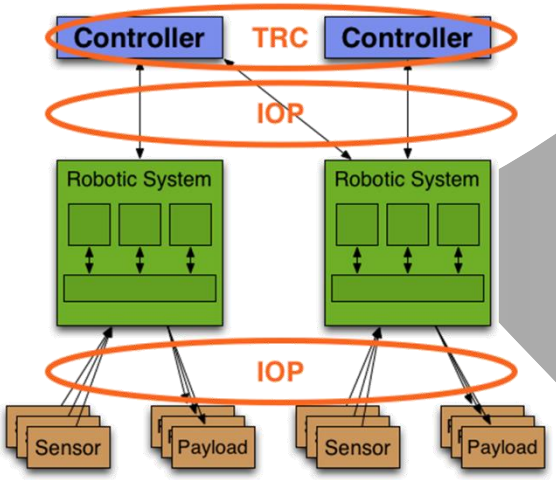
Combat Vehicle Robotics (CoVeR) **program will advance autonomous behaviors to enable mounted Manned Unmanned Teaming**

Robotic Combat Vehicles

OPEN MODULAR GROUND VEHICLE AUTONOMY

Autonomous Ground Vehicle Reference Architecture (AGVRA) - Set of guidelines to enable the robotics community to fulfill the Army's Robotic and Autonomous System (RAS) commonality objectives by establishing an affordable means to deliver advanced capability to the Warfighter by utilizing architectural best practices and standards.

Key standards for unmanned systems

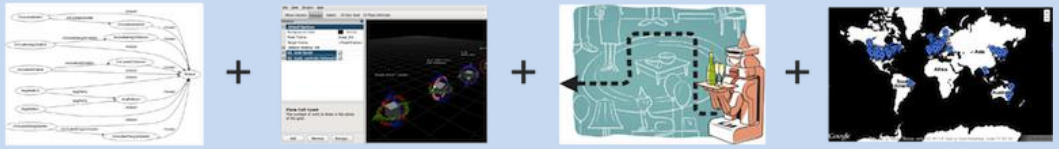


Interoperability Profile (IOP) defines software massaging & hardware interfaces between major subsystems of unmanned ground systems utilizing existing standards

Autonomy Software Framework (ROS-M)

ROS is an open source software framework for robotic development that provides the following features to allow for modular software development:

Less time spent here *means* **More time to spend here**



Plumbing	Tools	Capabilities	Ecosystem
Flexible, node based communications infrastructure	• 3D Simulation • Logging/Analyzing Sensor Data • System visualization, etc.	Modular addition of capabilities by adding nodes to the system	Large number of users actively contributing to ROS community

Ground Vehicle Robotics (GVR) Modular Software Approach (MSA)

- Defined modular autonomy software architecture for Army ground autonomous systems
- Success of this approach relies on strong government and industry collaboration developing interface standards at the appropriate level between applications.
  - Library of GPR autonomy software (ITAR compliant) provided to industry through software distribution agreement (20+ outside entities have the software)
  - Enabling competition at the software module level (prevents vendor lock, mitigates talent migration, enables gov't to capitalize on industry innovation)
  - Common software framework/architecture to streamline test and evaluation process (Delta test for new capabilities rather than totally new system)
  - Transition path for future capabilities such as AI / ML enabled autonomy