## Objectives

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

- Perceive and understand dynamic & unknown environments, including creation of a comprehensive model of the surrounding world
- Autonomously plan and execute military missions; readily adapt to changing environments and scenarios; learn from prior experience; share common understanding with team members
- Seamlessly integrate unmanned systems into military and civilian society
- Manipulate objects with near-human dexterity and maneuver through three-dimensional environments

## Technical Areas

- Perception
- Intelligence
- Human-Robot Interaction
- Manipulation & Mobility

### Alliance

- General Dynamics Robotic Systems
- Carnegie Mellon University
- Florida A&M University
- University of Central Florida
- University of PA
- Boston Dynamics
- QinetiQ North America
- Cal Tech/Jet Propulsion Lab
- US Army Research Lab
Plan and execute military tasks & missions

- 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

- Intelligence framework
- Cognitive reasoning & behavior generation
- Learning & Adaptation
- Meta-cognition & transparency
- Distributed intelligence & scaling

Intelligence framework
Perception

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)

- Sensing
  - Terrain and object classification, identification & reasoning

- Activity detection & Understanding

- Distributed & collaborative perception
Human-Robot Interaction

Seamless integration of robots into military & civilian activity

- 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

- Understanding human-robot intra-team cognition
- Multi-modal communication
- Collaborating socially, organizationally & culturally
Manipulation of objects with near-human dexterity & unfettered mobility in 3-D

- Human-like manipulation
  - Range of motion
  - Dexterity
  - Strength
- Control
- Efficiency
- Automation/Intelligence
- Close coupling of perception, planning, & control
- Mobility in complex three-dimensional environments
  - Urban
  - Jungle/Riverine
  - Confined spaces
- Animal-like adaptability to changing conditions - reconfigurable
- Learning from prior experience

- Dexterous manipulation
- Unique mobility
- Next generation actuation
Research to enable future autonomous unmanned systems

Provide technology to enable:
• Greater level of autonomy for:
  • Ground vehicles
  • Air systems
  • Surface vessels

Teaming:
• With soldiers
  • Combat multiplier
  • Team member
• With unmanned systems
  • Heterogeneous groups
  • Following commander’s intent

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