ROBOTICS COLLABORATIVE TECHNOLOGY ALLIANCE

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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
Using the best resources in Government, Industry and Academia to develop and validate robotic technologies that meet current and future Army needs...

Robotics CTA Overview

Army Needs + Experience = Applied Research

Network Centric
- Battle Team Focus
- Constrained Bandwidth
- Info. Dissemination

User Centric
- Human Performance
- Trust in Automation
- Workload Theory

Robot Centric
- Autonomous Mobility
- Tactical Behaviors
- Safe Operations

Hybrid Architectures & Reactive Behaviors

RCTA Intelligent Control Architecture

Other CTAs
- C&N, P&E, ADA, Sensors

2001-2010

C2 Vehicle

1-n UGVs ↔ 1-n UGSs ↔ 1-n UAVs

C2 for Manned / Unmanned, Air / Ground Battle Teams
Robots CTA Task Areas

Requires advancing the state of the art in three critical areas:

- Perception
- Intelligent Control
- Human Machine Interface

Requires integrating research advances from all three areas using a system-level approach to provide a mechanism for:

- Field experimentation and research validation
- User input
**Consortium Members**

- General Dynamics Robotic Systems (Lead Industrial Partner)
- Carnegie Mellon University
- Applied Systems Intelligence
- Jet Propulsion Laboratory
- Alion Science & Technology
- BAE Systems
- Sarnoff Corporation
- SRI International
- Florida A&M University
- University of Maryland
- PercepTek
- Robotic Research
- Signal Systems Corp
- Howard University
- NC A&T University
- University of Pennsylvania
- Skeyes Unlimited

**Objectives**

*Make the research investments that support the Army’s robotic system development goals:*

- Develop perception technologies that allow robotic vehicles to sense and understand their environment;
- Develop intelligent control technologies and architectures enabling robotic systems to autonomously plan, execute, and monitor operational tasks undertaken in complex, tactical environments;
- Develop human-machine interfaces that allow soldiers to effectively task robotic systems and minimize operator workload.

**Technical Areas**

- Advanced Perception
- Intelligent Control & Behavior Development
- Human / Machine Interfaces
Advances in Sensors and Perception

LADAR Development & Processing Algorithms

Terrain Classification

Moving Agent Understanding

Air / Ground & Mid-Range Sensing
Advances in Intelligent Control

Global Planning for Robotic Vehicles

Local Planning for Robotic Vehicles

Tactical Behaviors

Collaborative Operations

2007
Advances in Human Machine Interface

Scalable Human Machine Interfaces

Multi-Modal Input

Workload / Trust in Automation

HMI Interface Extensions
### Stages of Experimentation and Integration

<table>
<thead>
<tr>
<th>Proof of Concept Testing with COTS Hardware</th>
<th><img src="image1.jpg" alt="Image" /></th>
<th><img src="image2.jpg" alt="Image" /></th>
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</thead>
<tbody>
<tr>
<td>Researchers test proof of concept in their own labs with commercial off-the-shelf (COTS) hardware. The image at right is from the Carnegie Mellon Robotics Institute Laboratory.</td>
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<tr>
<th>Perception and Autonomous Navigation Testing with GDRS Standardized Test Facilities</th>
<th><img src="image3.jpg" alt="Image" /></th>
<th><img src="image4.jpg" alt="Image" /></th>
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</thead>
<tbody>
<tr>
<td>GDRS facilities are used to test perception and autonomous navigation tasks. Data is analyzed against the ground truth of known obstacles. ARL and NIST design quantitative experiments.</td>
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<tr>
<th>Simulation Testing with RCTA SIL</th>
<th><img src="image5.jpg" alt="Image" /></th>
<th><img src="image6.jpg" alt="Image" /></th>
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<tbody>
<tr>
<td>The RCTA Systems Integration Lab (SIL) at GDRS provides a hardware-in-the-loop simulation testbed for Advanced Perception, Intelligent Control Architecture (ICA) and Human Machine Interface (HMI) technologies.</td>
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<tr>
<th>Integration and Testing in Realistic Environments</th>
<th><img src="image7.jpg" alt="Image" /></th>
<th><img src="image8.jpg" alt="Image" /></th>
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<tr>
<td>New technology is integrated and tested on the Demo III XUV and commercial vehicles in various terrains including rolling and forested terrain, as well as a MOUT environment at Fort Indiantown Gap.</td>
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Hardware-in-the-Loop Simulation

- Capability Developed in FY 2007
- Leverages Visualization Technology from COTS Gaming Technology
- Exploits Graphics Technology to Emulate Vehicle Sensors
<table>
<thead>
<tr>
<th>Metric</th>
<th>FY02-06</th>
<th>FY07</th>
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</thead>
<tbody>
<tr>
<td>Scholarly Papers</td>
<td>182</td>
<td>26</td>
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<tr>
<td>Invention Disclosures</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Patent Applications Filed</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Masters Degrees Awarded</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Ph.Ds. Awarded</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Graduate Students Supported</td>
<td>88</td>
<td>14</td>
</tr>
</tbody>
</table>
Provided the technical foundation for FCS-ANS and the demonstration in 2003 that was instrumental in funding FCS unmanned ground systems

- Field-tested LADAR hardware
- LADAR processing algorithms for obstacle detection, classification algorithms for obstacle detection, and terrain classification
- Engineering visualization tools for LADAR and vehicle planner development
- Field-tested robotic testbed platforms (with interfaces to navigation sensors), capable of data collection and archiving in realistic tactical environments
- LADAR optics, TX/RX electronics and processing firmware (FFT, multi-pulse, ranging, etc.)
- Passive perception system algorithms; stereo correlator, rectification and pyramid algorithms
RCTA Transitions to TARDEC VTI
Advanced Development Programs

- Hardware and software perception sensors
- Sensor processing algorithms, including pedestrian detection algorithms
- Vehicle planners
- Planning algorithms via Terrain Reasoner
- Selected tactical and cooperative behavior algorithms
- Perception technologies from the 3500-pound XUV testbed to the 18-ton Stryker vehicle
- SMI related components
RCTA Transitions to PM-FPS MDARS

- Perception Sensors (LADAR and EO/IR)
- Sensor processing algorithms
- Vehicle planners and OA Planning algorithms
- LADAR optics and TX/RX electronics
- LADAR processing firmware (FFT, multi-pulse, ranging, etc.)
- Acadia Vision Processor
RCTA Transitions to AATD UACO

- UGV Perception Sensors and Demonstration Platforms
- UGV and LADAR Sensor Processing Algorithms
- Vehicle planners and OA planning algorithms
- Market-Based Collaborative Tasking Algorithms
- SMI Interface, Decision Support System, and Terrain Reasoner
- Air / Ground Cooperative C2
- Test and Demo Facilities
Entered Low Rate Initial Production in December 2007

- Perception Sensors (LADAR and EO/IR)
- Sensor processing algorithms
- Vehicle planners and OA planning algorithms
- LADAR optics and TX/RX electronics
- LADAR processing firmware (FFT, multi-pulse, ranging, etc.)
- Acadia Vision Processor
Providing key technology for future Army unmanned systems

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