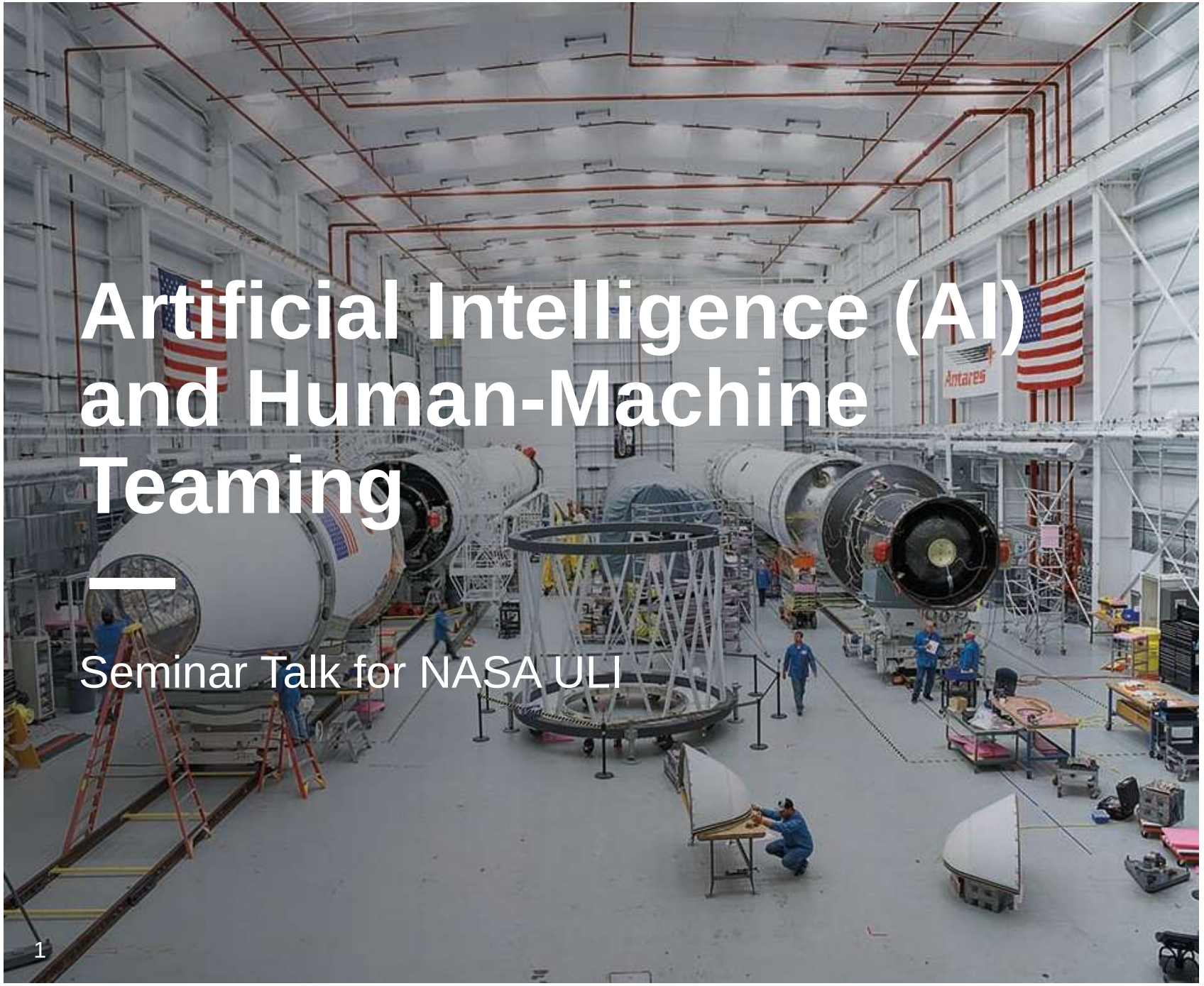

Artificial Intelligence (AI) and Human-Machine Teaming

Seminar Talk for NASA ULI

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Senior Manager of Strategic Planning

Oct 2020

Northrop Grumman Today

Leading global security company

$33.8 billion sales in 2019

- 85% U.S. / 15% International

$64.8 billion total backlog

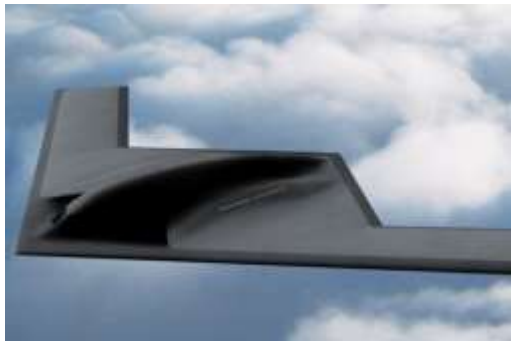
(as of December 31, 2019)

~90,000 employees

Leading capabilities in:

- Autonomous Systems
- Cyber
- C4ISR
- Space
- Strike
- Logistics and Modernization

Focus on Growth and Performance



Four Operating Sectors at a Glance

Aeronautics Systems


Autonomous Systems

Aerospace Structures

Advanced Technologies and Concepts

Aircraft Design, Integration and Manufacturing

Long-range Strike

Multi-Domain Integration and Operations

Intelligence, Surveillance and Reconnaissance

Battle Management

Defense Systems


Integrated Air & Missile Defense

Defensive Cyber and Information Operations

Platform Modernization and Fleet Operations Support

Advanced Weapons

Precision Munitions

Software Systems Modernization and Sustainment

All-domain C4I

Propulsion Systems

Mission Systems


Airborne Sensors and Networks

Artificial Intelligence/Machine Learning

Cyber and Intelligence Mission Solutions

Navigation, Targeting and Survivability

Maritime/Land Systems and Sensors

Engineering & Sciences

Emerging Concepts Development

Multi-domain C2

Agile/DevSecOps Systems

Space Systems


Launch Vehicles

Propulsion Systems

Commercial Satellites

Military and Civil Space Systems

Science and National Security Satellites

Human Space and Advanced Systems

Space Components

Missile Defense

Space Exploration

Space ISR Systems

Artificial Intelligence Campaign

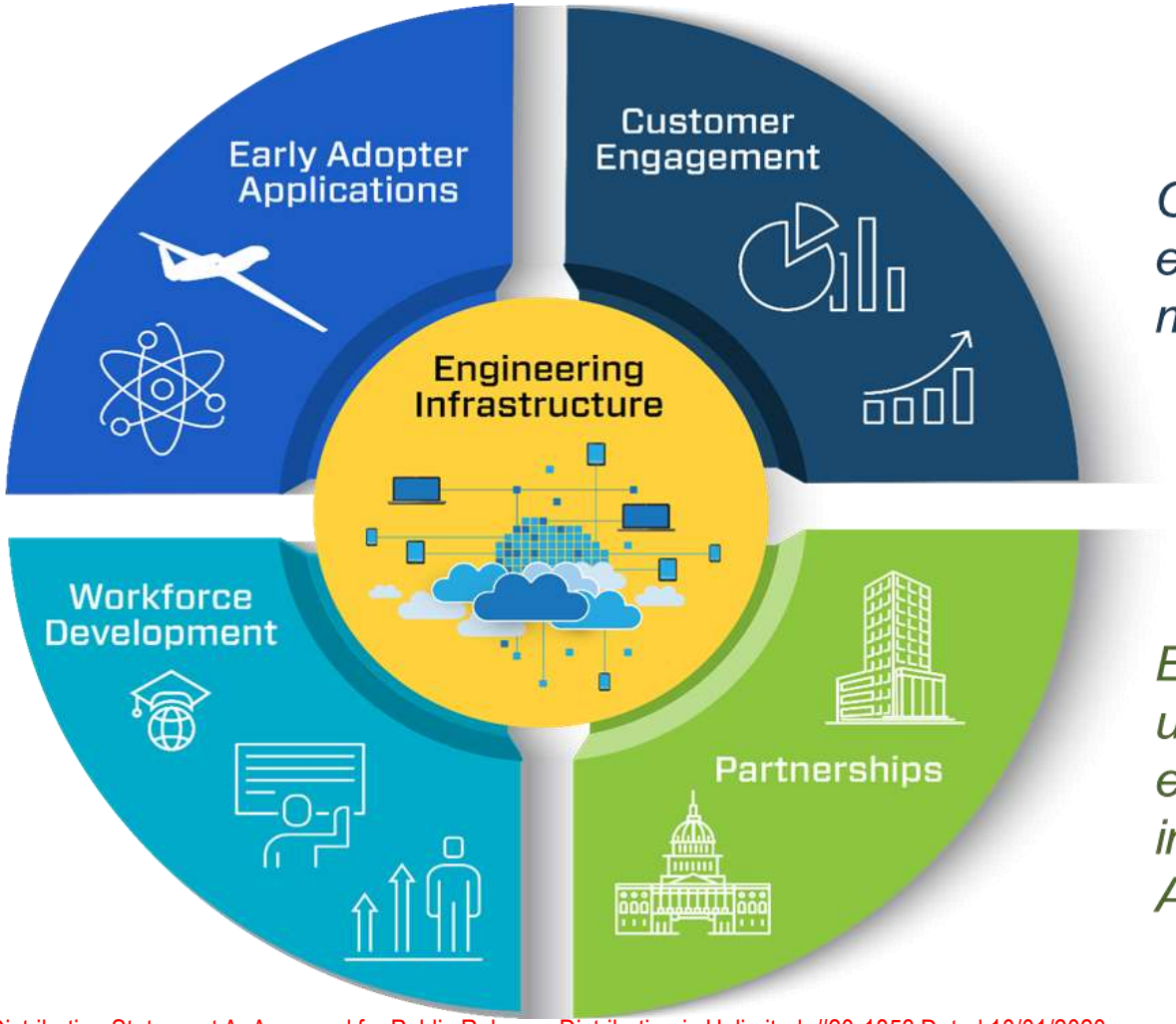
Goal: Accelerate the adoption and integration of Artificial Intelligence technology into Northrop Grumman offerings

Early Adopter Applications

AI Integration into Northrop Grumman offerings, expand existing programs and create new flagship programs

Workforce Development

Develop a world class mission focused AI workforce



Customer Engagement

Coordinate customer engagement and AI messaging

AI Ecosystem

Expand industry and university partnerships, establish AI infrastructure, expand AI development toolkit

Accelerating AI Integration

2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025

AI Augmentation

TRL 5 — Lab demo — TRL 7 — Live tests — Operationally ready — TRL 8/9

Upgrade and improve current platforms and mission systems

Tactical Air

HALE

Attritables

Selection Criteria *(more near term):*

- Built upon existing Northrop Grumman footprint (mission systems or platform)
- Customer interest in AI technology insertion
- Focus on Customer Programs of Record

Maritime

C2

Intelligent Autonomous Systems

Create new class of platforms and mission systems

Multi-domain swarms and automated COA/C2

Selection Criteria *(more long term):*

- Executing or capturing CRAD relevant to future systems ***(Customer funded)***
- Customer-identified need for systems in future ***(Likely transition program)***

Human-Machine Teaming (HMT)

Achieving the Right Balance of Human and Machine Capabilities

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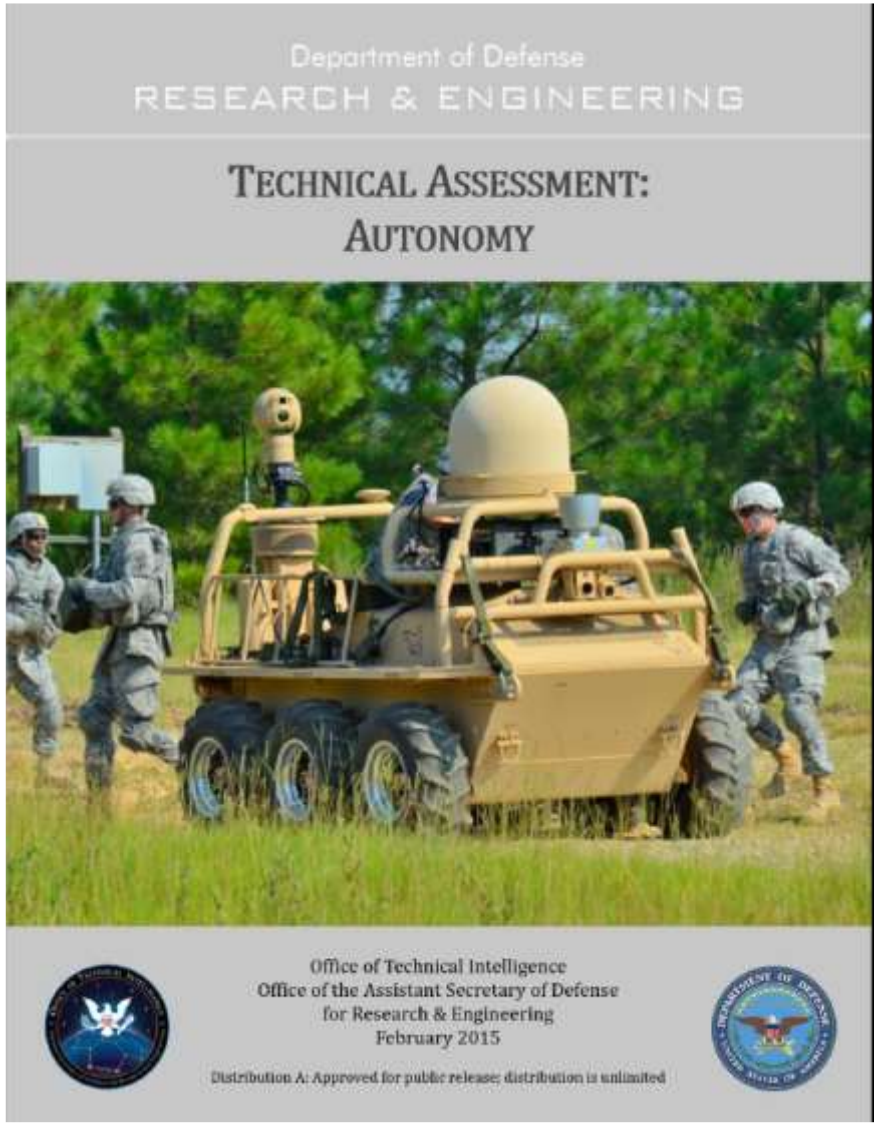
Human-Machine Teaming: Humans and artificial intelligence (AI) integrated and collaborating within high-tempo, complex decision-making environments to provide significant mission performance improvements over that which humans or machines can achieve alone.

- Automate mundane, repetitive tasks
- Integrate data sources to extend knowledge
- Deliver information on demand and in *anticipation* of needs
- Augment human decision-making
- Secure/mitigate against bias and deception
- Maintain confidence and appropriate trust
- Adapt to context and user

Expanding Current Capabilities



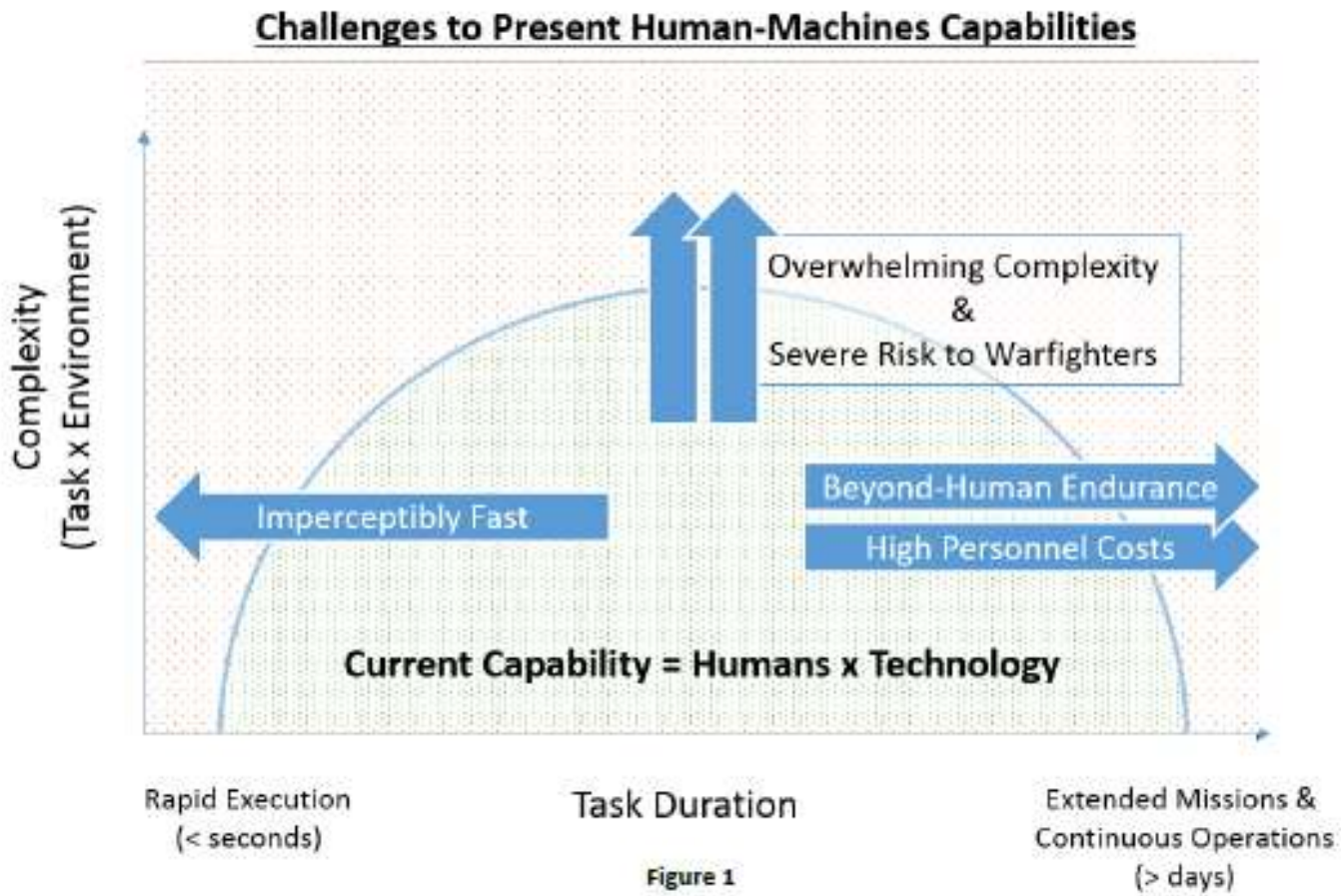


Figure 1

HMT Examples

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Example 1: Swarm/Formation Alert

Challenges:

Sensors create thousands of maritime tracks each day

Analysts need to detect swarms/formations and anomalous behaviors that threaten protected assets

Detecting these potential threats in the clutter of tracks is difficult for the unaided human eye

Hours of monitoring for rare events can lead to fatigue and loss of vigilance

Swarm/Formation Alert

Radar/Fused Display without AI

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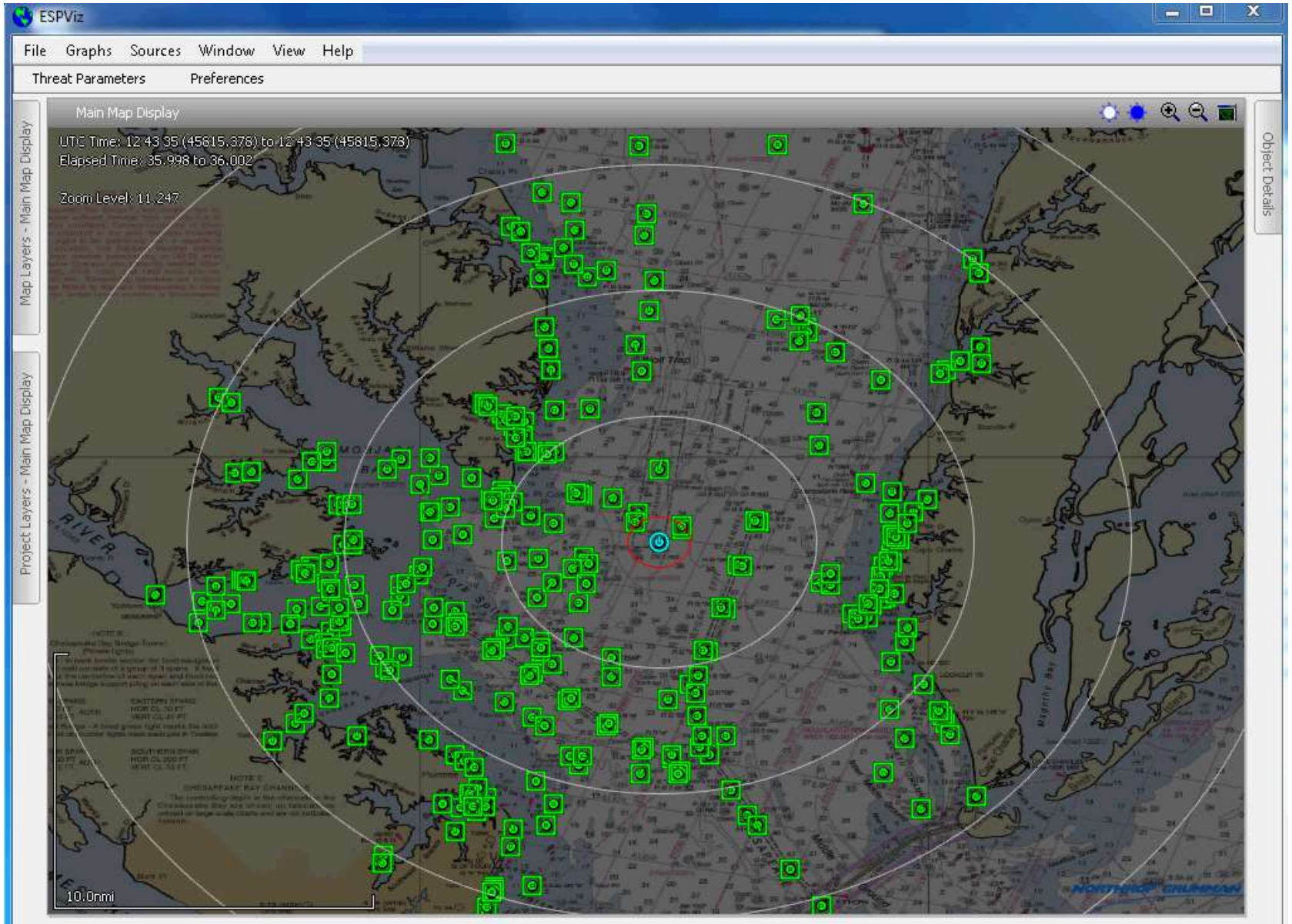

Swarm/Formation Alert

Radar/Fused Display with AI

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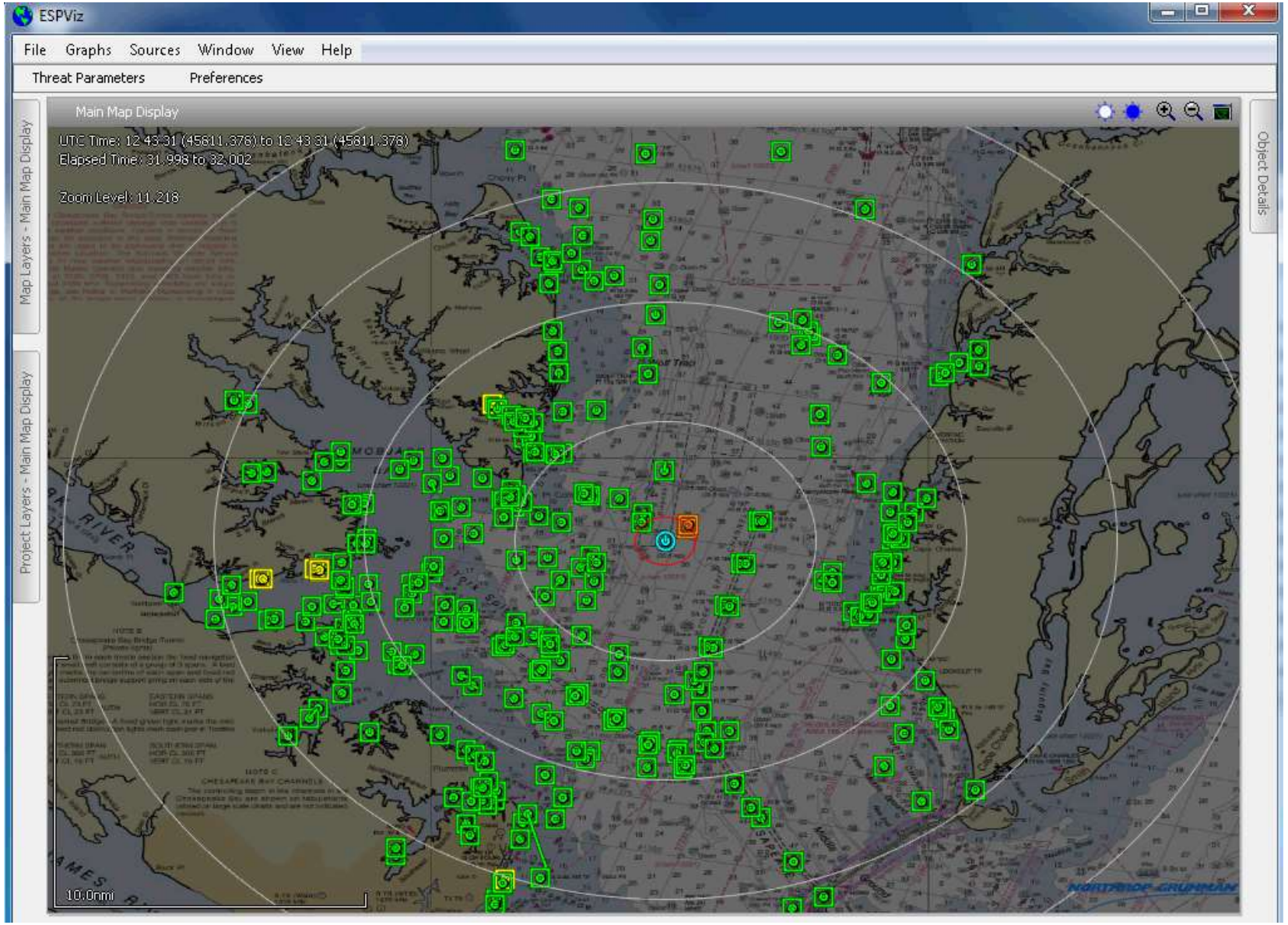

Formation/Swarm Display

40% more time to make a decision

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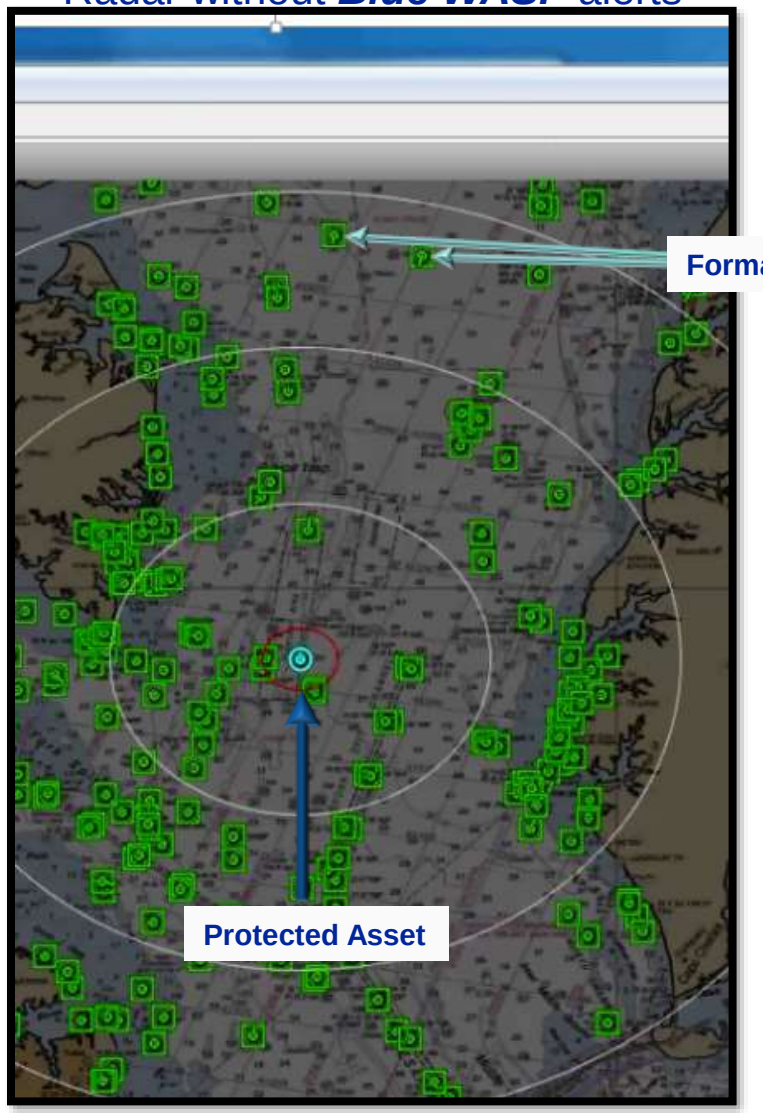
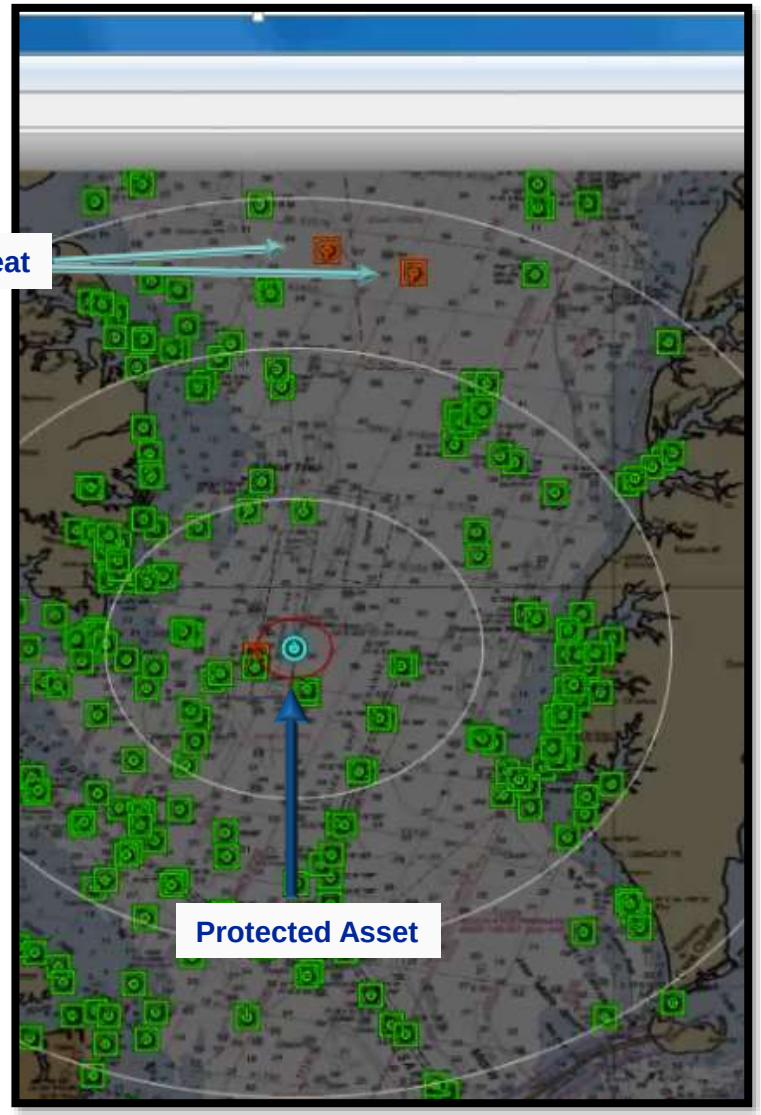
Radar without ***Blue WASP*** alerts



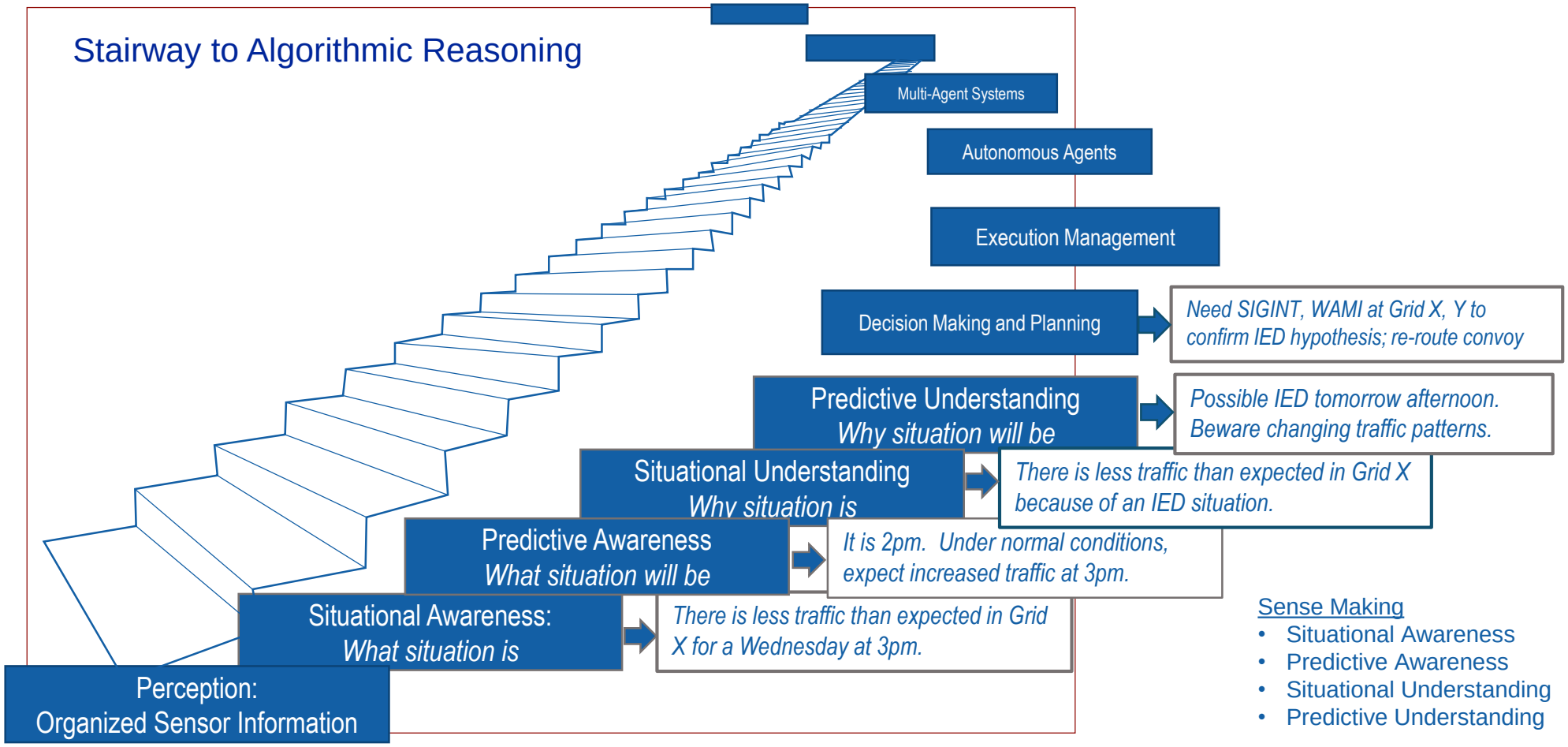
Radar with ***Blue WASP*** alerts



Collision / Intercept + Formation Alerts

Situation Awareness

Rapid Fielding and Spiral Improvement of AI Systems



Sense Making

- Situational Awareness
- Predictive Awareness
- Situational Understanding
- Predictive Understanding

Combine mission domain knowledge with existing and emerging capabilities from machine learning, physics, and algorithmic systems engineering, to Deliver Advanced Real-World Sense Making Capabilities

Example 2: Swarm Commanding

Challenges:

Humans cannot be expected to individually control hundreds of heterogeneous robotic air and ground vehicles

Swarm commanders need intuitive interactions to convey higher-level intent (e.g., secure a perimeter), with AI enabling execution of that intent

Swarm tactics needs to be rapidly created and tested in simulated environments

Swarm Commanding in Urban Environment

https://www.youtube.com/watch?v=km0LWvnMrtE#action=share

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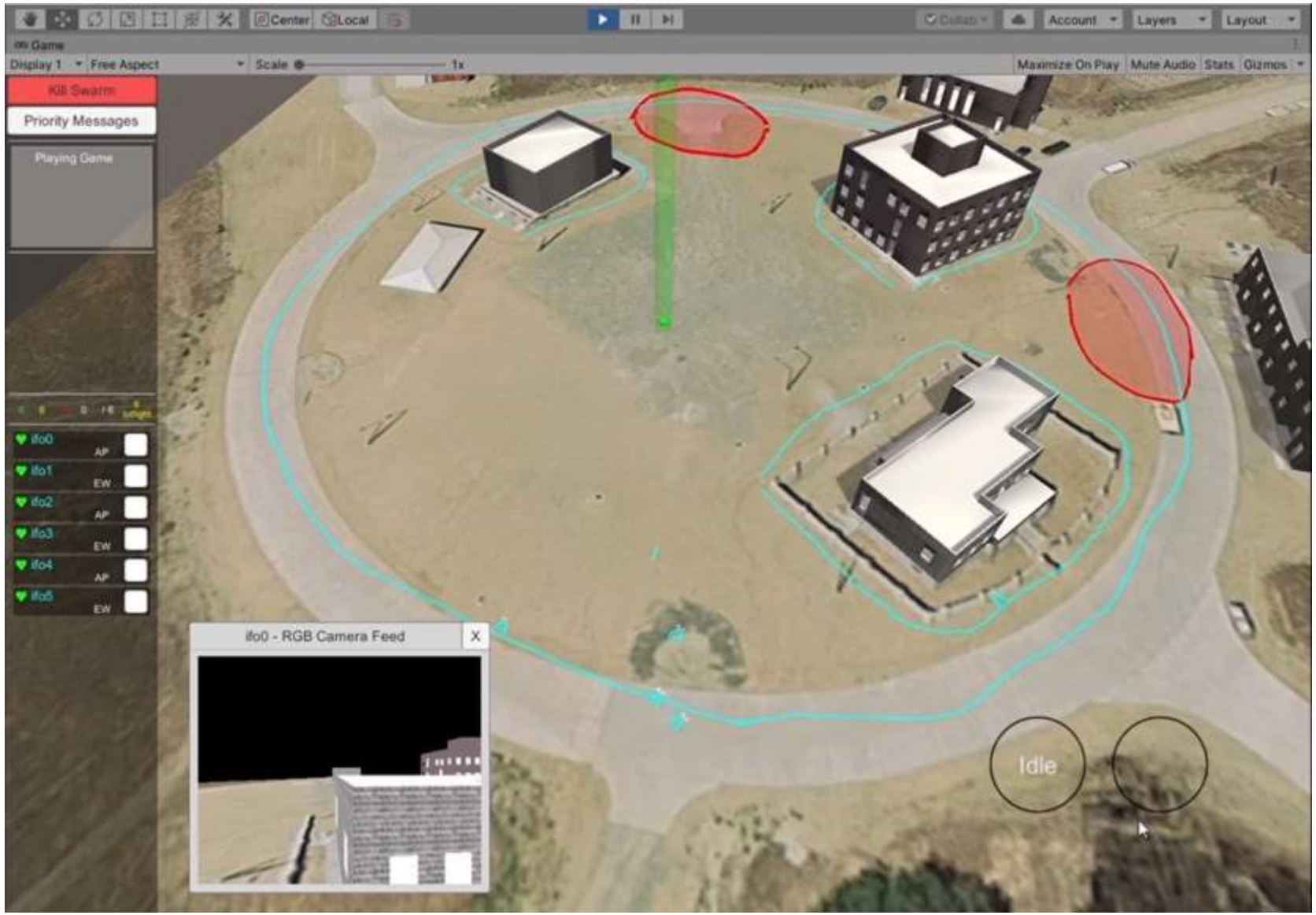
Intuitive Swarm Interactions to Convey Intent



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Example 3: Adaptive Autonomy and Interactions

Challenges:

Each operator has traits and cognitive/physical states that are persistent (e.g., personality) or change based on the situation (e.g., cognitive workload, fatigue, attention) and experience (e.g., trust)

A good teammate can recognize and adapt to teammates' needs

Machines currently lack the ability to recognize and anticipate human traits and states

What if the level of control and the type/mode of information given to a human operator could by dynamically adapted based on human cognitive state to improve mission outcomes?

Adaptive Interactions and Level of Autonomy

Machine Learning Classification of Cognitive State

Level of Autonomy & Human Interfaces Adapted

Data from worn sensors & performance metrics

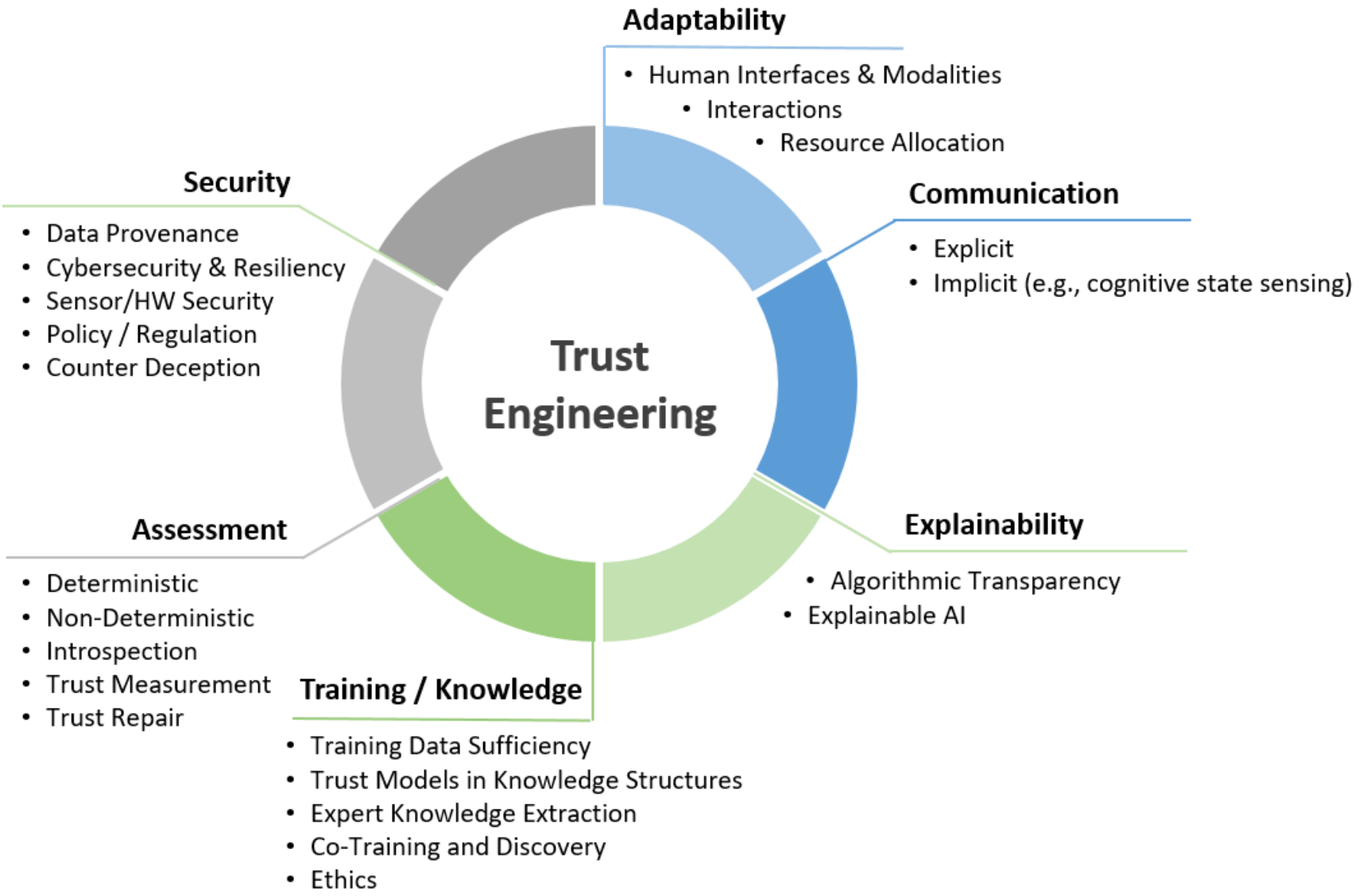
Image courtesy of RMIT University

Trust Engineering for HMT

Trust Engineering

- **Trust:** A measure of strength in the expectancy that interactions with another entity will result in positive outcomes within an uncertain and risky environment (Bhattacharya, Devinney, & Pillutla, 1998).
- **Trust Engineering:** Design decisions and methods that consider implications to trust in human-AI teams throughout system design, development, testing, and sustainment

Trust Engineering - Conceptual Model



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Summary

- Autonomy and AI does not eliminate the need for humans, but it does change their roles
- Challenges in HMT include maintaining situation awareness, enabling natural interactions to convey intent and adapting to human cognitive states
- Engineering appropriate trust into a Human-AI system requires design decisions to consider implications to trust throughout system design, development, testing, and sustainment

Interested in learning more?

AICampaign@ngc.com