



**TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.**

# TARDEC's Intelligent Ground Systems Overview

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# Report Documentation Page

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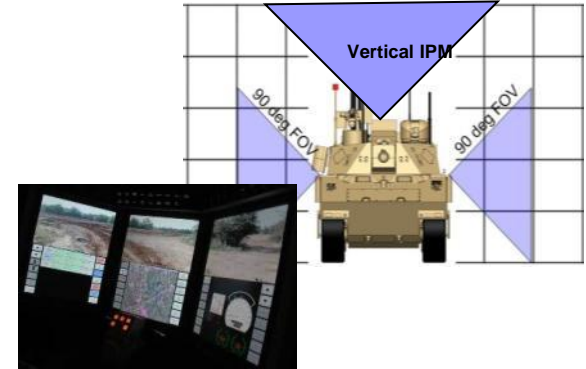
## Autonomous Behaviors



## Warfighter Support



## 360° Situational Awareness



## Architecture Development & Demonstration



## Human – Robot Interface



## Safe Operations



**Mission**  
 Integrate, Explore, and Develop Robotics, Network and Control Components with a Focus on Customer Driven Requirements to Provide Full System Solutions to the War Fighter

### Technology Components

Academic Partnerships

Integration

### Demonstrators

RVCA ATO

Robotic Decontamination

RF Stryker

TAGS-CX

SME Defined Scenarios

### Military Relevant Test & Experimentation

Robotics Collaboration and RVCA ATO Experimentation

ODIS T-3

Convoy Active Safety Technologies War Fighter Experimentation #1

Tech Transfer

Integration Technology Development Lessons Learned to Enable Early Technology Insertion

### Transition and Requirements Development

Future Force SMI

FCS MULE

FCS ANS

FCS JTRS

Initial Capabilities Document (ICD)

Current Force Convoy Operations

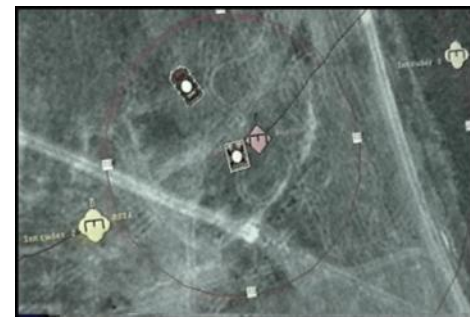
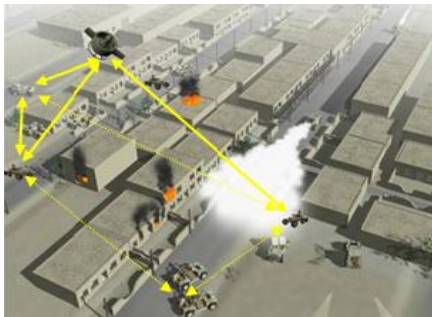
- System Integrator
  - Integration of capabilities (sensors, software, hardware) onto UGV platforms
- Technology Development and Demonstration
  - Army Technology Objectives (ATOs)
  - In-house Research and Development
  - CRADAs and SBIRs
  - Other
- Technical Evaluation
  - Evaluate technologies and capabilities for customers like RSJPO
- Soldier Experiments
  - Support experiments and tests at locations like Ft. Benning
- Feed Requirements Generation

## Purpose:

Increase the level of autonomy of Unmanned Ground Vehicles (UGVs) toward operational consideration

## Products:

- Near-autonomous UGV operations in dynamic environments
- Near-autonomous dynamic UGV/MGV Tactical Formations
- UGV System Self Security through pedestrian Intent inference



**Purpose:** Develop the tools, techniques, & autonomy to maximize mounted and dismounted control of ground and air unmanned systems and optimize Soldier-robot and robot-robot ground and air teams

### Scalable Interface:

- Increased scalability, portability and tailorability of Soldier Machine Interface—reduces training burden
- Control multiple unmanned system— one device can support unique robots from different vendors

### Driving Aids:

- Enables Soldiers to take actions of a semi-auto vehicle while staying in obstacle avoidance
- Increased mission OPTEMPO, reduced intervention times
- Provides Situational Awareness of unmanned system
- Increased insight in unmanned system planning activities



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360/90 Day/Night  
Near-field Sensor Coverage



Soldier Monitoring  
& State Classification

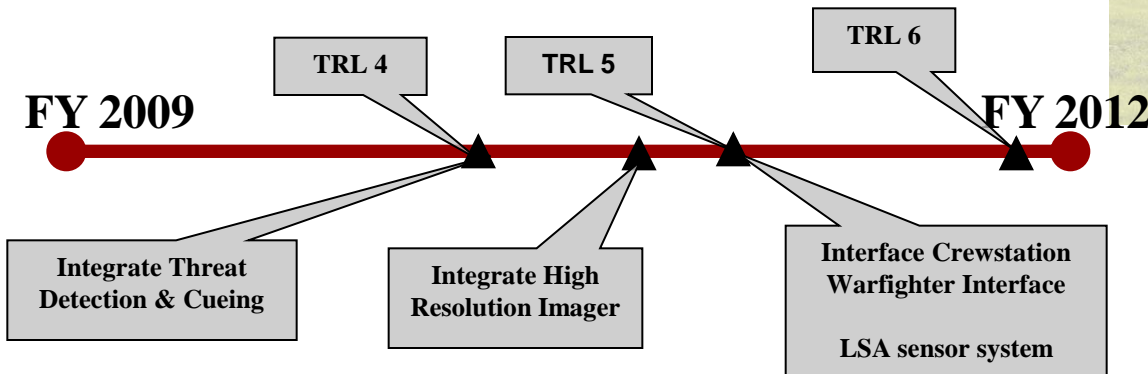


Advanced  
Crew Stations



Enhance, Integrate and Demonstrate  
360/90 LSA/Assisted Mobility/Human  
Dimension to Maximize Indirect Vision  
360/90 LSA and Mobility Capabilities  
(Secure Mobility)

- Focus on closed-hatch operations, indirect vision
- 360/90 degree local area awareness
- Improved mobility via non-LADAR and LADAR based solutions
- Improved assessment and integration of operator performance in real-time
- Increase situational awareness for all crew members







- Safer operations of UGVs in proximity to pedestrians and vehicles
- Increase in vehicle autonomy to enable less supervisory burden
- Increased UGV situational awareness
- Robust Soldier/robot and robot/robot teaming behaviors
- Robust UGV performance in all environments/conditions
- Simulation of platform, payload and algorithms in relevant operational environment



**FY 2009**

Perception & Control Technologies,  
Tactical/Mission Behavior Technologies,  
TRL=5

**FY 2012**

Perception & Control Technologies,  
Tactical/Mission Behavior Technologies,  
TRL=4

Perception & Control Technologies,  
Tactical/Mission Behavior Technologies,  
TRL=6

## Program Goals:

- Provide low cost (\$10-20K) convoy automation (Leader/Follower) capability for current force Army vehicles
- Support Warfighter requirement for convoy automation and active safety
- Provide Robotics capability in CS/CSS community
- Leverage RF, RDECOM and other FCS Technologies

### Enhanced Soldier Protection

- Increased Situational Awareness
- Reduced Collisions
- Reduced crew driving tasks
- Reduced fatigue
- Increased Driver Cognition



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## Program objectives:

- Increase Soldier Directly address risks associated with employing UGVs in dynamic environments
- Identify risk areas of operating UGVs around moving traffic, pedestrians & dismounted forces
- Integrating FCS representative technologies
- Dismounted forces safety
- Maintain lane among civilian traffic
- Develop the tools, techniques & autonomy to maximize mounted & dismounted control of ground and air unmanned systems and optimize Soldier-robot and robot-robot ground & air teams



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## Purpose:

Integrate, enhance, and demonstrate a 360° Spatial Awareness System using Ultra Wide Band for Dismounted Following and Mounted Autonomous Tactical Behaviors.

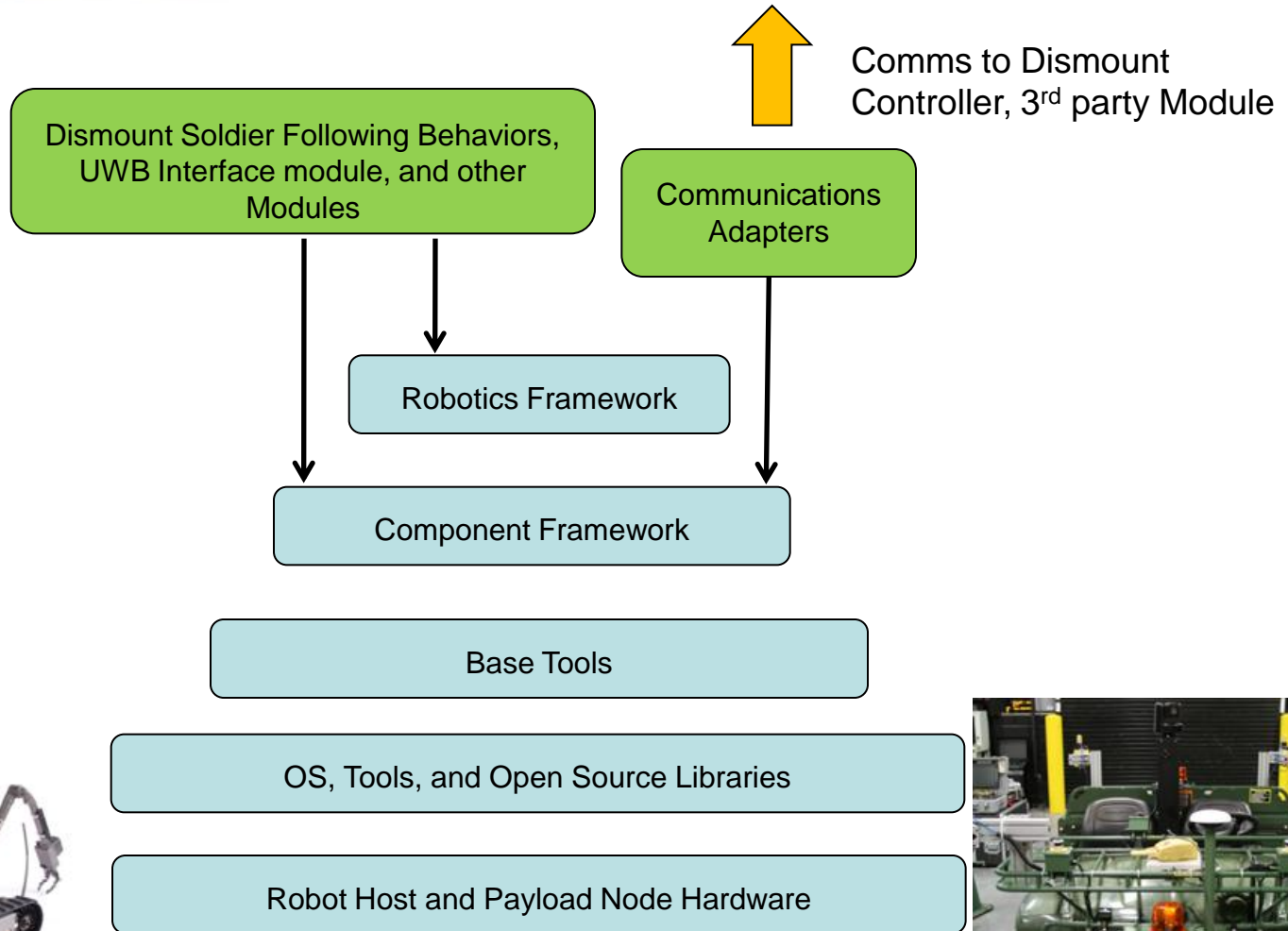
## Payoff:

Drastically minimizes the amount of soldier intervention required to take unmanned systems along in dismounted operations. Provides 360° Spatial Awareness for all assets in the system (manned and unmanned).



- Problem:
  - Robotic platforms require a lot of Soldier interaction, making them a detriment to most dismounted operations
  - Robotic Vehicles do not have adequate information about the formations around them to function autonomously in a tactical environment
- Purpose:
  - Integrate, enhance, and demonstrate a 360° Spatial Awareness System using Ultra Wide Band for Dismounted Following and Mounted Autonomous Tactical Behaviors
- Results:
  - Integrated and improved UWB tracking system on ATV vehicle for doing soldier tracking
  - **Enhanced TARDEC's Robotic Controller to support the developed 360deg Situational Awareness and Dismounted Following**
  - Upgraded ATV vehicle to use Robotics Intelligence Software and added control for UWB dismount following





- Simple Tele-operation behavior
  - Subscribe to steer angle and speed publication from the Dismount Communications adapter module
  - Parameters set with script like maximum velocity and maximum steer angle
  - Evaluate outcomes from behavior system assess utility against desired speed and steer command values
  - Vote for action within behavior system, weighed against other behaviors like obstacle avoidance
- Dismount Follower behavior
  - Set follow distance, speed using parameters in script
  - Subscribe to Soldier locations from UWB interface module (provides UWB positions), identify leader using published leader id from Dismount Communications adapter module
  - Follow leader – simple point towards leader and follow (does not follow path)
- Other Modules
  - Mode manager to track and set mode of operation (tele-op, follow, idle, etc)
  - Module that interacts with UWB positioning system, communications to dismount controller







# fastIGS – 3<sup>rd</sup> party module integration



- Prototype navigation module from Phase II SBIR
  - Hardware connects through Ethernet port on vehicle
  - Utilizes vision for obstacle avoidance, gesture recognition to start/stop vehicle, and UWB positioning information for following
  - Follows the actual path of the Soldier that is identified as the leader
  - Gesture recognition syncs with UWB positions to determine the leader id
- Created a module utilizing the robotics intelligence software framework that adapts between the robotic intelligence software framework pub/sub system and the module, using Joint Architecture for Unmanned Systems (JAUS) standard
- Example of one way TARDEC IGS can help foster integration of different technologies



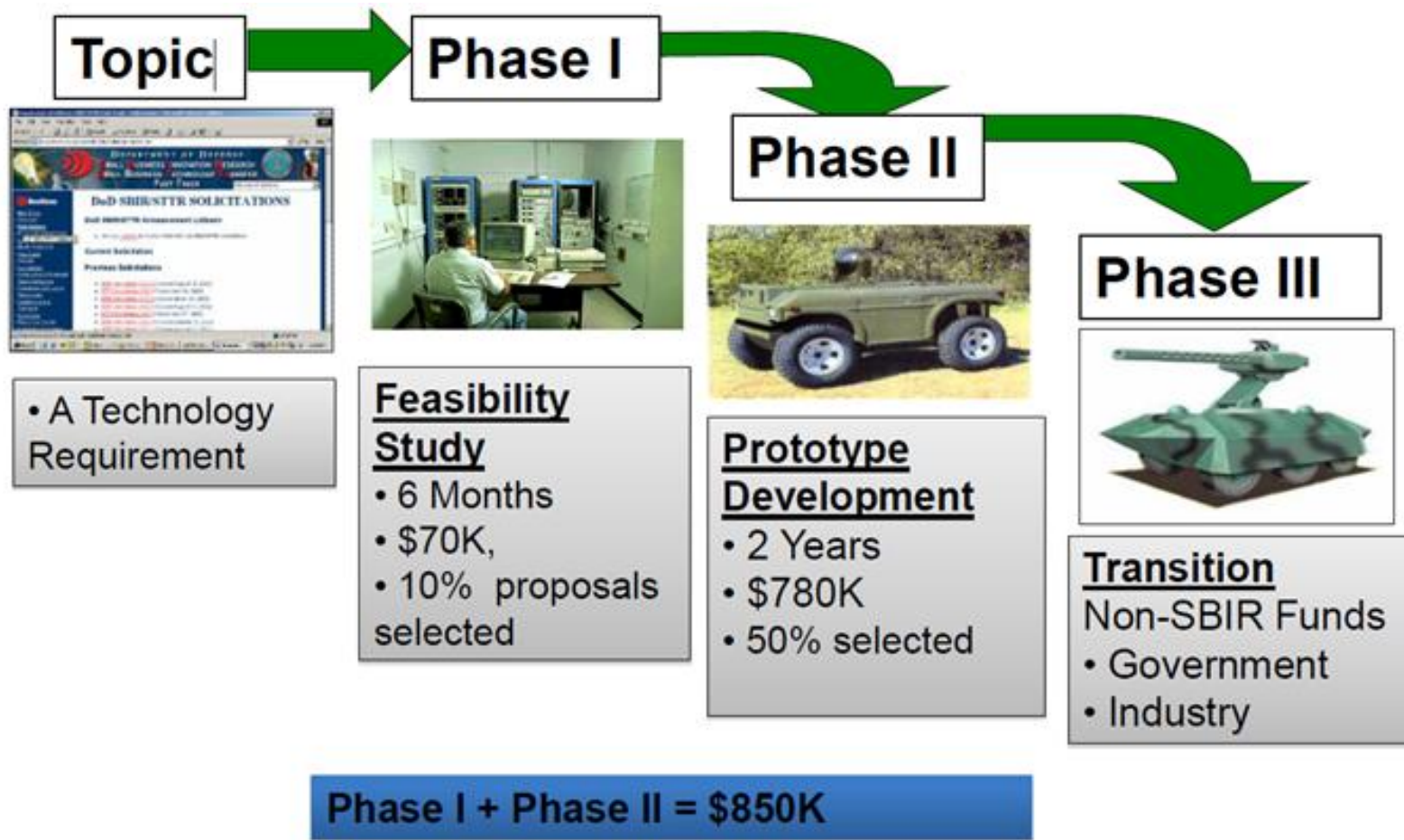
# Working with TARDEC/IGS



- Cooperative Research and Development Agreement (CRADA)
- Small Business Innovative Research (SBIR) program
- TARDEC Ground Vehicle Portal
- Joint Center for Robotics (JCR)

- Between Government Laboratories and commercial, academic, government or association partners
- Facilitate technology transfer between the parties
- Partner contributes personnel, services, property and funding
- Government contributes all the above, except funding
- More information can be found at <http://tardec.army.mil/briefings>
  - Dual-Use Briefings – CRADA Overview

- Purpose
  - Federal Government wide program
  - Increase small business participation in federally funded R&D
  - Transition Federal R&D into government programs and industry initiatives
- Requirements
  - Be a U.S. for-profit small business of 500 or fewer employees
  - All work must be performed in the United States; including subcontractors
  - During Phase I, a minimum of 2/3 of the effort must be performed by the proposing small business; a minimum of ½ of the effort in Phase II
  - Principal investigator must spend more than ½ of the time employed by the proposing small business
- More information can be found at <http://tardec.army.mil/briefings.asp>
  - Dual-Use Briefings – SBIR Overview



- Semi-autonomous Manipulator Control
- Autonomous Indoor Mapping and Modeling
- Improved Tele-Control for Manipulator Equipped Unmanned Ground Vehicles
- Standards Based Unmanned Ground Vehicle Mission Translator with Graphical Planning Tool
- Vision-Based Motion Sensing for Small Unmanned Ground Vehicles
- Teleoperation with High Latency



**TARDEC Technology Submission**

Soldiers are our NUMBER 1 priority. Help us make them your priority as well. Submit your ground vehicle systems technology concepts, ideas and innovations to TARDEC today using the electronic submission form below. Your submission will be treated confidentially, and a TARDEC technologist will thoroughly evaluate your proposal.

For all other inquiries, click on this link: <http://tardec.army.mil/contact.asp>.

**Your Submission**

\* Submission Title:

\* Submission:

Maximum 8,000 characters

Documents:  Browse  
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Click "Browse" and select the file you want to attach. Typing filenames in the fields above will not attach your files.

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Industry:

\* Name:

Job Title:

Address 1:

Address 2:

City:

State:

Zip Code:

\* Business Phone:

Mobile Phone:

Fax Number:

\* E-mail:

Web Address:

<https://tardec.groundvehiclegateway.com/>

- ❖ Online tool for technology submissions
- ❖ Formally announced at SAE World Congress 20 April 2009

- S&T Support to the RS-JPO
- Develops and Fosters external Relationships
- Matures technology for Insertion into ATO programs
- Robotics Outreach
- RS JPO Collaboration Cell Lead
- Support to IGS Capability Cells
- Robotics Academic Programs (Including Curriculum Development)



Government Partnerships	Industry Partnerships	Academia Partnerships	Community Outreach
	<p>Delphi                      Ford                      Foster-Miller                      General Dynamics                      GM                      Google                      iRobot                      JADI                      John Deere                      Lockheed Martin                      Oshkosh                      Polaris                      Quantum Signal                      Raytheon                      Soar Technology                      Think-A-Move                      Toyota</p>	<p>Auburn University                      Carnegie Mellon                      Lawrence Tech. University                      Michigan State University                      Michigan Tech                      MIT                      Oakland University                      University of Detroit Mercy                      University of Michigan                      U of M Dearborn                      Virginia Tech                      Wayne State University</p>	<p>TARDEC Robotics Quarterlies</p> <p>Robotics, Engineering and Technology Days</p>



Questions?