

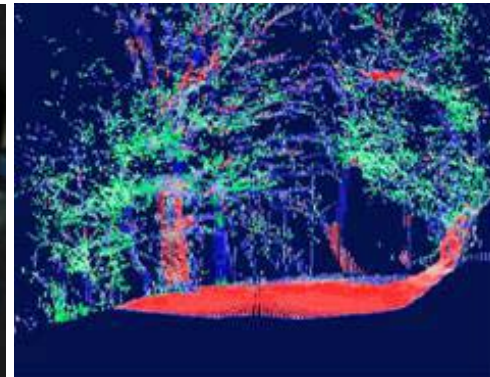
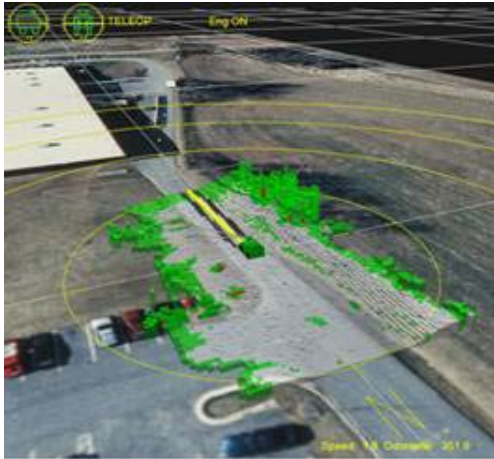
REPORT DOCUMENTATION PAGE

*Form Approved
OMB No. 0704-0188*

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|---|-------------------------|---|-----------------------------------|---|--|
| 1. REPORT DATE (DD-MM-YYYY) 01/01/2007 | | 2. REPORT TYPE Technical Report - Briefing Charts | | 3. DATES COVERED (From - To) | |
| 4. TITLE AND SUBTITLE Robotics Collaborative Technology Alliance | | | | 5a. CONTRACT NUMBER | |
| | | | | 5b. GRANT NUMBER | |
| | | | | 5c. PROGRAM ELEMENT NUMBER | |
| 6. AUTHOR(S) | | | | 5d. PROJECT NUMBER | |
| | | | | 5e. TASK NUMBER | |
| | | | | 5f. WORK UNIT NUMBER | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Army Research Laboratory Adelphi MD United States | | | | 8. PERFORMING ORGANIZATION REPORT NUMBER | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Army Research Laboratory Adelphi MD United States | | | | 10. SPONSOR/MONITOR'S ACRONYM(S) | |
| | | | | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) | |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT A = Approved For Public Release 12/4/2015 No | | | | | |
| 13. SUPPLEMENTARY NOTES | | | | | |
| 14. ABSTRACT | | | | | |
| 15. SUBJECT TERMS | | | | | |
| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT U | b. ABSTRACT U | c. THIS PAGE U | | | 19b. TELEPHONE NUMBER (Include area code) |

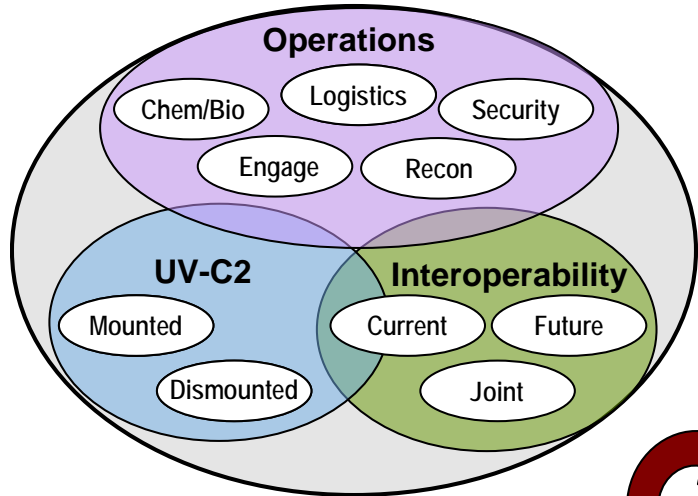
ROBOTICS COLLABORATIVE TECHNOLOGY ALLIANCE



Jon Bornstein
Collaborative Alliance Manager
Army Research Laboratory

Bill Borgia
Consortium Manager
General Dynamics Robotic Systems

Army Needs



+

Experience

=

Applied Research

Network Centric

Battle Team Focus
Constrained Bandwidth
Info. Dissemination

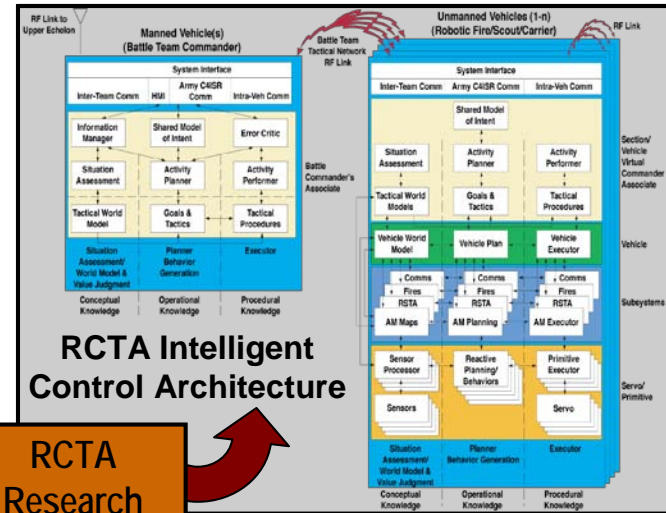
User Centric

Human Performance
Trust in Automation
Workload Theory

Robot Centric

Autonomous Mobility
Tactical Behaviors
Safe Operations

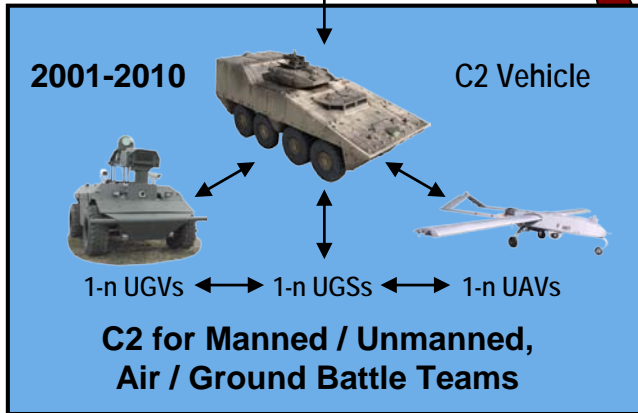
Hybrid Architectures
& Reactive Behaviors



RCTA Research



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



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

CTA Inception

- Terrain Based Preplanning
- Fixed Behaviors with Fragile Performance
- Limited Replanning Under Failure Conditions
- Extensive Human Interaction Required

Required

- Automatic Planning & Replanning with Limited Human Interaction
- Dynamic Replanning Based on Perception, Tactical Information, & Frag Orders
- Robust Behaviors to Operate Over a Wide Range of Situations

Human Machine Interface

Required

- Decision Aids for Offloading Operator
- Rapid Context Switching Between Multiple Platforms
- Robotic Platform Supervision & Tasking
- Multi-Model Input/Output
- Multi-Platform & Mixed Asset Tasking

CTA Inception

- Human Intensive Planning
- Extensive Teleoperation Required
- Operator Saturation

CURRENT

- Program making steady progress toward required capabilities

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

Intelligent Control

Perception

CTA Inception

- Road Following on Well Defined Surfaces
- Slow Cross-Country Navigation in Relatively Benign Terrain
- Highly Sensitive to Environmental Effects
- Vulnerability while Platform is in Motion

Required

- All Weather, Day/Night
- Complex Environments
- Recognition of Tactical Situations
- Speed Commensurate with OPTEMPO
- Perception for Mid-Range Planning
- Understanding of Moving Agents while Platform is in Motion
- Perception to enable Vehicle Safeguarding





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

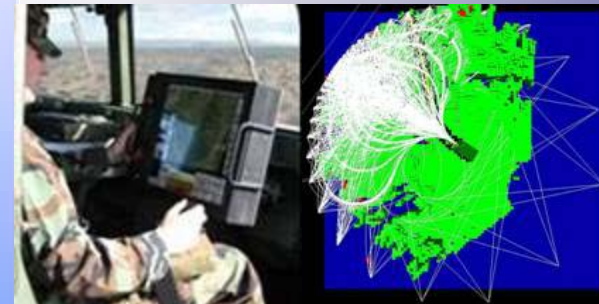
Objectives

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.*

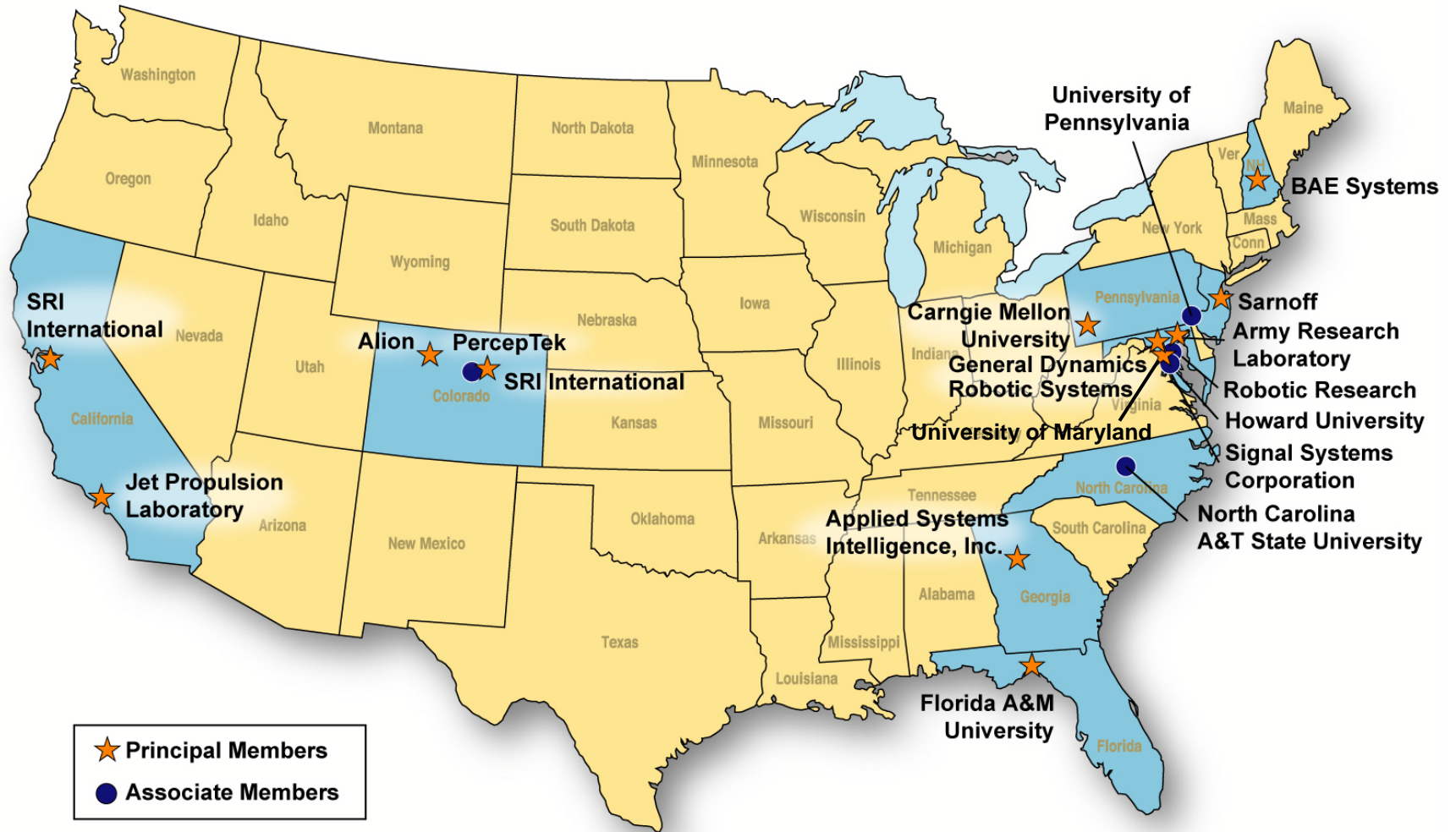
Technical Areas

- Advanced Perception
- Intelligent Control & Behavior Development
- Human / Machine Interfaces

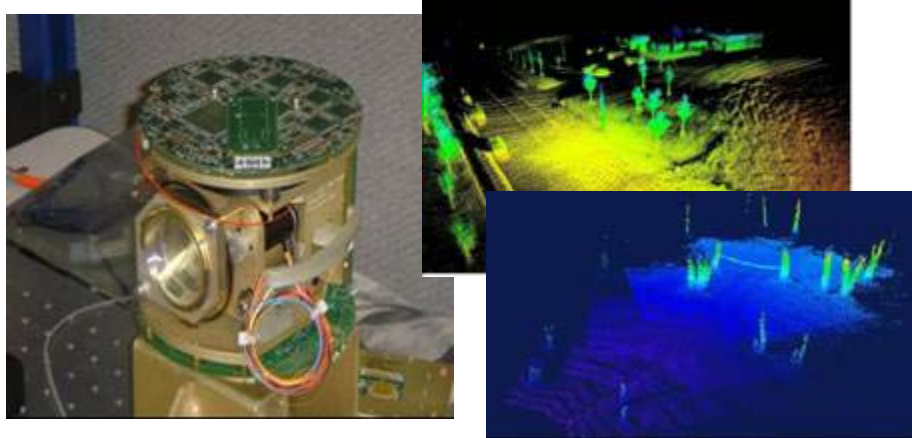




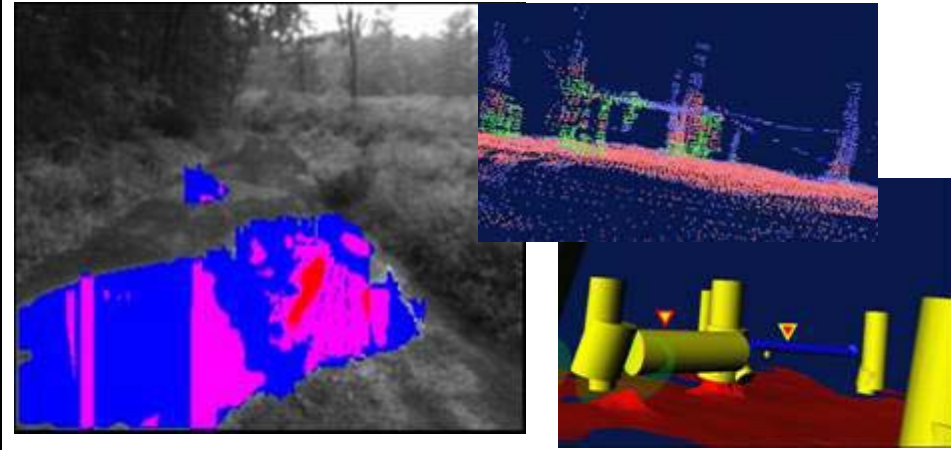
Robotics CTA – Member Distribution



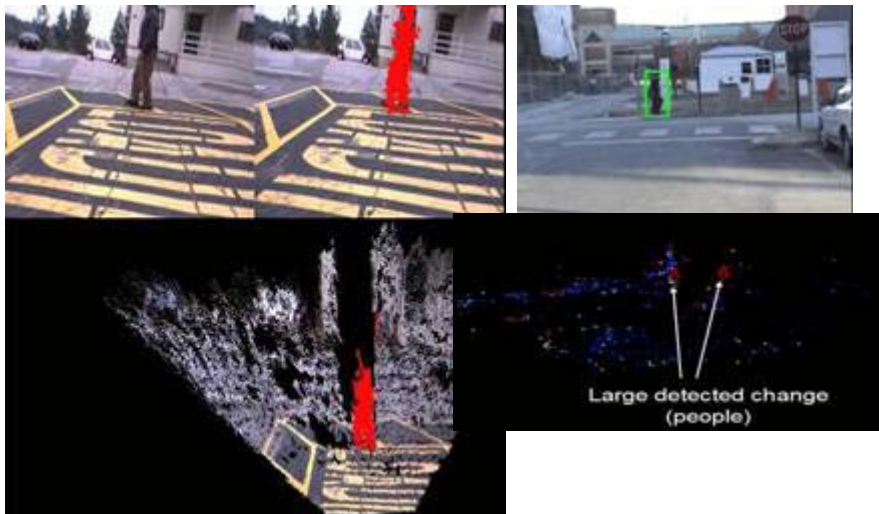
LADAR Development & Processing Algorithms



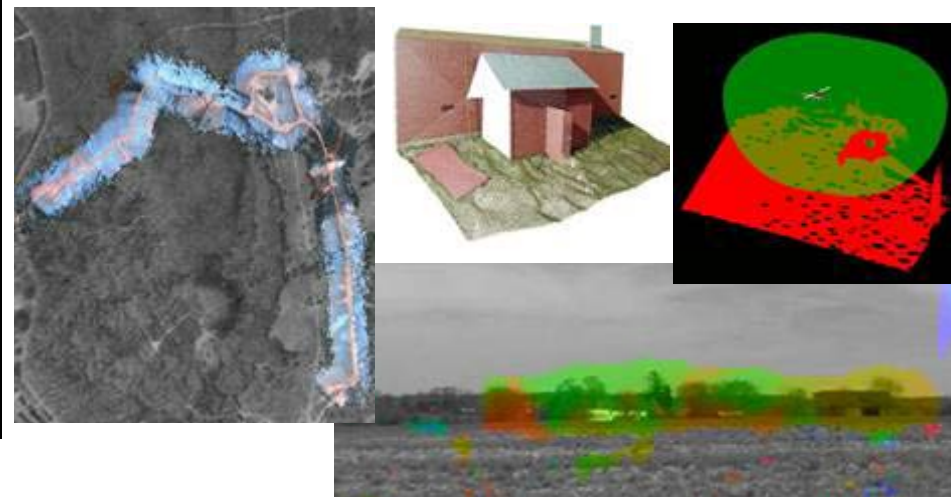
Terrain Classification



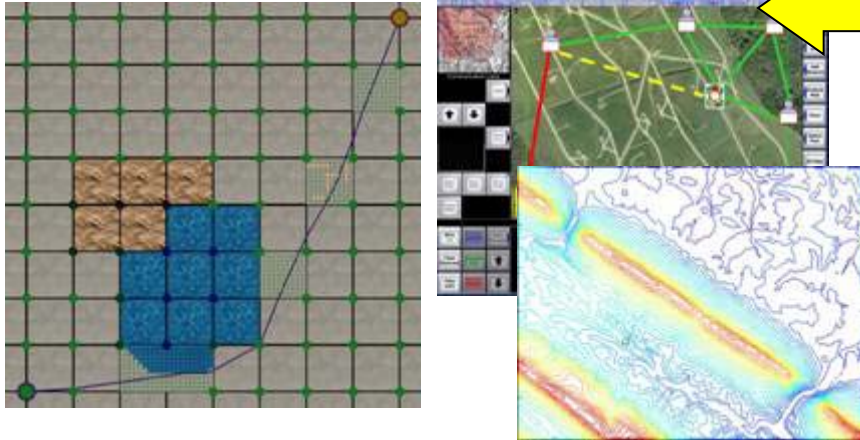
Moving Agent Understanding



Air / Ground & Mid-Range Sensing

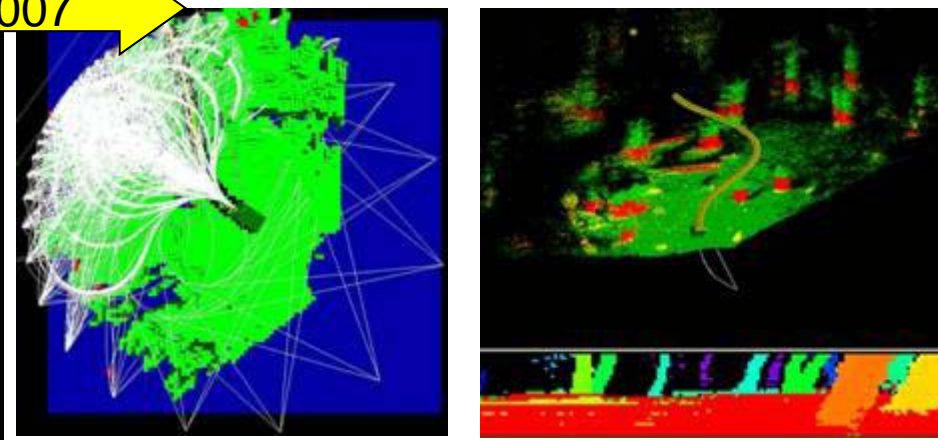


Global Planning for Robotic Vehicles



2007

Local Planning for Robotic Vehicles



Tactical Behaviors

ARV Tactical Engagement Behaviors - MOUT

Legend:
 Throughlines
 ARV-Return Path
 ARV-Path
 Obstacles

Scenario 1: ARV-A Counter-Draper
 With support from UAV 1, ARV-A, reconnaissance on the MOUT site. ARV-A, upon receiving the intelligence, sends signals to units. ARV-A determines the best route to be taken. ARV-A sends the route to ARV-A. ARV-A then is able to plan the route. ARV-A then is able to plan the route.

Scenario 2: ARV-A BLOC Engagement
 In the scenario from UAV 1, ARV-A, remains in its position until the counter-draper is engaged. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A.

Scenario 3: Draper Special Maneuver
 In the scenario from UAV 1, ARV-A, during reconnaissance, the area is scanned by ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A.

Scenario 4: Draper Special Maneuver
 In the scenario from UAV 1, ARV-A, during reconnaissance, the area is scanned by ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A.

Key of the company:
 (C) ARV-A (Counter-Draper) when speed is not crucial, follow as a normal speed when speed is important. CU: ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A.

(D) ARV-A (Counter-Draper) when speed is not crucial, follow as a normal speed when speed is important. CU: ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A. ARV-A then sends signals to ARV-A.

ARV-BSTA Path
 ARV-A Path

Collaborative Operations



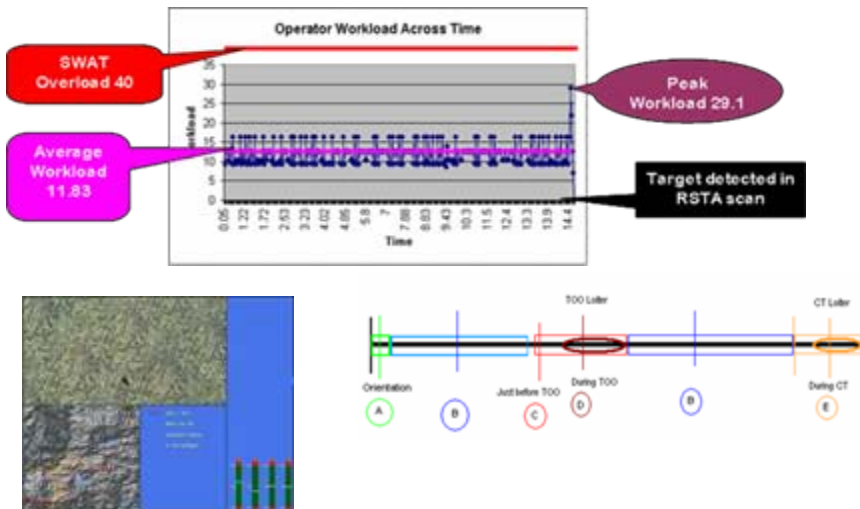
Scalable Human Machine Interfaces



Multi-Modal Input



Workload / Trust in Automation



HMI Interface Extensions



Stages of Experimentation and Integration

Proof of Concept Testing with COTS Hardware

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.



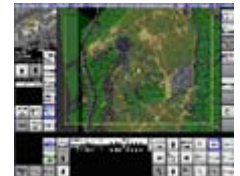
Perception and Autonomous Navigation Testing with GDRS Standardized Test Facilities

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.



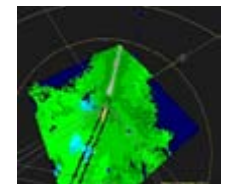
Simulation Testing with RCTA SIL

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.

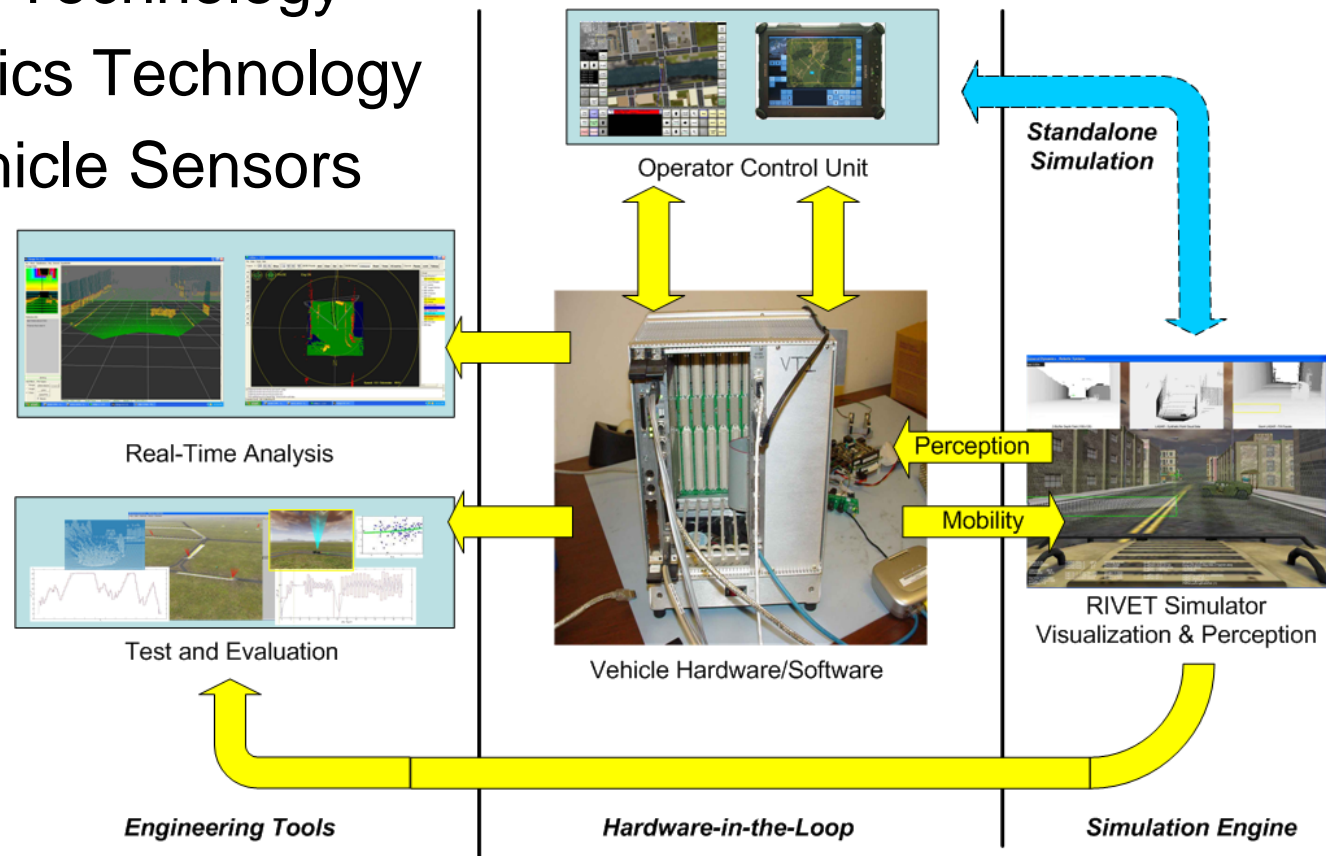


Integration and Testing in Realistic Environments

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.



- Capability Developed in FY 2007
- Leverages Visualization Technology from COTS Gaming Technology
- Exploits Graphics Technology to Emulate Vehicle Sensors



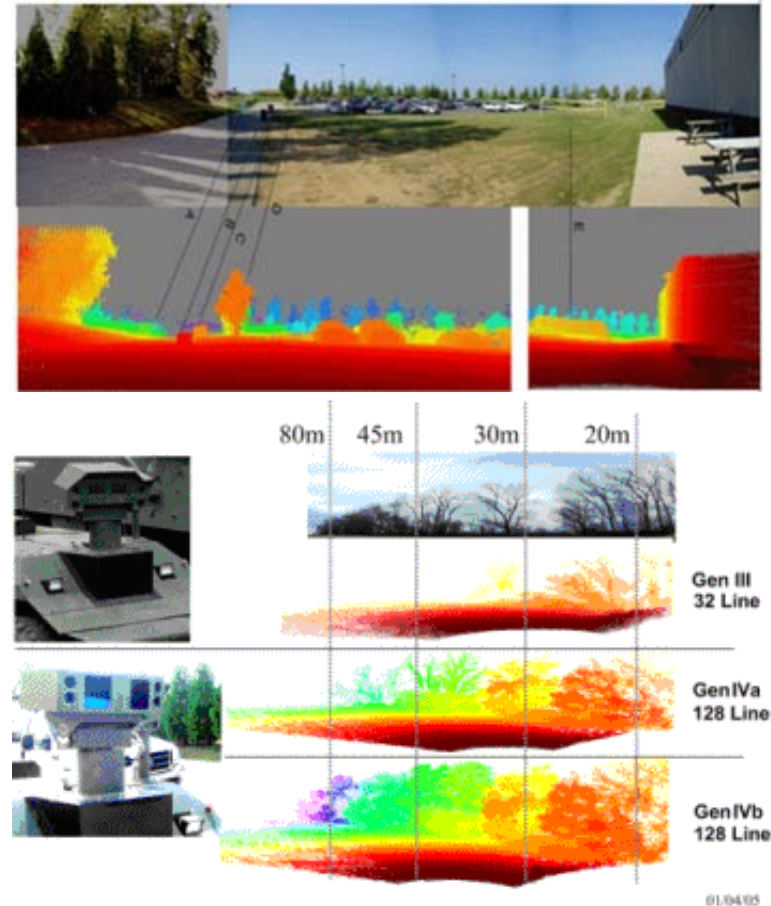


RCTA FY07 Metrics



| Robotics Collaborative Technology Alliance Metrics FY07 | | |
|--|----------------|-------------|
| Metric | FY02-06 | FY07 |
| Scholarly Papers | 182 | 26 |
| Invention Disclosures | 2 | 2 |
| Patent Applications Filed | 5 | 1 |
| Masters Degrees Awarded | 12 | 9 |
| Ph.Ds. Awarded | 10 | 4 |
| Graduate Students Supported | 88 | 14 |

- 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





- 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

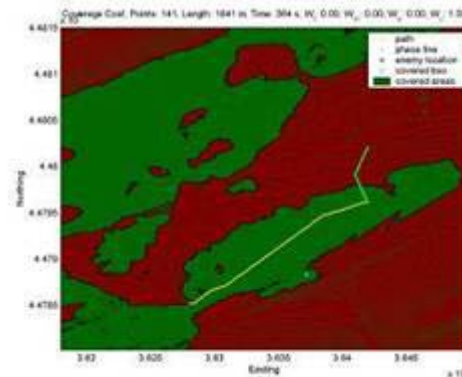
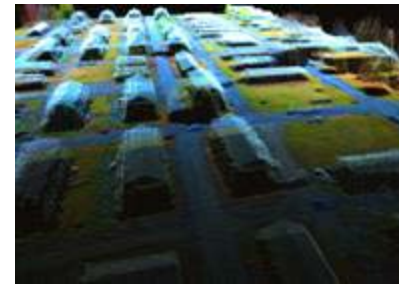




RCTA Transitions to AATD UACO



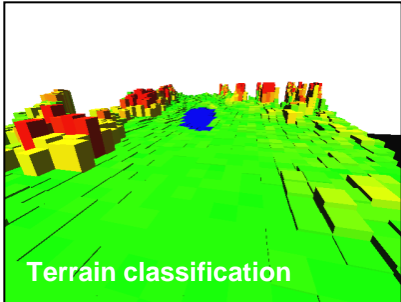
- UGV Perception Sensors and Demonstration Platforms
- UGV and LADAR Sensor Processing Algorithms
- Vehicle planners and OA planning algorithms
- Market-Based Collaborative Tasking Algorithms
- SMI Interface, Decision Support System, and Terrain Reasoner
- Air / Ground Cooperative C2
- Test and Demo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



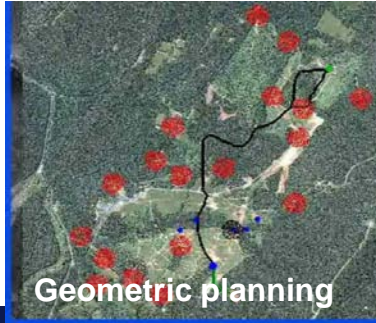
Entered Low Rate Initial Production in December 2007

- 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





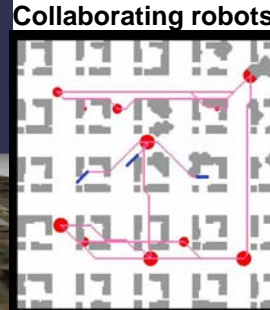
Terrain classification



Geometric planning



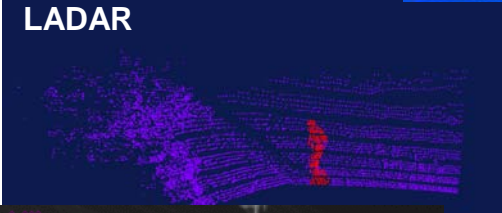
Planning for dynamic environments



Collaborating robots



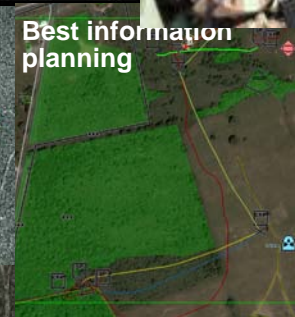
Scalable interfaces



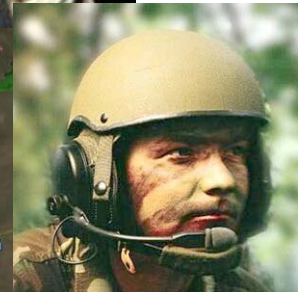
LADAR



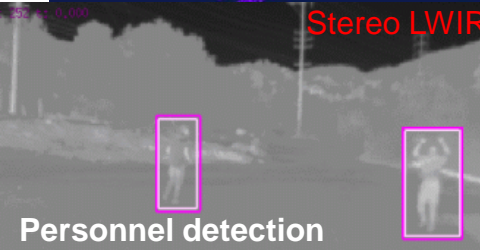
Planning with adversaries



Best information planning

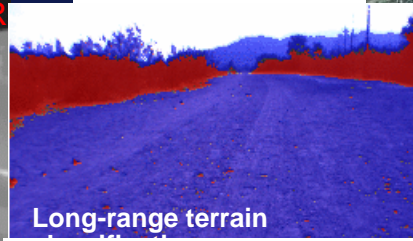


Multi-modal interfaces



Stereo LWIR

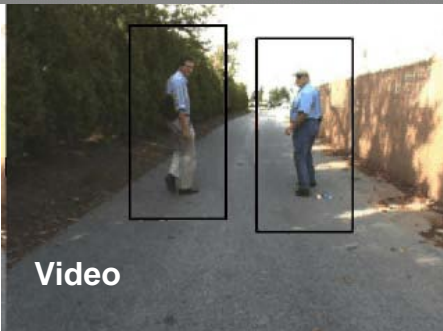
Personnel detection



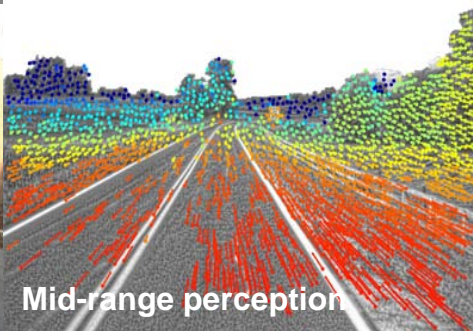
Long-range terrain



Control for difficult terrain



Video



Mid-range perception

Providing key technology for future Army unmanned systems

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.