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Autonomous Systems Overview

Harris Edge March 2017

The Nation's Premier Laboratory for Land Forces

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U.S.ARMY



RDECOM ARL Intelligent Systems Research



Enable the teaming of intelligent systems with humans



Focus on Army unique problem set

- Dynamic, unstructured environments
 - Active opponent & non-combatants
 - Unknown & potentially hostile
 - High operational tempo
- Lack of similar commercial market

Expand small unit sphere of influence - provide technology to enable:

- Greater level of autonomy for heterogeneous systems:
 - Ground, air, & surface vehicles
 - From micro-systems to combat vehicles
 - From single units to swarms of devices
- Teaming capability
 - Increased intelligence, modular behaviors
 - Shared situational awareness & trust



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RDECOM Director's Initiatives

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"Director's Initiatives. The RDECOM Director has identified several high-risk, high-payoff initiatives, which are defined in Appendix E. Each will provide the Army with a revolutionary new capability and, together, constitute Future State Demonstrations. The initiatives are informed by the changing nature of the strategic environment, TRADOC's highest priority capability gaps, ASA(ALT)'s Top Challenges, and the potential to provide a leap-ahead capability for the Soldier. Each initiative draws upon a wide range of RDECOM core competencies that require an enterprise approach, thereby focusing multiple RDECs and ARL efforts on high-priority challenges for the future. The RDECOM Director's Initiatives are:

• Expeditionary self-sustaining base camp

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- Long-range precision fires
- Counter unmanned aerial systems (UASs)
- Robotic team member
- Assured access to information"



Excerpt from "U.S. Army Research Development and Engineering Command Strategic Plan, Enabling Battlefield Dominance Through Technology — FY 2015 – FY 2040" page 14



RDECOM Director's Initiatives



"Robotic team member: Develop a robotic team member with the capability to provide logistics support, situational awareness, and direct and indirect fires for the small unit. This capability will include the ability to operate as a team member with minimal supervision by the Soldier. This will be accomplished through development and integration of novel mobility and manipulation technologies with sensors, fires, human-machine interface, and intelligent-processing technologies whose ultimate objective is to extend the situational awareness, survivability, and lethality of the Soldier and small unit."

Excerpt from "U.S. Army Research Development and Engineering Command Strategic Plan, Enabling Battlefield Dominance Through Technology —

FY 2015 - FY 2040" page 40

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Autonomous Systems Mobility and Manipulation Scope of Effort



What is Context of this Effort (Team/Individual, New/Ongoing/Concluding)?

This effort includes ARL internal research, Robotics Collaborative Technology Alliance (CTA), Micro Autonomous Systems Technology (MAST) CTA, and ARO sponsored research.

Robotics CTA: Carnegie Melon University, General Dynamics Land Systems, Florida State, Univ of Central Florida, Univ of Pennsylvania, Qinetiq North America, Cal Tech/Jet Propulsion Lab

MAST CTA: Univ of Maryland, Univ of California Berkley, Univ of Pennsylvania ,North Carolina A&T, Harvard, Cal Tech, Poli Milano.

ARO: Complex Dynamics and Systems and other projects ARL Internal Research: HRED, SEDD, VTD, WMRD Pursuing collaboration with DARPA

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ARL sponsors wide-ranging collaborative research conducted internally and with our collaborators (CTAs, MURIs, single investigator programs)



Scientific Foundations: What ARO or Other Academic Connectivity Exists?

 Most of the researchers have significant contributions to the relevant fields of mobility and manipulation including receiving relevant funding through ARO, AFOSR, DARPA, etc.
<u>Are there related efforts or connectivity to other ARL Directorates/DoD Agencies/others?</u>
Annual review of this program invites the participation of government organizations including all of ARL, many of the RDECs, NRL, AFRL, & DARPA

Unclassified **Robotics Collaborative Technology Alliance**



Technology to Enable Teaming of Soldiers and Robots for Small Unit Operations









Intelligence **Human-Robot Interaction** Reason, Learn, Plan, & Act Common view, Transparency, & Trust



Manipulation & Mobility Manipulate objects with near-human dexterity & maneuver in 3-D environments



California Institute of Technology

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QinetiQ



environments.



SBIR:

Advanced Programming and Teaching Interfaces for Autonomous System Control



Boston Dynamics Big Dog with Manipulator

Robot Programming with Real-Time Particle Simulation

Objective: Develop interface(s) to allow Soldiers to "teach" or program robotic manipulation and mobility through virtual simulation and through real-world demonstration (no need to write text-based code) which the robot can apply autonomously in various situations.

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Heterogeneous Teams of Humans and ARL Intelligent Machines

Vehicle Intelligence

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Solution through human-robot collaboration

Technology Focus

- Perception
- Learning & reasoning
- Human-machine interaction
- Interaction with the physical environment

Purpose:

• Enable effective teaming of humans and machines to resolve conflicts and provide relief in air, ground, and maritime environments

Products:

Underpinning science to enable:

- Fine grained understanding of situations, social cues, behaviors, and physical environment to support learning, reasoning, and behavior.
- Adaptive learning employing compact representations, adaptive on-line, "on-the-fly," interactive learning, for rapid reasoning, pattern recognition, dynamic locomotion, and manipulation.
- Effective, intuitive, bi-directional communication between humans and machines
- Interaction with complex 3-D environments to permit human scale and speed mobile manipulation & locomotion, understanding and movement through 3-D environments.

Payoff:

 Expanding the capabilities of humans to resolve problems through effective and efficient teaming with machines using natural dialog to communicate and minimizing the need for fine grained control of physical and software agents.

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Questions?