U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMY RESEARCH LABORATORY

Human Autonomy Teaming & the Information for Mixed Squads Laboratory

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Soldier-Guided Adaptation Thrust Lead, Human Autonomy Teaming ERP

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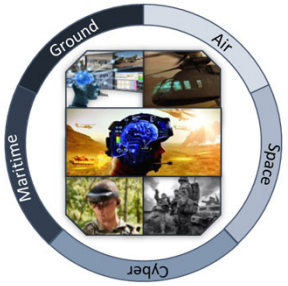
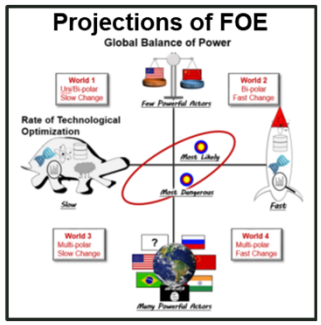
CHALLENGES IN FUTURE OPERATING ENVIRONMENT

Overwhelming Soldier's Capabilities to Decide and Act

Increases in technological sophistication, expanding operational scope, and narrowing time windows of opportunity are greatly exceeding projected future human capabilities.



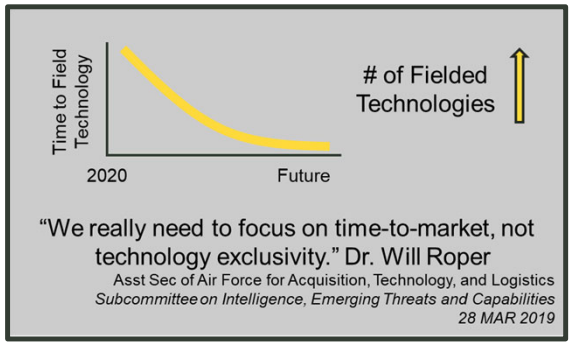


Constant Technological Change

Dramatic decreases in time to field new technologies combined with in-field learning is creating unforeseen emergent capabilities for friendlies and adversaries.

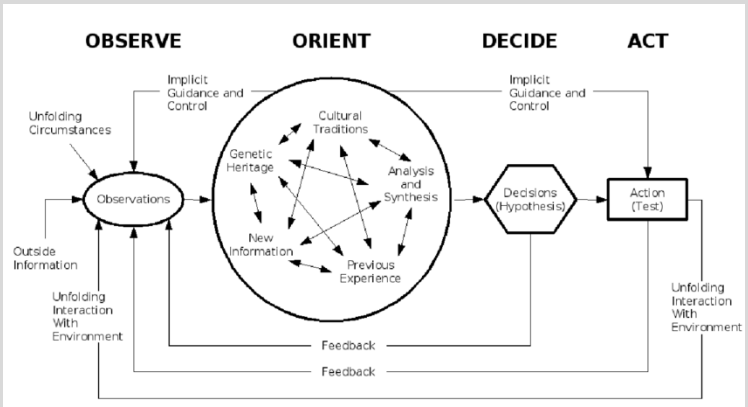
Greater Battlefield Intelligence

Non-human intelligence is increasing exponentially. Attempts are being made to substantially increase human intelligence in some areas of the world



Exploit differences in the abilities of humans and machines to create ultra-capable military systems to perform ***any*** mission and adapt to ***any*** situation

THE NEED FOR CONTINUOUS ADAPTATION



OODA Loop: Decision making process for combat operations; OODA guides how to focus attention to defeat an adversary and survive (Col. John Boyd).

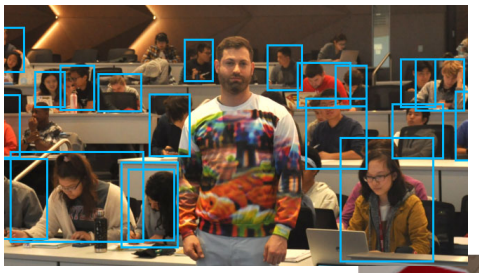
How do we integrate autonomy with Soldier teams to maximize combat output?

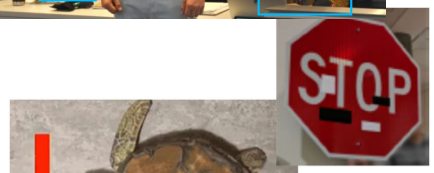
Simple Environment (Non-military)

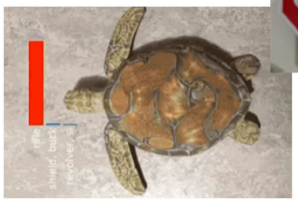
- Static / unchanging rule sets
- Known and unchanging autonomy capability

Focus on bi-directional communication and improving base AI capability to get inside the adversary's OODA loop

Complex Environments / Military Environments (FOE)



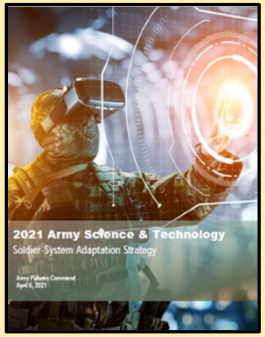




- Dynamic rule sets
- Adversarial activity could drive regular changes in autonomy capability
- Adversarial attacks will cause break downs in the OODA loop
  - Best case → stop decision making process
  - Worst case → drive decisions to create unfavorable situations

Much of the discussion about AI focuses on developing capability to get inside the adversary's OODA loop.

The Army must **ALSO** focus on rapidly **ADAPTING** capabilities to restore our own OODA loop when disrupted!

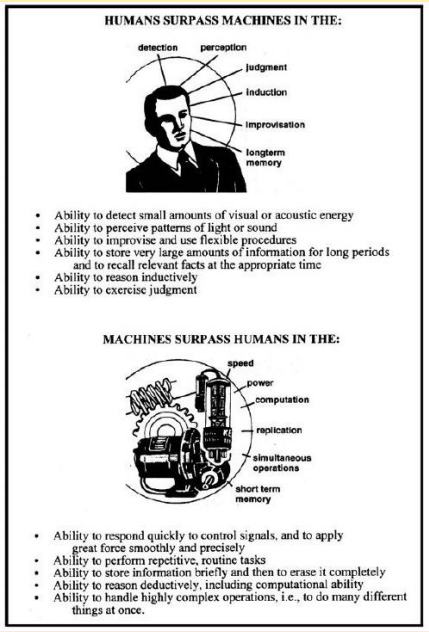


AFC Soldier System Adaptation Strategy

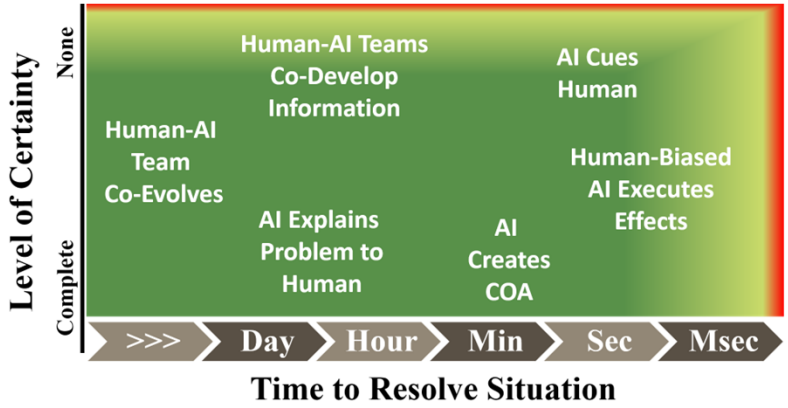
RECONCEIVING HUMAN-AUTONOMY TEAMING

Typical Problem Framing for HAT

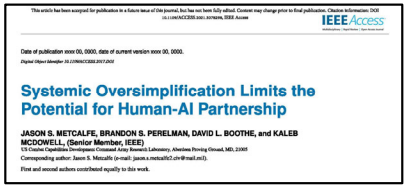
"Who gets what job?"



What interaction modes are needed to maintain the broadest range of operational capability for the Soldier-Autonomy / AI team?



Consider Soldier-Autonomy interactions as evolving relationships over time


IEEE Access

Systematic Oversimplification Limits the Potential for Human-AI Partnership

JASON S. METCALFE, BRANDON S. PERELMAN, DAVID L. BOOTHE, and KALEB MCDOWELL, (Senior Member, IEEE)

J. S. Metcalfe et. Al , "Systemic Oversimplification Limits the Potential for Human-AI Partnership," in *IEEE Access*, doi: 10.1109/ACCESS.2021.3078298.

RESEARCH THRUSTS

Faster than Human Decision-Making ⟷ *Constant Technological Change*

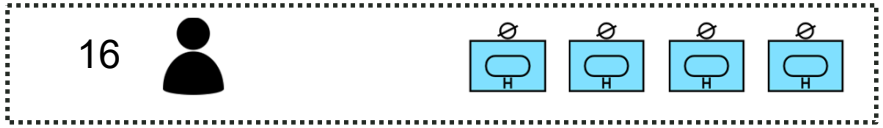
TEAM RESOURCE ALLOCATION	SOLDIER-GUIDED ADAPTATION	TEAM ASSESSMENT	CROSS-MISSION TEAM EVOLUTION
Algorithms and methods to dynamically allocate tasking across a team of Soldiers and systems based on the current state of the team, environment, and mission to provide resilient operational capability in response to changing events	Machine learning methodology that enables Soldiers to rapidly train and adapt autonomy in the field, to function effectively in Soldier-autonomy teams under new or changing situations	Technologies that enable specific military, science, and engineering expert stakeholders to process, visualize, and manipulate mission data in order to assess Soldier-Autonomy performance	Technologies for after action review and mission planning that maximize the value of time and information between missions, to optimize team interactions and ensure more robust and effective teaming
			

Goal: Enabling capability beyond what either the Soldier or Autonomy can do on its own!

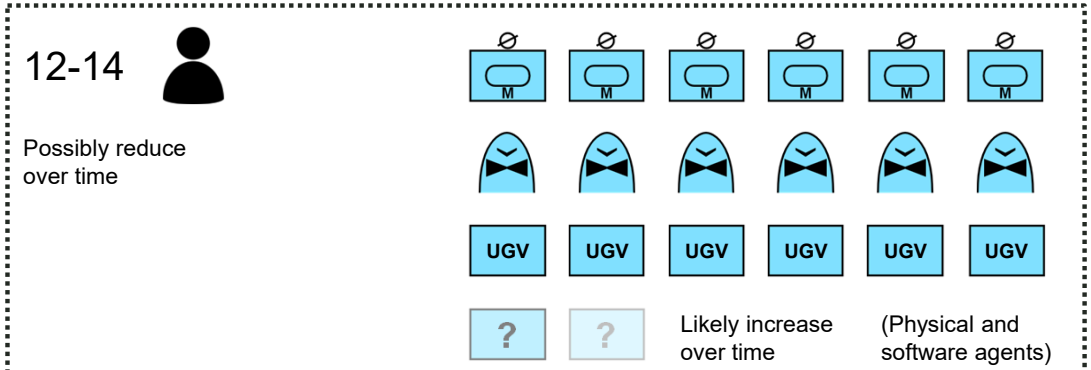
TEAM RESOURCE ALLOCATION

Working at Reduced Crew-to-System Ratios – The number of Soldiers available to control each system will significantly decrease compared to legacy platforms.

Legacy Platoon



NGCV Platoon



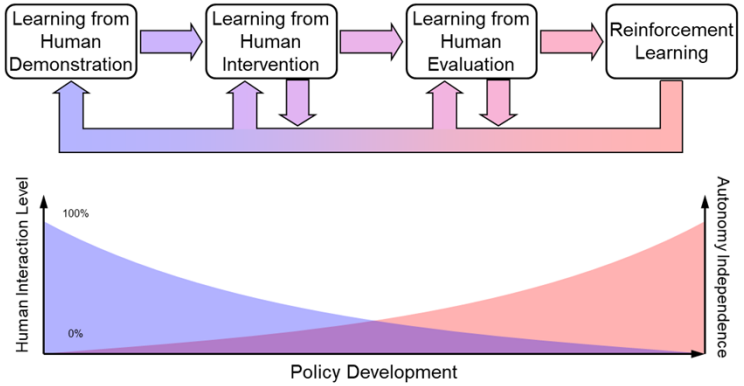
- **Crew-to-system ratio could change by more than a factor of 3 compared to legacy platforms**
  - 4:1 for Abrams compared to less than 1:1 for NGCV
  - Continue to decrease as new capabilities/assets are fielded
  - Includes physical (ex: UAV) and software (ex: ADS) agents
- **Mitigate Soldier control and oversight burden**
  - Should not result in poorer performance
- **Take advantage of increased combat power (and windows of opportunity)**
  - Utilize new capabilities to greatest effect

Army approach has to:

- Function at reduced crew-system ratio
- Apply assets intelligently to mitigate burden and increase effectiveness
- Integrate complex/dynamic asset and mission information for decision aides
- Support rapid team reconfiguration
- Leverage Soldier actions to adapt and incorporate new technologies
- Reduce reliance for AI/ML expert-(re)design of strategies and plays

SOLDIER GUIDED ADAPTATION

Improving Autonomous System Adaptability - Learn different mechanisms for humans to rapidly guide machine learning/AI development in mobility, target acquisition, and decision support.

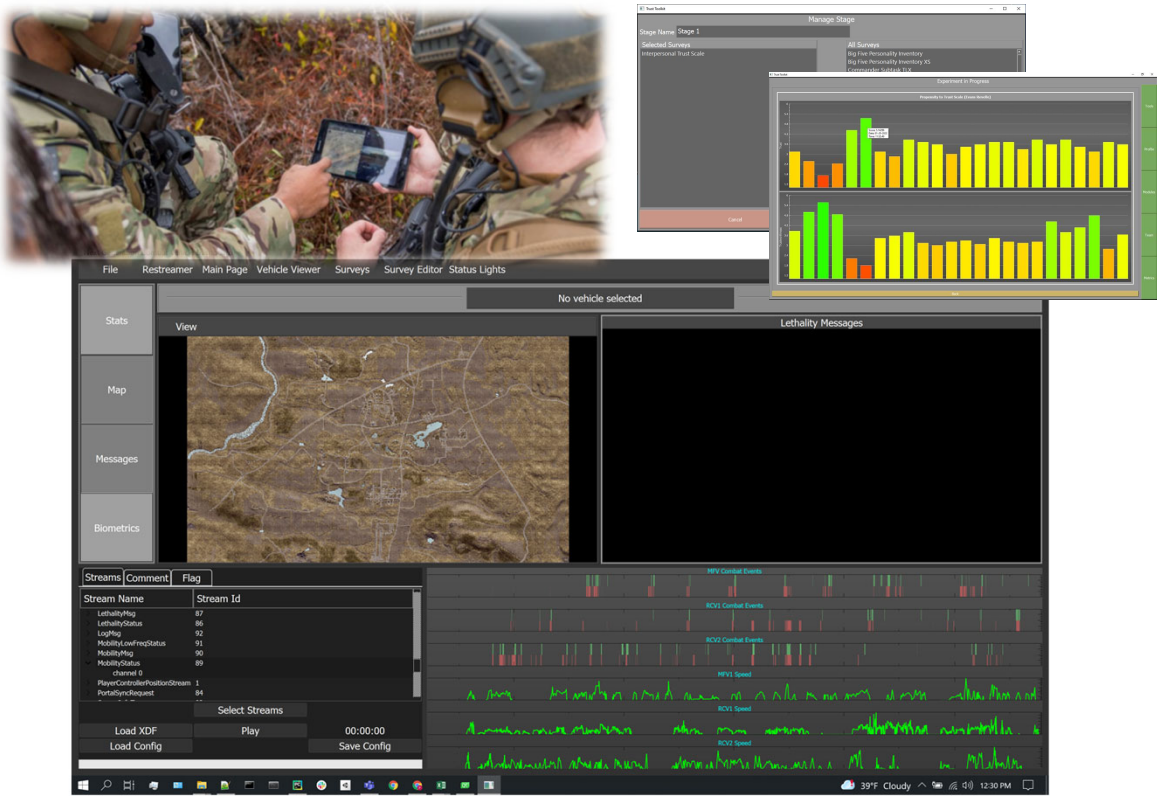


Army approach has to:

- Require less data
- Reduce need for labor intensive data labelling / processing
- Allow for must faster retraining time
- Not require experts
- Apply to different forms of Autonomy/AI

TEAM ASSESSMENT

Assessing Human-Autonomy Teams – Future military working teams will consist of humans, mounted vehicles, robots, AI decision support tools and other types of agents.



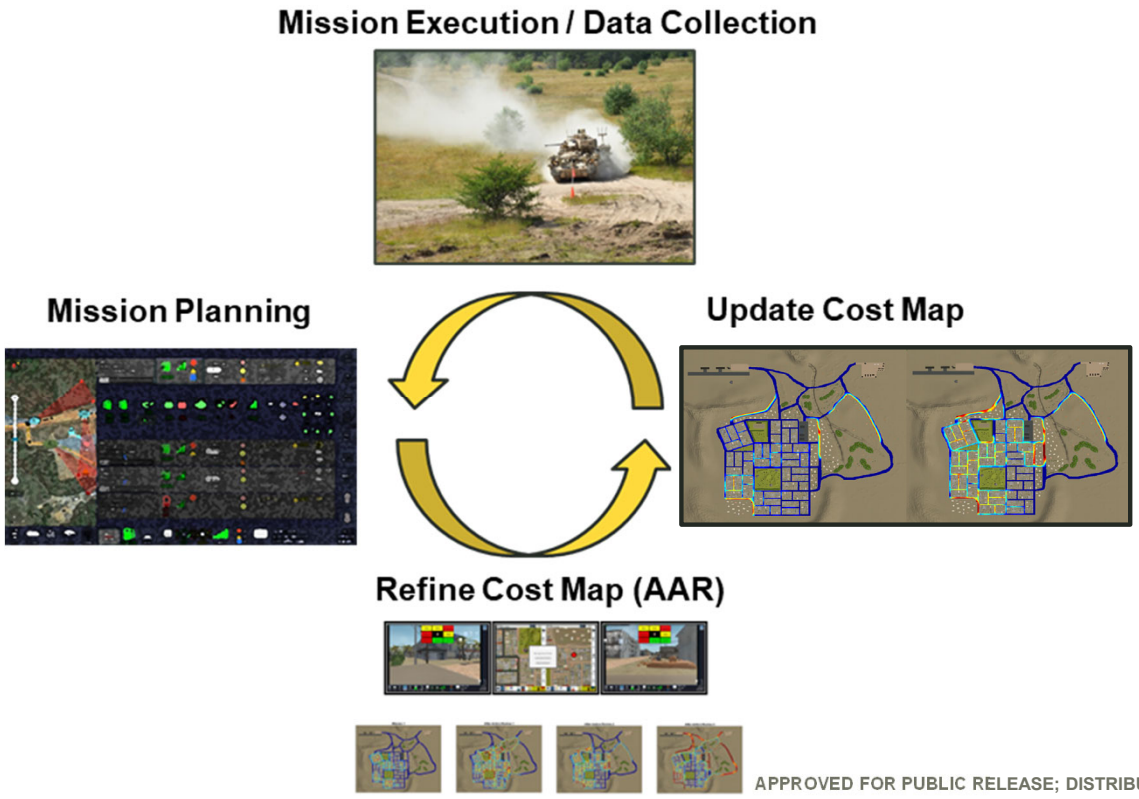
- **Future military working teams will consist of humans and non-human intelligent agents**
  - Decision-making capacity shared with machines
  - Individual aptitude insufficient to characterize team performance
  - Assessment must consider team interaction dynamics
- **Assessments conducted with multiple expert input**
  - No single expert has breadth of expertise to accurately assess team – requires input from military, scientific, engineering stakeholders
- **Continuous assessment to drive adaptation**
  - Continuous assessment at the edge provides commanders with ability to mitigate performance decrements during operations

Army approach has to:

- Support assessment with incomplete data / under conditions of uncertainty
- Use unobtrusively-sensed data
- Function continuously to drive adaptation
- Incorporate measures / assessments from multiple critical / expert sources
- Capture interaction dynamics, not just individual ability
- Account for individual and joint human-agent decision making

CROSS-MISSION TEAM EVOLUTION

Making Sense of Complex Data – Future human-autonomy teams will produce large complex data sets. How can we use this data to maximize value of time / information between missions?



- **Human-autonomy teams have the ability to produce massive amounts of highly complex data**
  - Currently these data sets are too complex to be actionable
  - Future tools must dimensionally reduce / process this data in order to produce useful mission planning products
- **Teams must evolve their capabilities / grow as organic unit over time**
  - Human-human teams learn from one another, compensate for strengths and weaknesses, and are flexible to absorb changes in composition.
- **Mission plans must account for novel METT-TC factors introduced by AI, autonomy, and robotics**
  - Mission plans presently account for mission, enemy, *troops available*, time, terrain, and civil considerations. Emerging technologies will introduce additional sources of variance that must be captured.

Army approach has to:

- Digest high-dimensional complex data and present it in a way that is understood by Soldiers
- Leverage unobtrusively / opportunistically collected data from the mission
- Enable both humans and technology to learn from prior mission experience / AARs

INFORMATION FOR MIXED SQUADS LABORATORY

First-of-its-kind Lab for Future ‘Louisiana Maneuvers-Style’ Experimentation

All-Phase Human Autonomy Teaming:

- *Mission Planning* technologies that account for human-AI interactions and performance
- Novel human-AI collaboration during *Mission Execution*
- Data collection and annotation during *After Action Review*
- Human-AI adaptation technologies expedite retraining in *Consolidation* before the next mission

NGCV-Focused Naturalistic Experimentation:

- 14 crew stations for *Platoon Experimentation*
- Same *NGCV Control Interface* as real vehicle
- Unscripted *Red Teaming* vs. human OPFOR
- Opportunistic / unobtrusive *Data Streaming*
- *Realistic Scenarios* enable crew to execute offensive, defensive, security, and recon ops