Army Robotics
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**Army Robots**

**Performing Organization**
US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA

**Sponsor/Monitor**
TACOM/TARDEC

**Distribution/Availability Statement**
Approved for public release, distribution unlimited

**Supplementary Notes**
The original document contains color images.
The Future: Interoperable unmanned systems working hand in hand with Soldiers

Today: Teleoperated, dedicated control unit, COTS systems

- Joint Shared Integrated Picture
- Increased Force Survivability
- Increased Operational Lethality
- Sensors, Shooters, Command, Control & Communications
- Reconnaissance / Surveillance
Common payload interface across platforms by mission or class

*Family of unmanned ground systems*

Payload Interface Standard Architecture

- Payload A
- Payload B
- Payload C
- Payload D
- Payload E

*Mission equipment payloads*
JPO Robotic Systems (Non FCS)

**Maneuver**
- IED Defeat Systems
- Disarm / Disrupt
- Reconnaissance
- Investigation
- Explosive Sniffer

**Maneuver Support**
- Area/Route Clearance
- Mine Neutralization
- Counter IED
- CBRNE

**Sustainment**
- Common Robotic Kit
- EOD
- Convoy
- Log/Resupply
TARDEC Joint Center for Robotics

- 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)

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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

Demonstrators

Military Relevant Test & Experimentation

Transition and Requirements Development

Integration Technology Development Lessons Learned to Enable Early Technology Insertion

Integration

SME Defined Scenarios

Robotics Collaboration and RVCA ATO Experimentation

Convoy Active Safety Technologies War Fighter Experimentation #1

Initial Capabilities Document (ICD)

Academic Partnerships

Integration

FCS MULE

FCS ITRS

FCS ANS

Current Force Convoy Operations

Future Force SMI

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
Autonomous Behaviors

Warfighter Support

360° Situational Awareness

UGV Safe Operations

Architecture Development & Demonstration

Human – Robot Interface

TARDEC Robotics
Recent Warfighter Experiments

Robotic Vehicle Control Architecture
In collaboration with PM-FCS (BCT)

Near Autonomous Unmanned Systems
ATO Capstone

Convoy Active Safety Technologies (CAST)

Robotics Collaboration ATO Capstone
Robotics for Current Operations

Under Vehicle Inspections

Remote Mine Detection System

Construction Engineering Robotic Kit

Robotic Decontamination
Autonomous Detection Vehicle
- Autonomous route investigation and hazard marking
- Fundamentally an appliqué kit for Husky
- Funding exists for developmental phase (JIEDDO to NVL)
- Leverage previous work by GDRS for NVL

Convoy Logistics
- Kit-based system for TWV automated leader-follower
- User assessment at Fort Hood in the September – October timeframe
- Funding exists for developmental phase
  - Potential to leverage JCTD for cycle development

Manned/Unmanned Teaming (MUT)
- Large armed robotic platform assumes role as a member of squad / formation
- Leverage existing ARDEC, AMREC, CERDEC technologies and Fort Hood rodeo for target acquisition and engagement capability

Persistent Stare
- Small robot with autonomous navigation to perform recon and surveillance
- Utilize robotic rodeo to demonstrate vendor capabilities

Robotics Rodeo
- Input from Army needs (ONS)
- Demonstration of related state of the art technologies
- Provide user and SME feedback to industry

VOIED
- Capability for autonomous VOIED defeat
- Utilize robotic rodeo to demonstrate vendor capabilities

Defeat
Future Force Technologies

Robotics CTA – Technology for Near Autonomous Systems

Robotic Platform for Engineer Missions

MAST CTA - Small “Creatures for Urban Terrain”

Command & Control of Robotic Entities

Air-Ground Collaboration

Following, Awareness, SafeOps, and Tracking through IGS (fastIGS)
**PAST**
- Workload reduction
- Embedded crewstation

**PRESENT**
- Robotic control (mounted, dismounted)
- Driving aids (Soldier assist)
- Scalable, portable Interface

**FUTURE**
- Soldier monitoring and task assist
- Intelligent agents
- 360 degree situational awareness
Purpose: Incorporate actual hardware both fielded and prototypes using simulation, stimulation and emulation to test concepts and validate capabilities.

- Hardware In The Loop includes:
  - Vehicle Warfighter Machine Interface
  - Dismounted Controllers
  - FBCB2 and other ABCS
  - SoSCOE
  - Autonomous Control Algorithms

Partners:

- Robotic Systems Joint Project Office (RS-JPO)
- Cross Command Collaboration Effort (3CE)
- Natick Soldier Center – Infantry Warrior Simulation (IWARS)
- Night Vision Labs – Comprehensive Munitions and Sensor Server (CMS2)
- Modeling Architecture for Technology, Research and EXperimentation (MATREX)
ARL Robotics Research

Large
Man-packable
Micro

Robotics CTA
Micro-Autonomous Science & Technology CTA
## 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
- Johns Hopkins University

## 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
Sensors and Perception

**Exploration of novel sensor modes**

- **Novel LADAR** for small systems
- **Spectral LADAR**

...to expand applicability and enhance available information

**Moving Agent Understanding**

**Terrain Classification**

- Improved environmental understanding, especially for dynamic environments
  - Application of learning techniques

**Goal is fusion of multiple techniques to improve accuracy and robustness**

- In clutter & complexity

- Different postures

- Topologic maps

- Sensing Mud

- Road Features

- RGB

- LWIR

- Polarization

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
Examining methods for real-time planning and execution of complex missions

Integration of multiple planners for real-time operation

Planning with uncertainty

...and time constraints

Full implementation of multi-layer planning

Dynamic Replanning Example

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
Advances in Human Machine Interface

Scalable Human Machine Interfaces

... and Multi-Modal Input

... to reduce soldier cognitive workload
Unmanned Systems become another soldier in the unit:
highly capable with scalable attributes to meet mission requirements; requiring reduced communication and minimal soldier interaction; flexible, robust, and reliable; able to adapt fully to new & different tactical and environmental conditions; following commanders intent; effectively operating in mixed environments; able to “learn from experience; maneuvering unfettered in complex terrain; able to “live” in a world designed for humans, to grasp small objects, to open doors, or to carry the wounded.

• What missions will they conduct?
• What level of capability?
• What degree of autonomy will they possess?
• How will they work with soldiers?
• Or function in general society?
• How will they be used in Urban operations?
• In complex terrain?
• How will they navigate in GPS denied environments?
Topics for Future Perception Research

**Perceive & understand a dynamic & unknown environment**

- **Sensing**
  - Greater resolution & range, lower cost
  - Increased fields of view; focus of attention
  - Scale
  - All weather/environments

- **Terrain/Object Understanding**
  - Broader vocabulary
  - Recognition of cues/saliency of observations
  - Robust & adaptive
  - Reasoning
  - Fusion

- **Understanding activity**
  - Human activity/intent recognition
  - Saliency of observations/ context & cues
  - Learning

- **World model**
  - Managed & validated
  - Long-term & short-term memory
  - Collaborative or distributed
  - Common ground (HRI)
  - Navigation (Intelligence, mobility & manipulation)

- **Sensors**
- **Information Fusion**
- **Perception Algorithms**
- **All environments**
- **All scales**
- **Relevant world model**
Plan and execute military tasks & missions

Some potential research topics

- Learn & Adapt
  - Deductive reasoning
  - Inference
  - Generalization/Rules of engagement
  - Uncertainty of future conditions
  - Probabilistic reasoning
  - Spatial & temporal reasoning
- Self-awareness/introspection
  - Transparency
  - Providing non-verbal cues
  - Human-robot collaboration
  - Fault detection
- World model
  - Common ground
  - Mixed initiative
- Scale
  - Adapting to resource limitations
- Tactically intelligent behavior
- Collaboration between homogeneous & heterogeneous systems

Robust
Adaptive
Learns from Experience
Transparent
Seamless integration of robots into military & civilian activity

Some potential research topics
• Shared situational awareness
  • Aware of cultural and behavioral norms.
  • Comprehend commander’s intent & act upon it
  • Understand the intent of surrounding humans for consideration in planning
  • Possess common spatial & temporal frames of reference – a “common ground”
• Trust & Confidence
  • Transparency of action
  • Cues to activity
  • Tolerance to failure
• Intuitive Communication
  • Language – unconstrained dialogue
  • Non-verbal cues, gestures, context, & behavior
• Operating within society
  • Adaptable to varying social cues & context
• Span of control

• Effective Control of multiple systems
• Human-robot Teaming
• Seamless integration of robots & society
Summary

• **Unmanned Systems will have a major impact on future military operations**

• **The technology is still in its nascent stages – the Army has made a firm commitment to its development**

• **The first systems, albeit teleoperated are already impacting current operations**

• **The first systems with significant autonomy will be fielded over the next 5 – 10 years**

• **How the Army employs the technology will, as much as the technology itself, determine its future impact**