Robotics and Autonomous Systems (RAS)

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Outline

• Ground Vehicle Robotics & TARDEC
• Commercial vs. Military
• Connection to RAS Strategy
• Strategic Direction
• Enablers
• Current Efforts
• Discussion

"Little David"
Circa 1950s

The Birthplace of Army Ground Robotics
RDECOM’s Support to TRADOC and ACQUISITION

SHAPING FUTURE REQUIREMENTS (Far Term)
- Develop And Demonstrate Advanced Warfighting Capabilities
- Validate Operational Concepts with Analytical Engineering Capabilities

SUPPORT THE CURRENT FLEET (Near Term)
- Develop Technology Solutions
- Provide Engineering Support

PROVIDE NEW REQUIRED CAPABILITIES FOR CURRENT AND EMERGING SYSTEMS

ACQUISITION & SUSTAINMENT
- PEO GCS
- PEO CS&CSS
- MARCORSYSCOM
- PEO Land Systems
- ILSC

ADVANCED CAPABILITIES TO THE WARFIGHTER

INDUSTRY
Potential Applications for RAS: “Unmanned Systems as Team Members”

Reduce the Burden
- Robotic follower
- Optionally-manned vehicles
- Logistics re-supply
- Mundane tasks

Mitigate Risk
- Capabilities for C-IED
- Capabilities for CBRNE
- Active Safety Technologies
- Pilot Decision Aides

Prevent Surprise
- Unmanned Wingman
- All-terrain Surveillance
- 360 Situational Awareness

Manned - Unmanned Teaming

Operationalize unmanned systems through Experimentation and CONOP Development

Extend the Reach
- Single-user multi-robotic control
- UAV/UGV collaboration & control
- Extended range unmanned operations

UNCLASSIFIED/DISTRO A
Challenges for Fielding Unmanned Vehicles

**Cultural**
- Trust and confidence issues related to autonomous behaviors
- Concern added UAS/UGV capability equates to force structure reduction
- Potential return on a robotic investment not realized

**Moral**
- Responsibilities associated with the unmanned application of force

**Social**
- Incurious nature (lack of curiosity in a machine)
- Lack of comfort for people to operate in close proximity to machines

**Policy**
- Who is responsible and liable for an autonomous asset?
- DOTMLPF-P

**Technical**
- Machine Intelligence, Perception, and Reasoning
- Human/Unmanned System Interaction & Collaboration
- Scalable Teaming of Autonomous Unmanned Systems
- Test & Evaluation and Verification & Validation

Need to Leverage Commercial Sector
## Commercial Versus Military Comparison

### Understanding the Environment

**Commercial**
- Structured Environment
- Potential for Vehicle-to-Vehicle and Vehicle-to-Infrastructure assistance
- Benign, Permissive

**Military**
- Unstructured Environment
- Minimal Command & Control Infrastructure
- Adversarial & GPS Denied
- Off-Road: Incl Jungle/Bldgs/SubT/MegC

### Human/Unmanned System Interaction & Collaboration

**Commercial**
- Consumer acceptance/trust
- Affordability
- Structured Environment
- Accepted operator interface

**Military**
- Soldier trust
- Affordability
- Dynamic, Unstructured Environment
- Current interfaces degrade normal conduct of operations

### Scalable Teaming

**Commercial**
- Primarily individual vehicle systems or adjudication of multiple systems operating independently

**Military**
- Small unit teams including heterogeneous systems

### Testing and Experimentation Protocols

**Commercial**
- Liability 101

**Military**
- Unknown and dynamic conditions creates necessity for learning

### Flexible, Adaptable, Systems that Learn

**Commercial**
- Necessity for reliability and uniformity of response in structured environment limits requirement for learning

**Military**
- Unknown and dynamic conditions creates necessity for learning

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**Commercial**: large numbers, structured env.
**Military**: smaller numbers, dynamic & high OPTEMPO, makes risk
Why a Robotics and Autonomous Systems Strategy?

• TRADOC’s 2014 Robotics Research Study confirmed the utility of Robotics and Autonomous Systems (RAS) systems based on 14 years of war; RAS platforms provide vital human stand-off from dull, dirty, and dangerous tasks

• Most RAS procured through contingency funding... to become an enduring capability, the Army must transition to programs of record

• The **Army Operating Concept** lists RAS as an enduring capability that will:

  ✓ *Reduce risk to Soldiers and units*
  ✓ *Provide opportunities for increased efficiencies*
  ✓ *Provide differential advantages over U.S. adversaries*

The Army is developing a strategy to deliver RAS capabilities, rather than an itemized list of things to purchase – taking a similar approach with the Combat Vehicle Modernization Strategy.
Purpose:

- **Aligns** and prioritizes robotics and autonomous systems requirements across all formations
- **Describes** operational employment of RAS in Force 2025 and Beyond
- **Integrates** RAS as an increase in capability and a key to the Army’s *differential advantage* over adversaries

Vision:

RAS capabilities for *expeditionary maneuver* with forces that can:

- See and fight across extended distances
- Share situational awareness and promote operational understanding across all echelons
- Operate widely dispersed while maintaining mutual support
- Gain and maintain contact with the enemy to set favorable battlefield conditions
- Sustain high tempo operations at the end of extended and contested lines of communication
- Establish and maintain security across wide areas and pose enemy forces with multiple dilemmas *while reducing risk to Soldiers and units*

*RAS must enable Army formations to retain overmatch, support expeditionary and joint combined arms maneuver, and enable Army forces to win in unified land operations*
Framing the RAS Strategy in Three Phases

As the Army develops its Robotics and Autonomous Systems (RAS) Strategy seeks integration across multiple Warfighting Functions, the vision will show realistic capabilities in the near term, feasible capabilities in the mid term, and visionary capabilities for the far term. Each successive phase is linked and builds from the achievements of the previous phase.

**Near Term Capabilities**:
- Leader Follower Convoy Technology Employment
- Lighten the Soldier load
- Enhance stand-off from threats and improve situational awareness

**Mid Term Capabilities**:
- Technologies improve the autonomy of unmanned systems
- Technologies will enable unmanned cargo delivery
- Robots act as a “team mates” rather than tools
- Micro autonomous air and ground systems will also enhance Platoon, Squad, and Soldier situational awareness.

**Far Term Capabilities**:
Technologies will enable manned and unmanned teaming in both air and ground maneuver through investments in scalable sensors, scalable teaming, Soldier-robot communication, and shared understanding through advancements in machine learning.

Source for All Listed Capabilities: TRADOC Pam 525-3-1, Army Operating Concept, Appendix C-2.
Strategic Capability Progression

“Maturation, Integration, and Demonstration”

- Active Safety Driver Assist Appliqué Kits (2015)
- Unmanned Air Systems Autonomy (2020)
- Autonomous Convoy Operations (2020-2025)
- Extend the Reach of the Warfighter (2020)
- Synergistic Unmanned-Manned Intelligent Teaming (SUMIT) (2020-2025)
- Combined Arms Maneuver (2030-2035)
- Dynamic Force & Mission Autonomy (2030-2040+)

2020

2030

2040
Increase throughput & tempo with autonomous systems
Sampling of Autonomy-Enabled System Capability Demonstrations

**Capability Demonstration Purpose**

1. Familiarization of soldiers with DSAT technology for USASOC Soldiers.
2. Demonstrate use of a common controller to interface multiple vehicles for verification of IOP validity.
3. Demonstration of vehicle capabilities to SOCOM soldiers.
4. Operational Assessment of DSAT capabilities in Afghanistan.
5. Autonomous tactical resupply demonstration.
6. Table VI scout/gunery qualification demonstration with M240 armed (blanks, man-in-loop) autonomy-enabled system.
7. Multi-vehicle control from a single operator control unit, extending the range via mesh networking.
8. Engineering test on by-wire active safety kit.
9. ARCIC requested demonstration for identifying the realm of possibilities for unmanned systems.
10. Engineering test on autonomy kits.
11. Demonstration of higher truck speeds.
12. Provide vehicles to Soldiers & Marines for 8 weeks to use system in combat scenarios to determine if there is a military user assessment by COCOMS (CENTCOM and TRANSCOM).
13. Soldier testing for driver warning/driver assist for M115.
14. UGV Interoperability Profile demonstration at the NATO EOD CoE Demonstration and Trials Event.
15. Demonstrate the added capability resultant from merging unmanned air and unmanned ground systems with long-distance control capabilities.
16. Synchronized employment of Soldiers, manned and unmanned air and ground vehicles, robotics, and sensors to achieve enhanced situational understanding, greater lethality, and improved survivability.
17. Perform an extended duration RSTA mission with an autonomous marsupial vehicle and small UGV’s.
18. Demonstrate the ability to perform a high-risk mission at long distances without placing the Warfighter in harms way.
19. Technical integrator for TRADOC with MUM-T
20. Demonstrate ability to conduct extreme range tele-op
Teaming Technology Development

**Manned/Unmanned Teaming**
- Scalable/Joint Open & Modular Framework
- Scalable Autonomous Capability
- Human Machine Teaming Technology
- Enhanced Geospatial Information
- Autonomous M&S Capability

**UGV/UAS Teaming for logistic BCT**
- Large UAS/UGV Collaboration
- Enhance Long Distance SA
- Improved Testing Procedures

**Mounted Armed Wingman**
- Mounted Tactical Behaviors
- Robotic Weaponization
- Networked Engagement

**Robotic Weaponization**
- Unmanned Vehicle & Wireless Weapon Integration and Testing
- UGV Launched directed weapons
- Requirement Informing Experiments

**Assured PNT & Network Mission Command**
- An assured PNT system that is scalable and configurable for autonomous platforms
- Tools, protocols and architecture for networked autonomous systems

**Dismounted Squad UGV Maneuvers**
- Dismounted Tactical Behaviors
- Network and Mission Command
- Human Dimension

**Dismounted Soldier Deployed**
- Perception, Learning & Reasoning
- Human-machine interaction
- Interaction with the physical environment
- Dexterous manipulation & unique mobility
- Micro Mechanics, Electronics and Processing

**Soldier use of Micro UGV/UAS**
- Soldier Borne ISR
- Squad Organic Sensors
- Soldier Cognitive Science

**Human Dimension**
- Tactical Edge User Interface Concepts & Device Integration
- Cognitive Research and multi-modal displays/inputs
- Soldier and Squad In-The-Loop Interactive Assessments

**Technology Dependencies and Relationships**
**Technology Dependencies and Relationships**
- Mounted UAS/UGV Collaboration
- Mounted UAS/UGV Collaboration
- Human Dimension

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Enabling Capabilities

Pedestrian/Vehicle Detection, Classification, & Tracking

Autonomous Complex Dexterous Manipulation

Dynamics of Distributed Role Allocation in Teams

Modeling & Simulation

Autonomous Moving Object/Complex Terrain

Terrain Classification Technologies

Collaborating Socially, Organizationally & Culturally

Faster movement and terrain feature mapping through real-time adaptive learning

Interactively Understanding Situations, Contexts, and Activities

Plan Real-time Data Dynamic Re-Planning

Secure, Robust, High Speed, Low Latency Network enabling collaboration and compliant weapon systems autonomy
Example Enabling Capabilities

Plan

Real-time Data

Dynamic Re-planning

Interactively Understanding Situations, Contexts, and Activities
Plan Real-time Data Dynamic Re-planning

Interactively Understanding Situations, Contexts, and Activities

... Can assist soldiers as well

What fidelity and resolution is required in world map?

How is tactically relevant information passed back?
Example Enabling Capabilities

Pedestrian/Vehicle Detection, Classification, & Tracking

Faster movement and terrain feature mapping through real-time adaptive learning

Secure, Robust, High Speed, Low Latency Network enabling collaboration and compliant weapon systems autonomy
Autonomous Mobility Appliqué System (AMAS)

Purpose:
Provide tactical vehicles with an optionally manned capability to increase safety. AMAS develop, integrate, and demonstrate:
1. A vehicle-specific By-Wire/Active Safety kit to control the physical actuation of a vehicle.
2. A common, appliqué Autonomy kit that contains the primary intelligence and autonomous decision making. The Autonomy kit will function and inter-operate regardless of vehicle type.

Products:
- By-Wire Active Safety Kit: vehicle specific devices to retrofit current fleet
- Common Interfaces and Architecture
- Autonomous Testing Methodologies and Procedures

Payoff:
- Increased Operational Efficiency and Effectiveness
- Improved Situational Awareness
- Increased Driver Safety (reduce accidents/rollover avoidance)
- Improved Operations in no/limited visibility conditions
Purpose:
• Develop a suite of autonomy tools to enable dismounted soldiers to operate unmanned vehicles. Develop an open and extensible kernel for ground vehicle autonomy with Interoperability

Product(s):
• Operational and Performance Capabilities Summary
  • Fused Perception and World Model systems for advanced obstacle detection and avoidance
  • Optionally-manned Vehicles
    • Polaris MRZR
    • Jeep Rubicon
    • HMMWV
  • Multiple Modes of Operation
  • Advanced Communication
    • UWB low bandwidth C2
    • Rajant Radio higher bandwidth C2
  • Payload Integration
    • RSTA Sensors (CRADA)
    • “NATO Pallet” Payloads

Payoff:
• S&T Toolset for incremental development
• Feeder program for Autonomous Ground Resupply and Manned/Unmanned Teaming
Multi-UGV Extended Range

- Operational experiment to examine the feasibility of long distance operation of multiple unmanned vehicles deployed from an unmanned marsupial vehicle.
- Expand technical development in:
  - Soldier-robot interfaces
  - Multi-platform, long distance C2
  - Power, energy, and mobility requirements for long duration missions

Grayling II

- Utilize a UAV to deploy a UGV at remote locations without a soldier on the ground
- CBRN payload integration & mission execution
- Air Assault mission scenario
Discussion/Questions