DoD Priorities for Autonomy Research and Development

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DOD Challenges Addressed by Autonomy

Decentralization, Uncertainly, Complexity…Military Power* in the 21st Century will be defined by our ability to *adapt – this is THE hallmark of autonomy

<u>Manpower efficiencies</u>: Insufficient manpower to support complex missions such as command and control and surveillance across relevant battlespace

<u>Harsh environments</u>: Operational environments that do not reasonably permit humans to enter and sustain activity

<u>New mission requirements</u>: Need adaptive autonomous control of vehicle systems in face of unpredictable environments and challenging missions

Autonomy—Technical Challenges

Working definition of "Autonomy" from recent DOD workshops: Having the capability and freedom to self-direct. An autonomous system makes choices and has the human's proxy for those decisions. This does not mean the autonomous system is making decisions in isolation from humans, just that the system makes the choices. The balance between human and system decision making is defined by policy and operational requirements.

1. **Machine Reasoning and Intelligence**
2. **Human/Autonomous System Interaction and Collaboration**
3. **Scalable Teaming of Autonomous Systems**
4. **Testing and Evaluation (T&E) and Verification and Validation (V&V)**

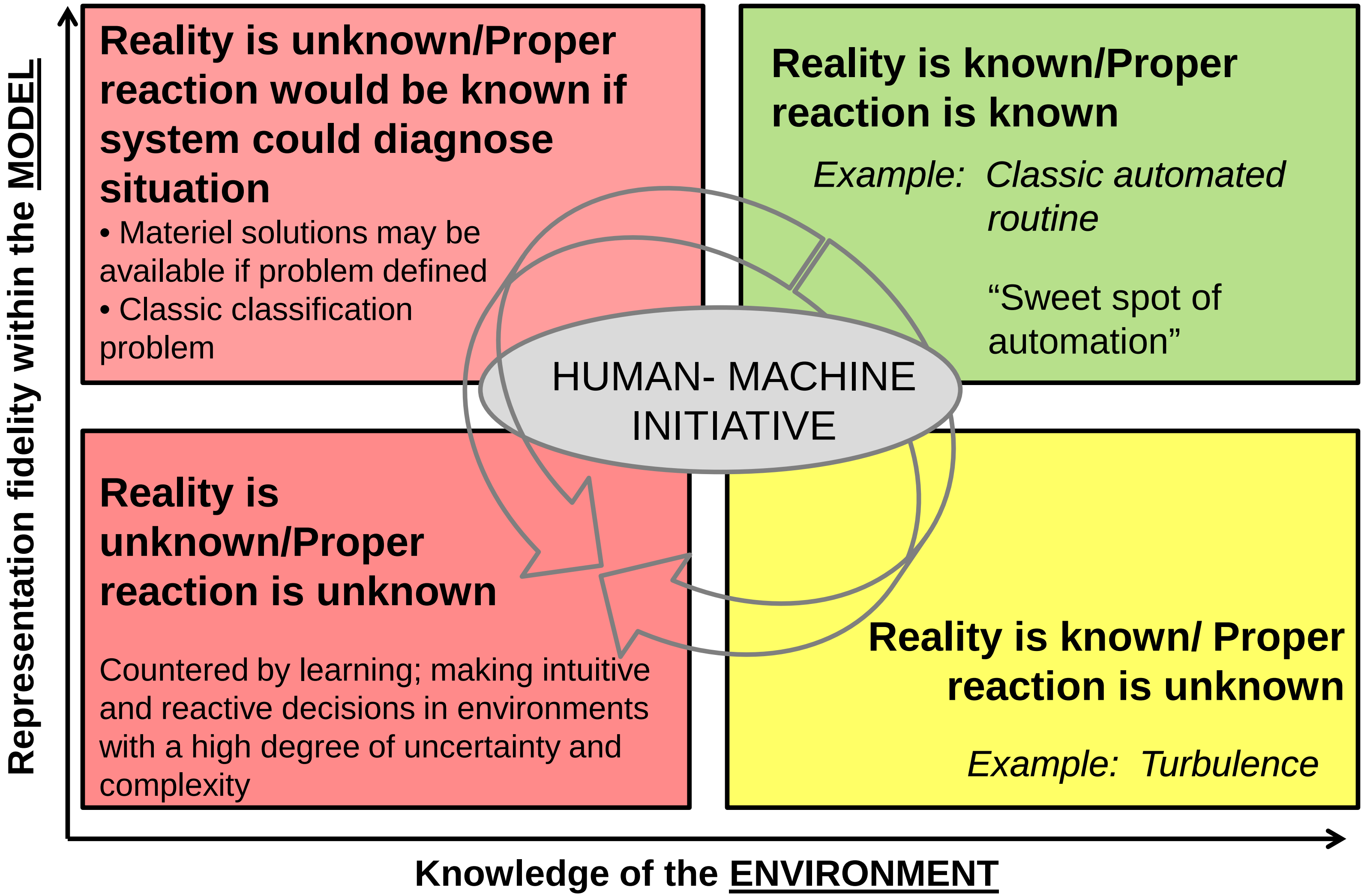
All address Two Sources of Uncertainty/Brittleness:

1. **Dynamic and Complex Mission Requirements**
2. **Dynamic and Complex Operational Environments**

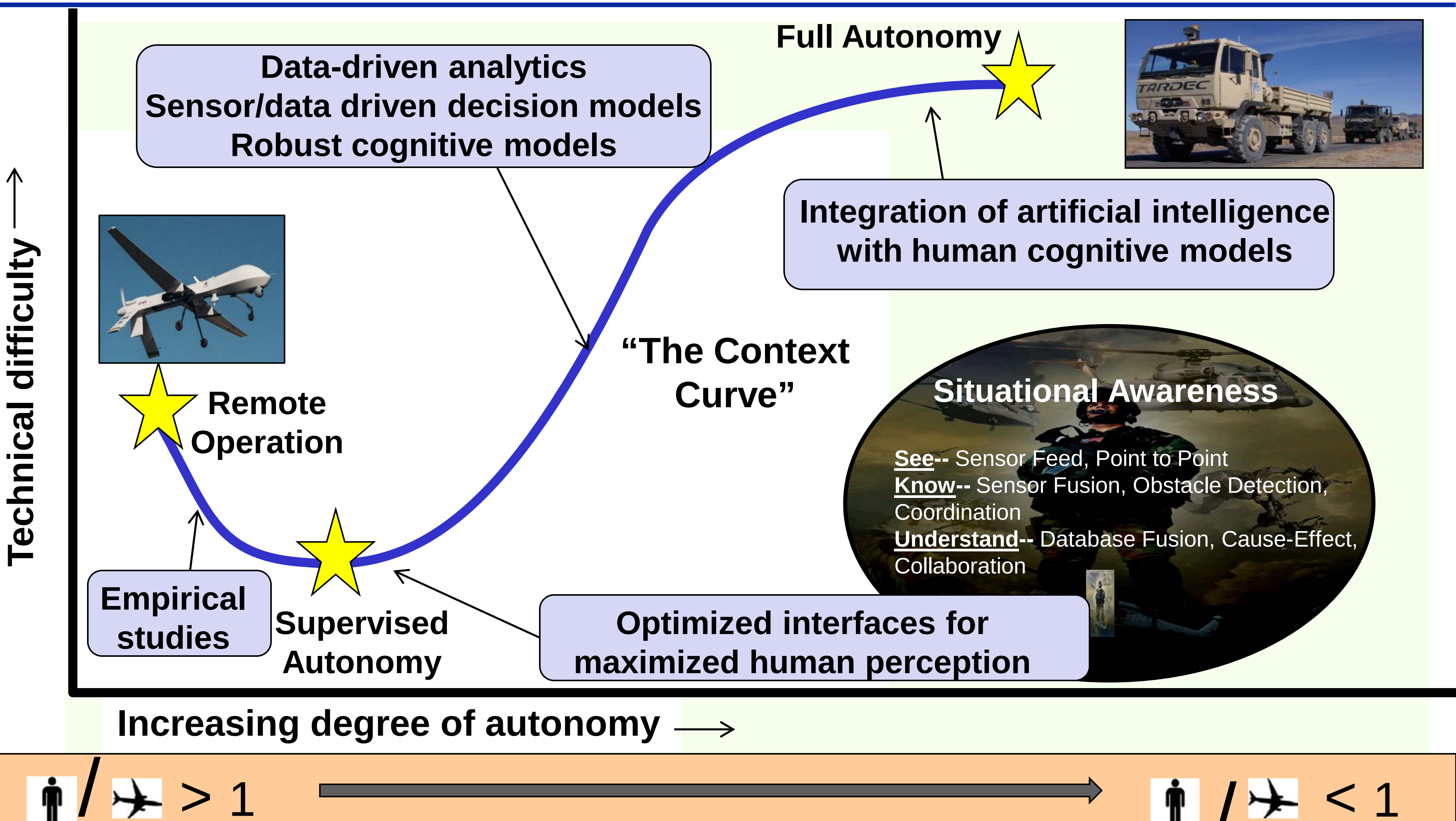
Overarching Problem Statement:

In a static environment, with a static mission, automation and autonomy converge. However, in reality, where dynamic environments collide with dynamic missions, automation can only support a small fraction of autonomy requirements.

Autonomy Parameter Space

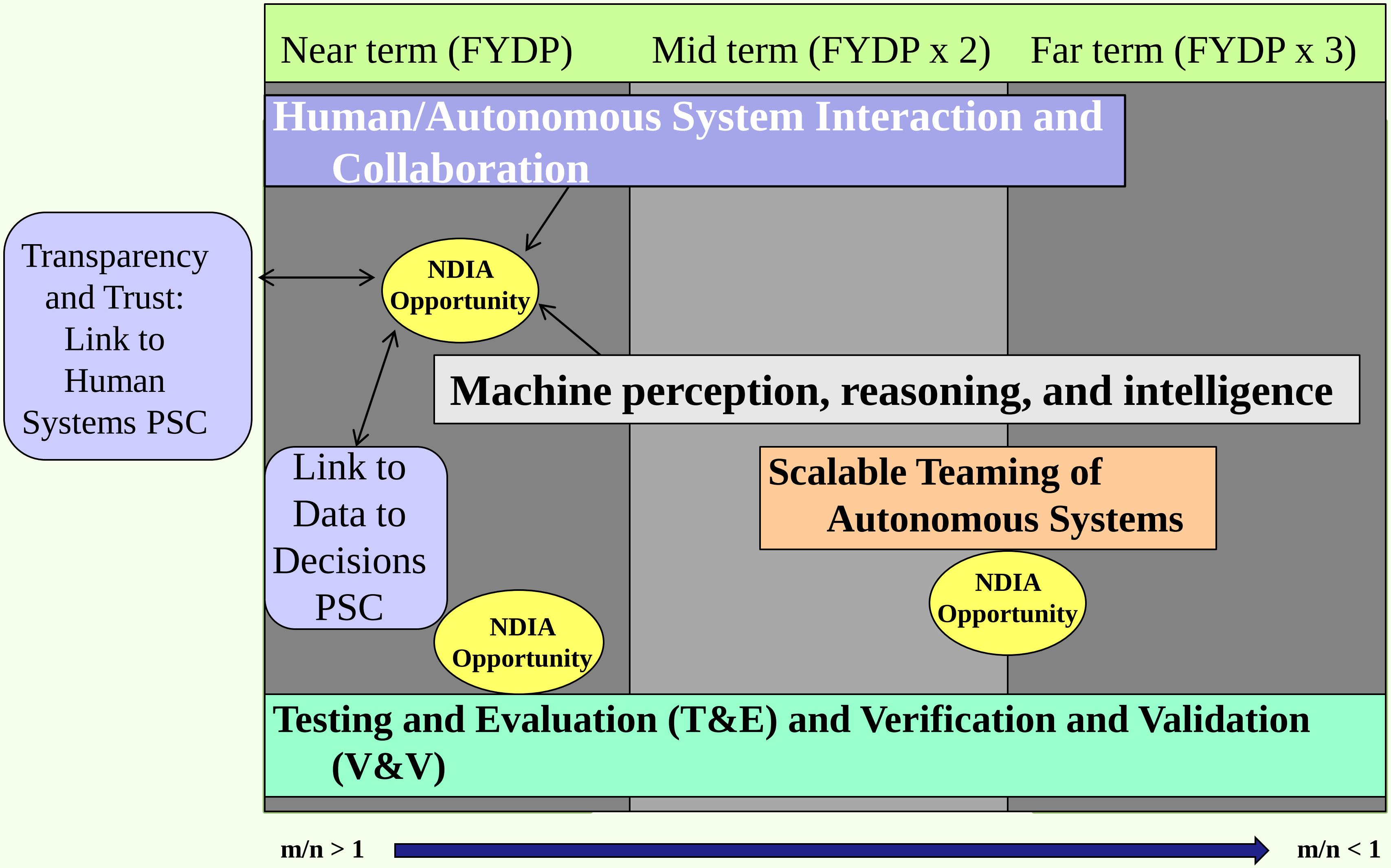


Technology-Driven Capabilities



Data drives functionality

Notional Depiction of Technology Stage-Gating



Opportunities for NDIA: Coordinated Platform Reasoning

Human/Autonomous System Interaction and Collaboration	Machine perception, reasoning and Intelligence
• Collaborative approaches to enable humans to flexibly shape and redirect the plans, behaviors, capabilities of highly complex distributed autonomous systems in real time to meet the ever changing requirements of warfighters operating in a dynamic battlespace • More natural, cognitively compatible, and effective multi-modal interactions between humans and autonomous systems for rapid coordination and collaboration • Intent-understanding relative to team members, adversaries and bystanders • Adaptable levels of autonomy • Transparency (link to Human Systems initiatives)	• Perception and comprehension (includes ATR as relevant to autonomy) • Onboard processing to reduce bandwidth requirements • Assessment/Planning in uncertain and unstructured environments (e.g. common sense reasoning, abductive reasoning, planning with partial goals, etc) • Learning, experience, adaptation: includes the ability to enhance the networks capability to rapidly achieve perception and assessment • Implementation: includes issues of computational platforms, computational and reasoning architectures, etc. • Distributed decision making coordination to mission completion

Notional examples: Multi-vehicle coordinated object discrimination and distributed decision making

Opportunities for NDIA: TEVV of Autonomous Systems

Scalable Teaming of Autonomous Systems

- Robust self-organization, adaptation, and collaboration among highly heterogeneous platforms and sensors in a dynamic battlespace
- Decentralized mission-level task allocation/assignment, planning, coordination and control of heterogeneous systems for safe navigation, sensing, and mission accomplishment
- Space (air, land, water) management operations in proximity to manned systems and units
- Sensing/synthetic perception across large numbers of distributed entities

Future solicitations to be determined

Testing and Evaluation, Verification and Validation

- Test and evaluation and Verification and validation approaches that support exponential growth projected in software lines of code as well as new algorithms types (e.g. non-deterministic)
- Analysis tools that work with realistic assumptions including supporting timely and efficient certification (and recertification) of intelligent and autonomous control systems
- Common architecture

Test Methodology— Assess machine reasoning in dynamic environments (Phase 1) and under dynamic mission requirements (Phase 2). Largely service-specific.

Examples of BAA's, MURI's, and SBIR's that Support DOD Requirements for Autonomy-related R&D

Organization	Opportunity	Contact
AFOSR (Reliance Optimization for Autonomous Sys)	BAA-AFOSR-2012-02	Joseph Lyons
AFRL/RW (Armament Technology)	BAA RWK-10-0001	Judie Jacobson
AFRL/711 HPW (Warfighter Interface Tech Adv R&D)	BAA 09-04-RH	Ronald Yates
ONR (Behavior of Complex …Autonomous Systems)	BAA/MURI 11-026	Marc Steinberg
ONR (Long Range BAA for Navy and Marine Corps S&T)	ONRBAA12-001	Cheryl Nagowski
DTRA (Scalable Teaming of Autonomous Systems)	BRBAA08-Per5-C-008	Robert Kehlet
DTRA (TEV&V)	BRBAA08-Per5-c-0020	Robert Kehlet
DTRA (TEV&V)	BRBAA08-Per5-c-0027	Michael Robinson
ARL /ARO (Basic Scientific Research)	W911NF-07-R-0001-05	Varies by topic

Summary

- DoD will be investing in and advancing the state-of-the-art in autonomy research
- DoD will be one of many players in this rapidly expanding area
- Investment represents significant opportunity for broad range of industrial partners, such as:
  - Transport
  - E-commerce
  - Healthcare
  - Public Safety
  - Non-traditional Defense Industries
- Autonomous technology will fill a major role in future DoD operations

Autonomy Priority Steering Council Membership

- USAF/AFRL – Morley Stone (Lead)
- US Army/TARDEC - James Overholt
- US Army/ARL- Jonathan Bornstein
- US Navy/ONR – Marc Steinberg
- DTRA – Stephen Dowling