Distributed and Collaborative Intelligent Systems and Technology (DCIST)

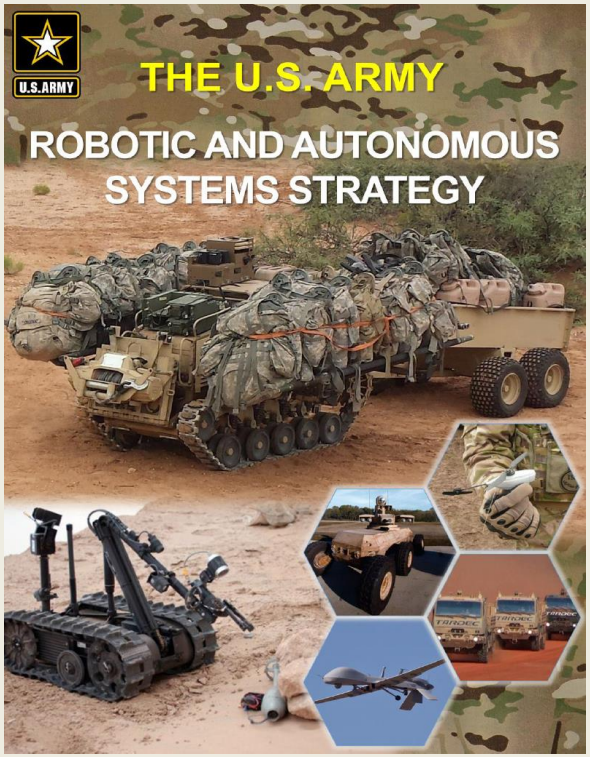
Collaborative Research Alliance (CRA)

Army/DCIST Priorities and Motivating Scenarios

U.S. Army Robotic and Autonomous Systems Strategy

Far-Term Priorities

- **Increase situational awareness** from swarming systems
- **Improve sustainment** with autonomous aerial cargo delivery
- **Facilitate maneuver** with advancements to UCVs

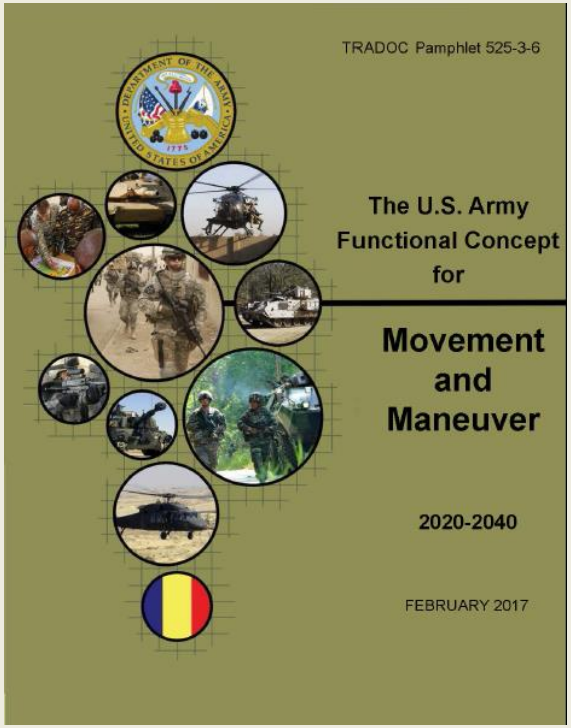


To **facilitate maneuver**, formations benefit from

- **Ground and aircraft robotic platforms working alone or in pairs** deep in enemy territory.
- UCVs **move and maneuver autonomously**, extending the effects of the manned-unmanned team.
- Technologies **enable manned and unmanned teaming in both air and ground maneuver.**
- RAS allow commanders to retain the initiative during **high-tempo, decentralized operations**.
- **Rapidly deployable RAS** capable of connecting mission command systems will **allow for mission command on-the-move.**
- RAS also increase **situational understanding in urban environments** through reconnaissance and mapping of subterranean systems.
- Expendable RAS platforms will provide commanders the **ability to take operational risks** previously unimaginable with solely manned formations.

Movement and Maneuver

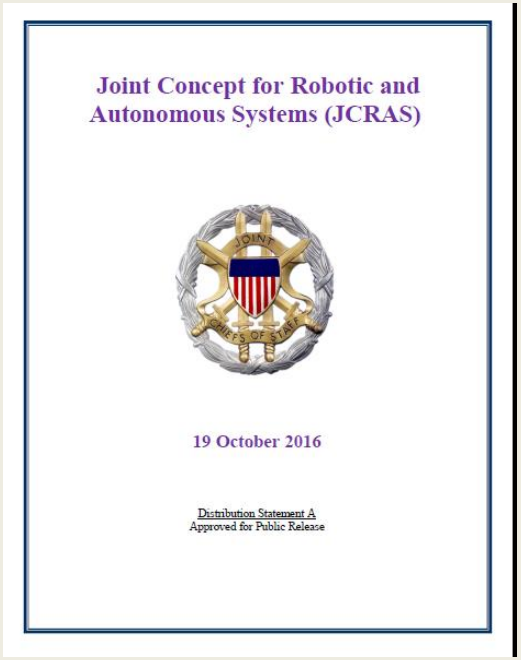
- **Units integrate emerging UAS, AI, robotics, and autonomous systems.**
- Autonomous unmanned robotic systems integrated into combat formations **allow the maneuver force from squad to the BCT** to reduce force density in conditions of uncertainty, extend the area and time of the formation operational effectiveness, and enable freedom of movement and action.
- The ability to assign tasks to UGS and **passively control or over watch multiple assets at the same time** is critical.
- Future systems are capable of a high degree of autonomous operation including the **decision analysis and execution of simple to advanced tasks without Soldier intervention**.
- **Advanced sensors and autonomous robotic systems teamed with Soldiers** allow formations to conduct continuous reconnaissance, early warning and to maintain enemy contact.



- A **swarm of autonomous unmanned systems** can be used for offensive or defensive missions to **overwhelm enemy platform** capabilities.
- Autonomous unmanned systems will respond to digital and verbal commands and **act as members of the squad or crew.**
- Autonomous unmanned systems will function as members of the formation **executing tasks as well as providing oversight for subordinate systems.**

JCRAS

- The JCRAS envisions a Joint Force that employs robotic and **autonomous systems teamed with humans across all joint functions**.
- Will employ **integrated Human-RAS teams in diverse combinations**
- This concept envisions highly-capable and interconnected **RAS into every echelon and formation**.
- **RAS evolve from tools** for basic tasks **into team members**.
- Advanced RAS with improved physical capabilities and machine cognition will have several advantages:
  - **Ability to learn, Greater situational awareness, Provide greater flexibility, Increase tempo by operating at machine speed, Provide potential to generate mass, and Enable distributed and dispersed operations.**

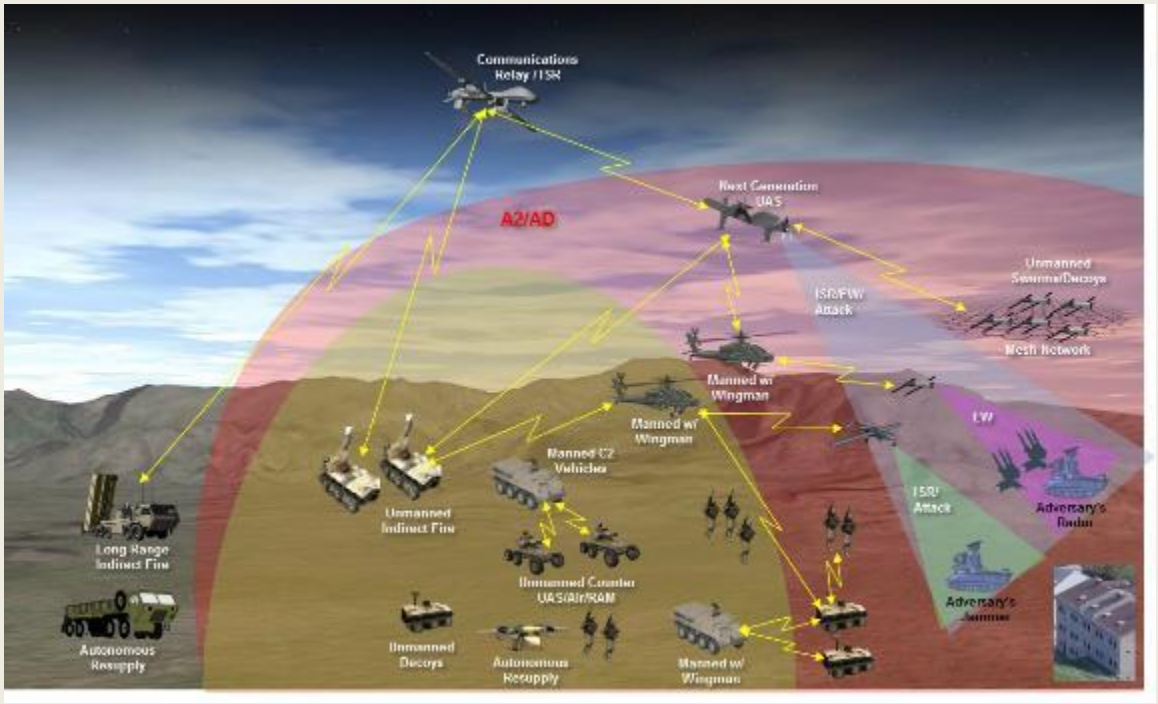

Joint Concept for Robotic and Autonomous Systems (JCRAS)

19 October 2016

Distribution Statement A
Approved for Public Release

- **Mission requirements** and the state of **technology** will **determine the composition** of Human-RAS teams - and Human-RAS ratios.
- The **relationship will range** from support of humans, to teaming with humans, to autonomous cooperative behavior. Humans retaining overall responsibility for mission accomplishment.
- Future **RAS will range** from very capable and expensive to low-cost expendable systems
- Joint Force commanders and planners **must understand the unique capabilities, limitations, and advantages of RAS** to develop innovative concepts of operations (CONOPS).

Future Multi-Domain Battle

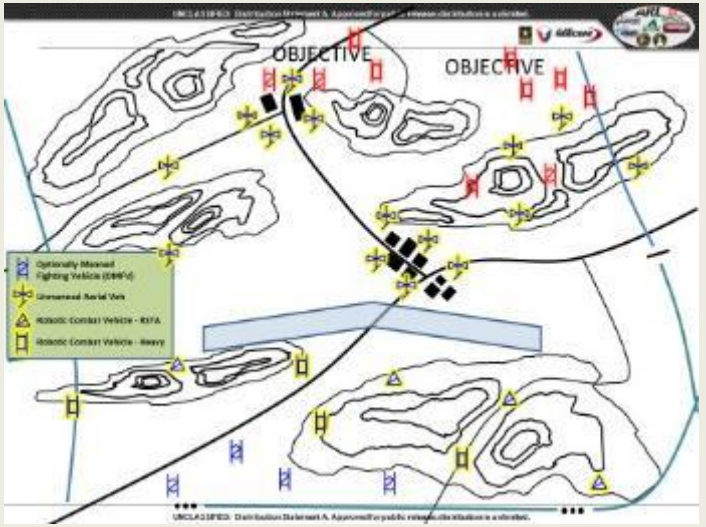


Manned-Unmanned Teaming Concepts

Underlying Assumptions

- Large #'s of agents – **10s to swarms**
- **Heterogeneous** mix
  - Large/Small
  - Air/Ground
  - Soldiers in multiple roles
- Highly **collaborative** systems
- Highly **distributed** systems
- Access to **knowledge sources** and increased perception and awareness
- Increased cognitive behaviors and real-time op-tempo (at the **speed of battle**) **adaptable** operations
- Operation in complex and contested environments – **adversarial capabilities**

DCIST Motivating Scenarios:



Mounted Manned/Unmanned Maneuver over Terrain to Contact:

- Mounted **Soldiers interact** with unmanned systems **through manned crew stations**
- Large numbers of heterogeneous unmanned **ground and air assets collaboratively maneuver**
  - Globally distributed over large areas and large terrain features
  - Locally varying terrain and with intermittent contact with enemy forces and obstacles
  - Zone reconnaissance conducted over a large areas to inform the larger maneuver force
    - Local and global situational awareness
  - Decoy operations performed to cover intent/Rapidly employ mass to overcome adversaries
  - UAS provide over watch, distribute sensors, and provide communication nodes
  - Tactical computing and reach back to knowledge sources likely
- Larger UAS/UGVs may **provide autonomous resupply through** cleared corridors

How does DCIST basic research scale and inform this level of maneuver?

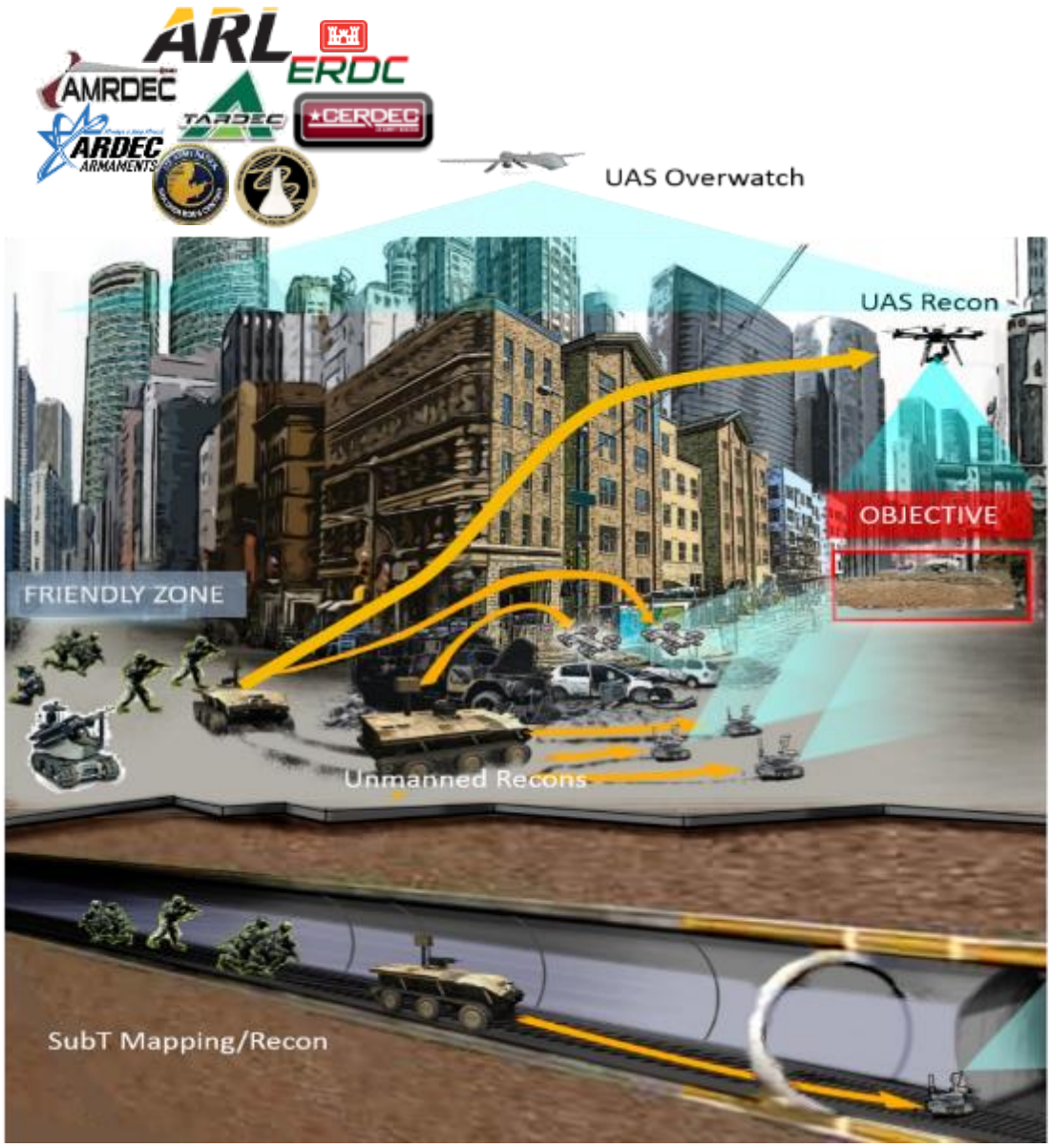
DCIST Motivating Scenarios

<u>RAS Enhanced Dismounted Unit Maneuver Through a Contested Dense Urban Area</u>:

- Dismounted Soldier and Intelligent systems interact at varying levels from tools to teammates
- Human-RAS Units collaboratively move through dense urban areas
  - Collaboratively indoor/outdoor map, identify, and track threats covering several blocks to full city
  - Highly dynamic and complex 3-Dimensional environment including subterrean
  - Close and rapid contact with enemy forces – Peer level capability with ability to deny infrastructure
  - Incorporation of increased # of expendable operations and assets
  - Unmanned systems may provide short haul autonomous aerial resupply, distribute sensors, provide communication nodes over narrow corridors.
- Human-RAS Units collaboratively provide
  - 360 on-the-move situational awareness; unit or location perimeter surveillance; provide deception and protection; swarming to overmatch adversary; dismounted breach operations; etc.

How does DCIST basic research enable operation in this complex environment?

Dismounted Robotic Breach



Tactical Scenario: Dismounted infantry tasked to seize a fortified crossroads in contested urban environment augmented by an organic heterogeneous mix of air/ground unmanned assets controlled by the infantry via tablet/speech recognition with tailorable, multi-mission capability.

- Screen dismounted elements
- Provide AP/command-wire route clearance
- **Conduct initial air/ground/SubT mapping, and perceive population dynamics (Super surface, Surface, and Sub surface)**
- Map / establish communication networks / fuse data /enable JBCP
- **Provide situational awareness of obstacles, threats, and population dynamics (augmented reality)**
- Enable obscurants and serve as remote weapon stations providing both covering fire and concealment allowing placement of an unmanned breaching charge or unmanned physical breach.
- Unmanned remotely weaponized systems are the first elements through or around the breach to secure the flanks prior to seizure of the objective by manned assets.
- Autonomous short haul Aerial/ground resupply upon consolidation
- CASEVAC

Axes of Complexity

Factors that limit operational capability:

- Complexity of the physical environment and prior access or knowledge of the environment
- Availability of supporting infrastructure
- Operational tempo
- Ability and presence of peer adversaries

Factors that complicate design & operation:

- Number of agents
- Degree of heterogeneity of the agents
- Agent complexity and adaptability
- Degree of communication among agents (both machine and human)

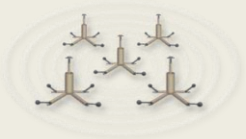
The Army challenge: complex unknown environments, little or no infrastructure, and high operational tempo.

Intelligent System Components S&T Needs and Gaps

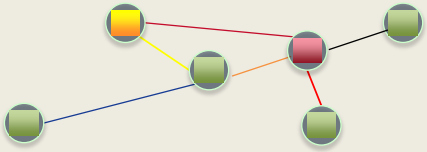
Control

Autonomy / Swarms

Soldiers, Medics, First Responders



Sensors



Network

Semantics

Knowledge Bases & HPC

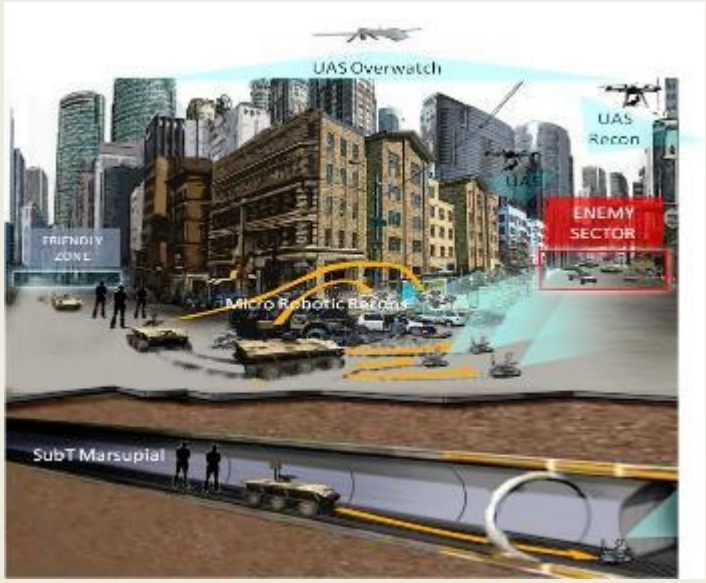
Experts

- Sliding levels of autonomy
- Systems with adaptive and multiple roles
- Sliding levels of control – centralized to decentralized
- Self deploying infrastructure
- Local/global perception

- Humans at multiple levels of interaction
- Faster than human decision making
- Varying levels of computing power
- Local/global adaptive mission control
- Perception-Action-Communication loops

DCIST
S&T Needs and Gaps

- **Hierarchical and composable representations**
  - Where abstraction and hierarchy are dynamic and determined by the task at hand
- **Asynchronously fuse inferences**
- **Perception-Action-Communication loops**
- **Reasoning and adapting to change**
  - Sliding levels of autonomy & adaptive roles
  - Sliding levels of control architectures
  - Self deploying infrastructure



- **Autonomously synthesize mission objectives into team action plans & tasks**
- **Extend emerging techniques for AI/ML to**
  - Hierarchical and compositional learning
  - Learning across heterogeneous platforms with varying representations
  - Cognitive learning compatible with human representations
  - Combine with data driven approaches for on-line op-tempo operations

How do diverse, embodied agents collectively sense, infer, reason, plan, and execute in face of a peer adversary?

DCIST CRA

- DCIST is critical to realizing these scenarios
- The Army relevant scenarios, axis of complexity, and S&T gaps should be motivating drivers to focus and shape DCIST research
- You are a critical partner in identifying and pursuing innovative solutions
- Good fundamental science leading to understanding of the underlying problem spaces and pursuit of innovative solutions are essential and the principal goal of the program
- Experimental proof of concepts and transition to or informing 6.2+ programs and stakeholders is necessary to extend the program