Robotic Systems Capabilities Needs & Requirements and Partnerships for Effective Solution Implementation

Strategic Development Framework for

Autonomous Systems Research & Development at MIT Lincoln Laboratory

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DoD Autonomous Systems Needs

National Security

Defense Objectives

National Defense Strategy Defense Priorities†

- Defending the homeland, paced to the growing multi-domain threat
- Deterring strategic attacks against the United States, Allies, and partners
- Deterring aggression, while being prepared to prevail in conflict when necessary, prioritizing the PRC challenge in the Indo-Pacific, then the Russia challenge in Europe
- Building a resilient Joint Force and defense ecosystem

Joint Warfighting Concept

- Joint All Domain C2
- Joint Fires
- Contested Logistics
- Information Advantage

OUSD(R&E) National Defense Strategy	Unmanned Strategic Objectives	Autonomy* Opportunity Areas
Build a More Lethal Force	Key capabilities modernization	Space and Cyber missions, C4ISR, joint lethality, advanced expeditionary autonomy
	Innovative operational concepts	Application of heterogeneous teams, including human-machine teams
	Mobile and resilient force development	Resilient and agile logistics, unmanned systems deployment planning
Strengthen Alliances and Attract New Partners	Deepen interoperability	Algorithms and architectures robust to platform and sensor variety
Enhance ability of DoD to deliver Greater Performance and Affordability	Deliver performance at relevant time scales	Continuous adaptation, scalability, modularization
	Rapid, iterative development to field	Rapid prototyping, testbeds and simulation environments

**Adapted from Department of the Navy Unmanned Campaign Framework March 16, 2021*

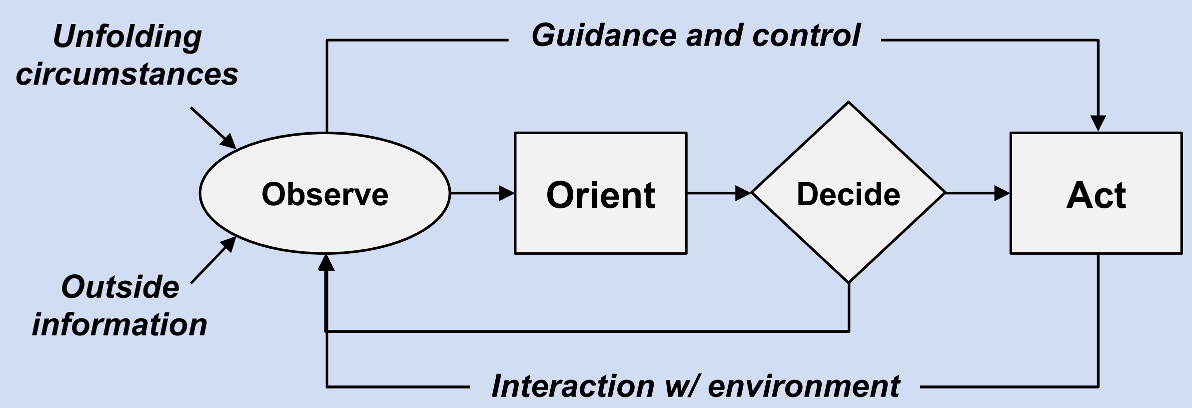
† National Defense Strategy March 28, 2022

AUTONOMY IN DYNAMIC SYSTEMS

- **MIT IR&D Autonomous systems objective**
  - **Enable a platform or team to execute a decision-making framework with reduced human intervention**
  - **Application of AI or other decision-making to systems in motion**

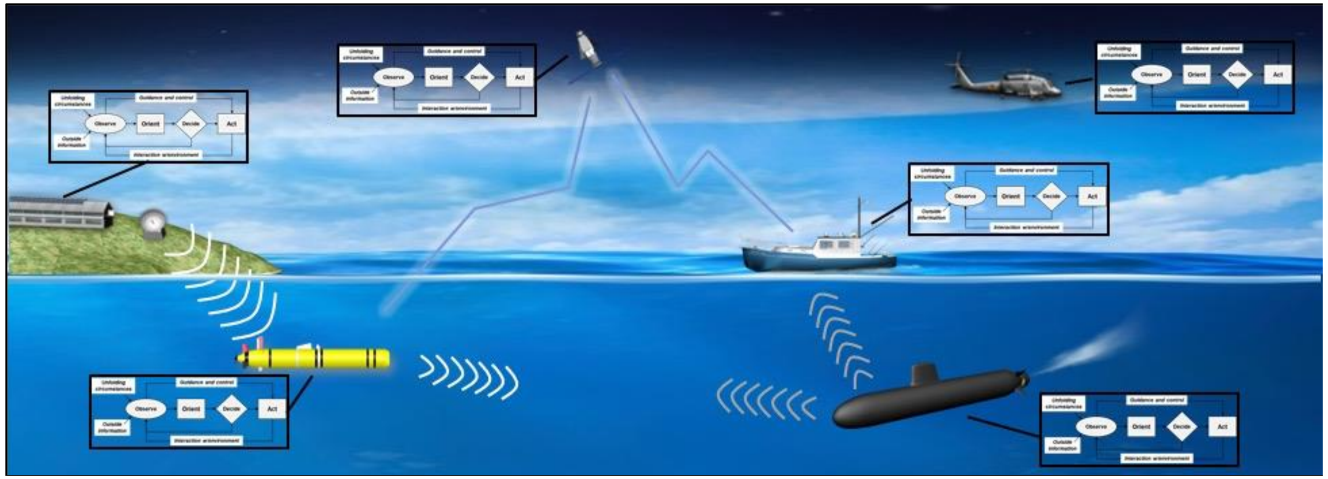
- **Functional and operational Technology Pillars of an autonomous system**
  - **Sensing & Perception**
  - **Planning & Decision-making**
  - **Execution & Control**
  - **Coordination, Collaboration, & Reorganization**

OODA Loop Decision-Making Framework

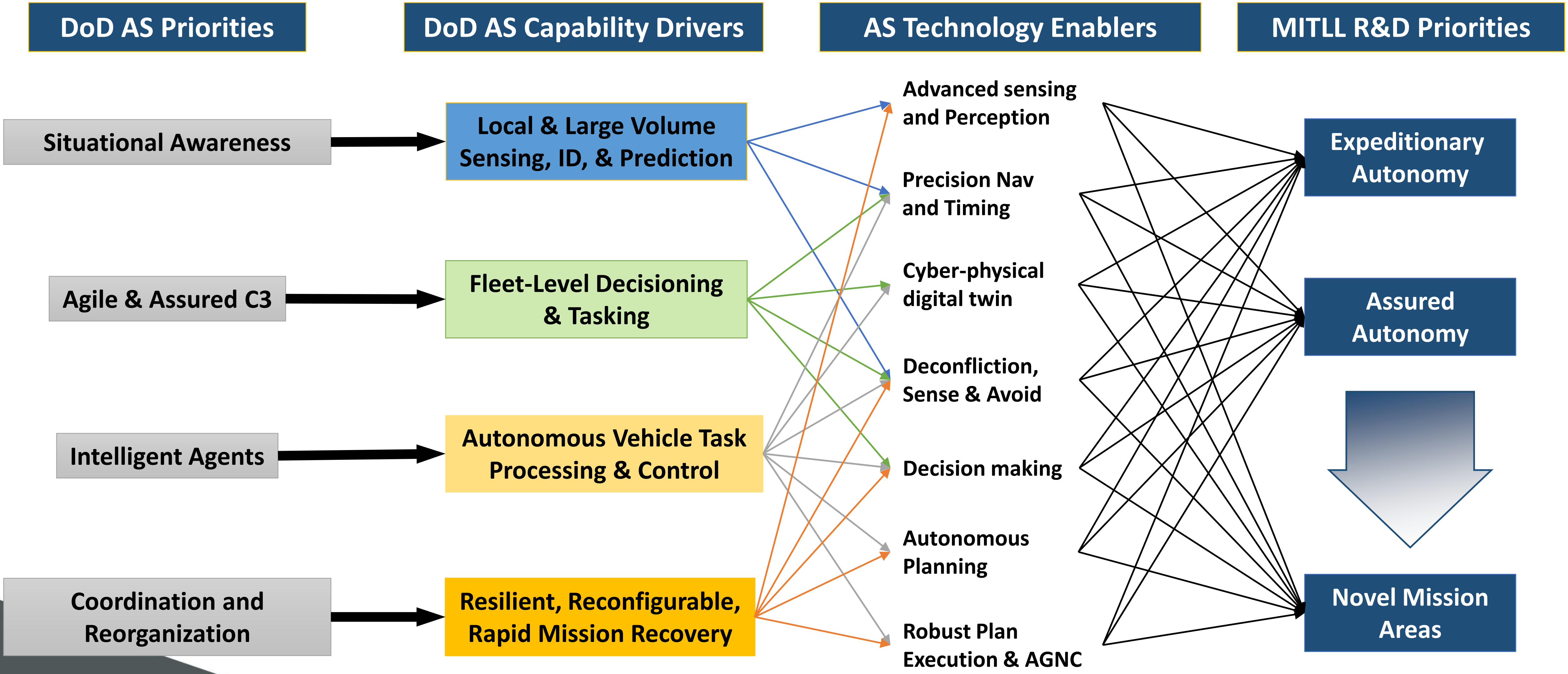


Adapted from Col. John Boyd, "The Essence of Winning and Losing"

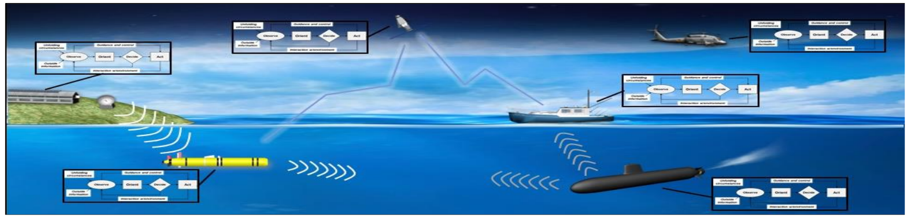
Cross-Domain Heterogenous Team of Autonomous Agents



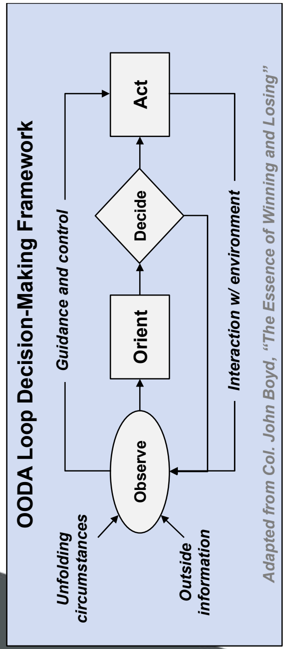
Autonomous System IR&D Investment Priority Strategy



MIT Lincoln Autonomous System Technology/Thrust Rubric



Autonomous Systems Technology		Autonomous System Capability Thrusts		
Major Technology Classes	**Technology Sub-Classes**	**Expeditionary Autonomy**	**Assured Autonomy**	**Novel mission Areas**
Perception & Estimation	Perception State Estimation Fault Detection & Identification (FDI)			
Planning & Reasoning	Mission & Resource Planning / Scheduling Motion Planning Fault Accommodation			
Execution & Control	Guidance & Trajectory Design Control			
Heterogeneous Teaming & Interoperability	Behavior & Intent Prediction Goal & Task Negotiation Operations Trust			



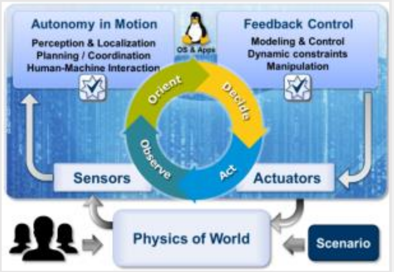
AUTONOMOUS SYSTEMS: ANALYSIS OF STATE OF THE ART

Gaps, Drivers, Needs, and Opportunities

Expeditionary Autonomy

- [D] Intelligent perception, decision making, reasoning, & GNC in adversarial, uncertain environments
- [D] Scalable, distributed and robust multi-agent systems for C2, data, and/or PNT
- [G] Analytic and AI/ML algorithms for low SWaP expeditionary systems
- [G] Minimal human control in dynamic & unpredictable scenarios
- [O] Force multiplication of complex tasking with swarms of simple agents

Assured Autonomy

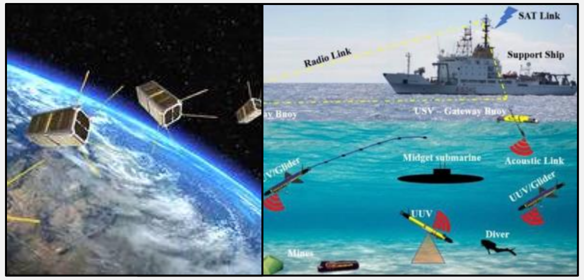


- [D] Trust-enabling V&V of AS operating in complex environments, including human-machine teaming
- [D] Methods and algorithms to develop and test behavioral bounding
- [N] Learning how to learn
- [N] Developing intelligence with common sense
- [O] Autonomy-driven real time decision support to provide better situational awareness to humans

Human-Machine Teaming

- [O] Scalable teaming of autonomous systems
- [N] Effective human-machine interaction for teaming and autonomy-augmented performance
- [O] Collaboration (heterogeneous teaming) vs. coordination & cooperation (homogeneous teaming)

Enabling Novel Mission Areas

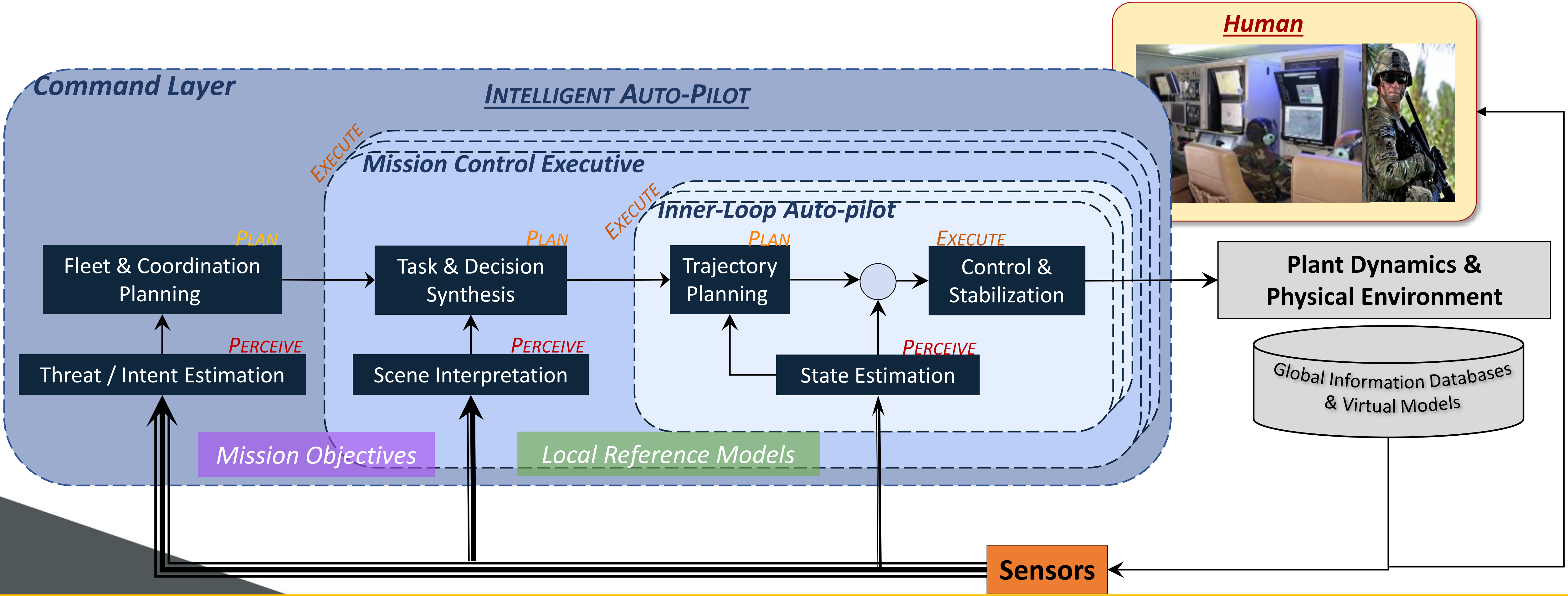


- [G] Autonomy-focused mission utility analysis and studies in adversarial, degraded, and extreme environments
- [D] Mission-tailored vehicle & autonomy architectures
- [N] Evaluations and trades to include novel sensor & actuators

GNC: Guidance, Navigation, & Control
C2: Command & Control
PNT: Precision Navigation & Timing
AI/ML: Artificial Intelligence/Machine Learning
SWaP: Size Weight & Power
V&V: Verification & Validation

Autonomous System Architecture Framework

Goal: Develop advanced algorithms and technologies that enable autonomous platforms to conduct missions of national security relevance in dynamic, unpredictable, and unstructured environments



HAVE A QUESTION?

Q&A