AFRL

711HPW/RH

Targeted Overview for BoHSI Committee on Human-AI Teaming (HAT)

MARK H. DRAPER, PH.D. / ADAPTIVE WARFIGHTER INTERFACES CTC LEAD

AIRMAN SYSTEMS DIRECTORATE

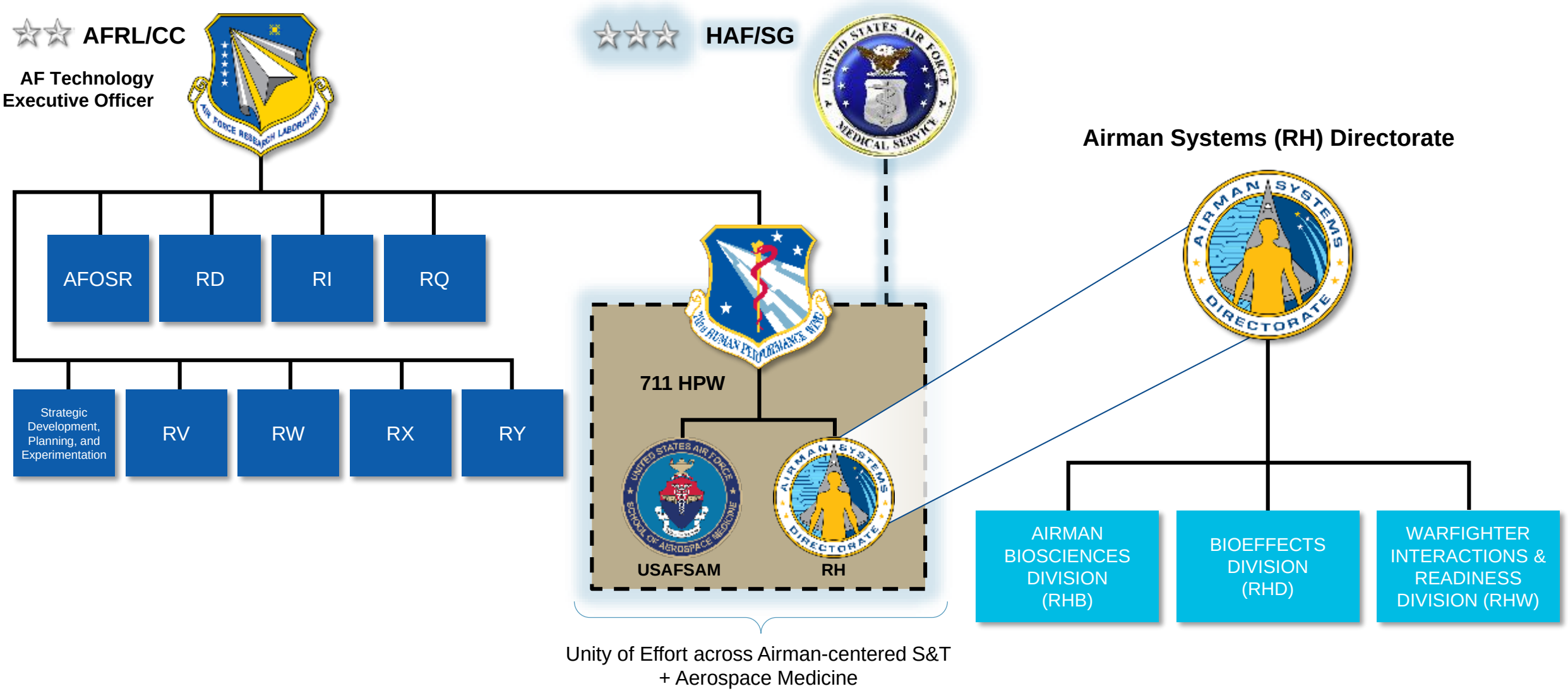
Overview

- **711HPW/RH Overview**
  - Summary of AI/autonomy Related Research
  - Major international connections related to HAT

- **Introduction to Joint All Domain Operations (JADO/JADC2)**
  - Envisioned components & capability (and what unique about it)
  - HAT-related ‘concern areas’
  - “Notional” examples of HAI in JADO

- **Requests & Expectations for this Committee**

"The Wiring Diagram"



Airman Systems (RH) Directorate

Vision

- Lead the Air Force in Airman-centered Research

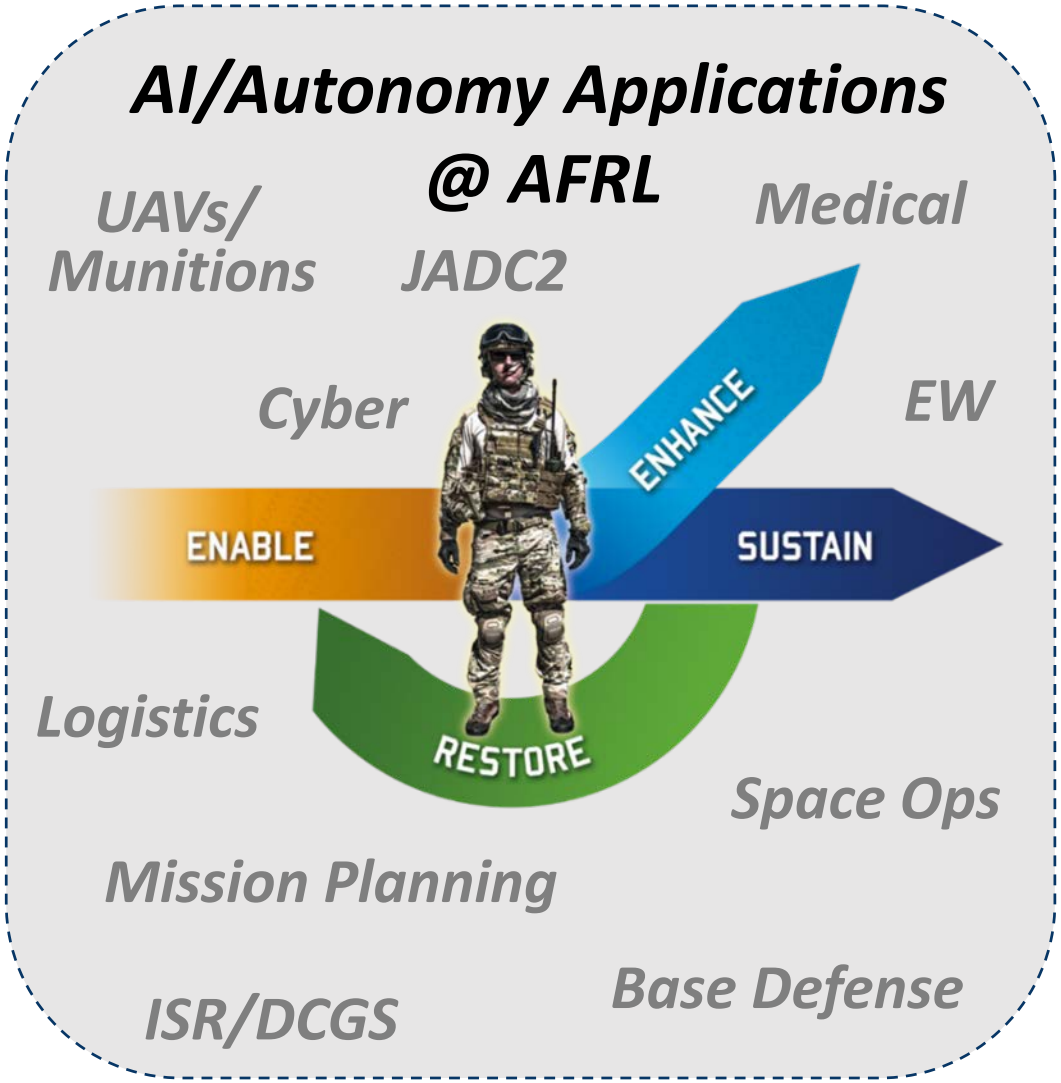
Mission

- Exploit biological, medical and cognitive S&T to optimize and protect the Airman's capabilities to fly, fight and win in air, space and cyberspace

Enduring Challenges for RH are to Enable, Sustain, Enhance & Restore:

- Multi-domain capable Airmen
- Airman-machine operations

Human-Autonomy Teaming Challenges across RH



Operational Challenges Facing Us:

- *Greater technological parity*
- *Increasing roles for autonomous systems*
- *Shorter decision timelines and cycles*
- *Integrated (i.e., Joint All-Domain) operations*
- *Changing roles of warfighters*

HAT-related Research Challenges:

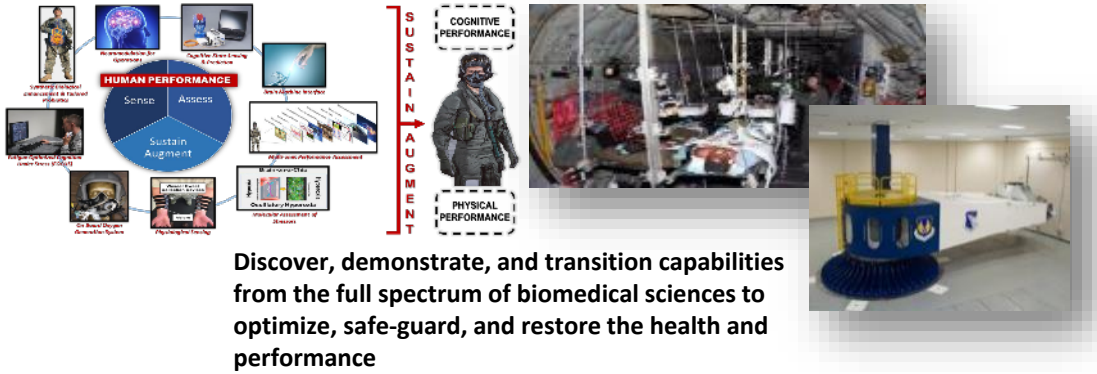
- *Naturalistic Interaction/Communication*
- *Shared Awareness, Comprehension*
  - *Trust & Bi-directional Understanding/Transparency*
- *Problem Solving/Decision Making*
- *Dynamic, Adaptive Task Allocation*
- *Interactive Learning & Training Synthesized w/ ML Env.*
- *Team Performance & Effectiveness*

711HPW: Core Technical Competencies

Training

Accelerate, enhance and reduce costs of training to enable mission effectiveness in a complex, evolving operational environment

Medical & Operational Biosciences



Discover, demonstrate, and transition capabilities from the full spectrum of biomedical sciences to optimize, safe-guard, and restore the health and performance

Bioeffects

Characterize biological and performance related molecular effects of the electromagnetic spectrum to enable and sustain the airman

Adaptive Warfighter Interfaces

Assess, enable and enhance airman-machine interaction and teaming into maximally collaborative warfighting teams

Exploit biological and cognitive S&T to optimize and protect the warfighter's capabilities to fly, fight and win in air, space and cyberspace

Adaptive Warfighter Interfaces CTC:
Core Research Areas & Top Research Priorities

Multisensory Perception & Communication
- *Exploiting Perceptual Abilities*
- *Enhancing HAT Comms*

Collaborative Interfaces & Teaming
- *Human-Autonomy Collab.*
- *Distributed Teaming Solutions*

Systems Analytics
- *Analytic-enabled Cognition*
- *AI-enabled Sense-making at Scale*

Major International Efforts related to HAT (Past & **Present**)

- NATO Efforts
  - HFM-247: HAT - Dynamically Adjustable Collaboration (HAT design patterns)
  - HFM-300: NATO Symposium on HAT (2018)
  - **HFM 322/330: "Meaningful Human Control" of AI-based Systems**
  - **IST-157: Human considerations in AI for C2**
- Project Agreements
  - **US-Netherlands (general human performance)**
  - **US-Australia (transparency, narratives, teaming metrics)**
- TTCP
  - Autonomy Strategic Challenge (Allied IMPACT HAT C2 Testbed)
  - **AI Strategic Challenge (transfer of authority)**

Joint All-Domain Command and Control (JADC2) Overview

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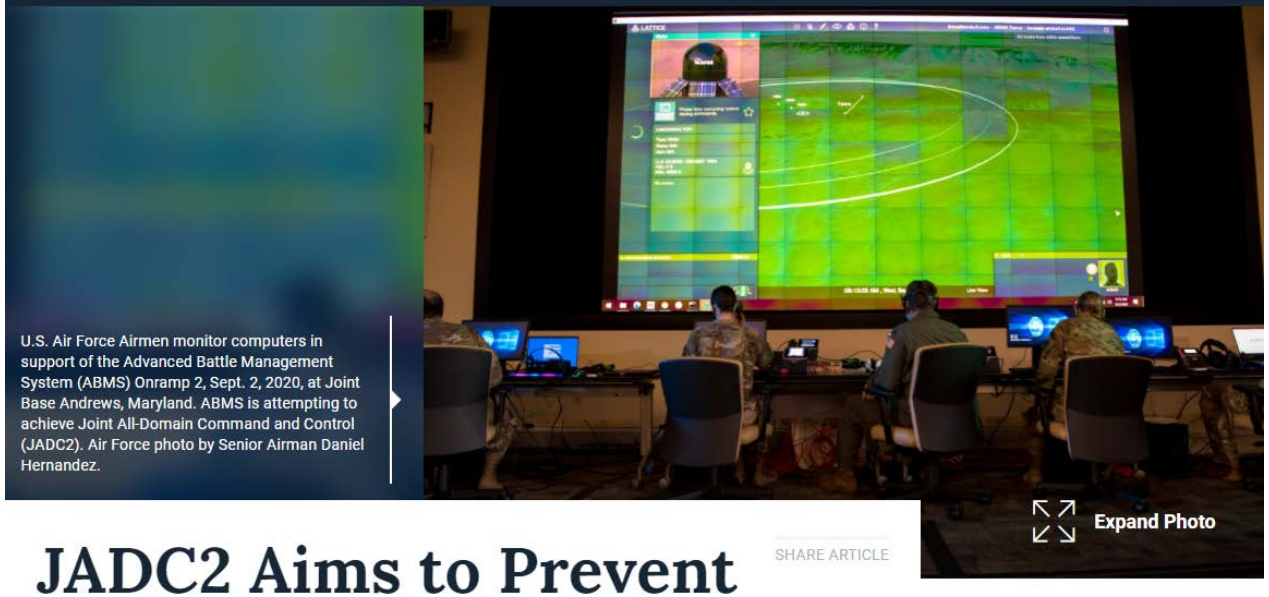


U.S. Air Force Airmen monitor computers in support of the Advanced Battle Management System (ABMS) Onramp 2, Sept. 2, 2020, at Joint Base Andrews, Maryland. ABMS is attempting to achieve Joint All-Domain Command and Control (JADC2). Air Force photo by Senior Airman Daniel Hernandez.

JADC2 Aims to Prevent Adversary from 'Cutting the Head off the Snake'

SHARE ARTICLE

July 12, 2021 | By Abraham Mahshie

In Defense Department wargames in 2018, America lost 18 straight competitions with a peer adversary. What was more troublesome, recalled Lt. Gen. S. Clinton Hinote, was that the United States was losing the war faster in each subsequent round.

Latest News

JADC2 Aims to Prevent Adversary from 'Cutting the Head off...

"If we (continue) to operate in stovepipes and in domains, we know how this is going to go, and it is **not going to go well** for the joint force."

"We started thinking very much as it all is connected together. And one of the things we saw was that our command and control was not up to the task."

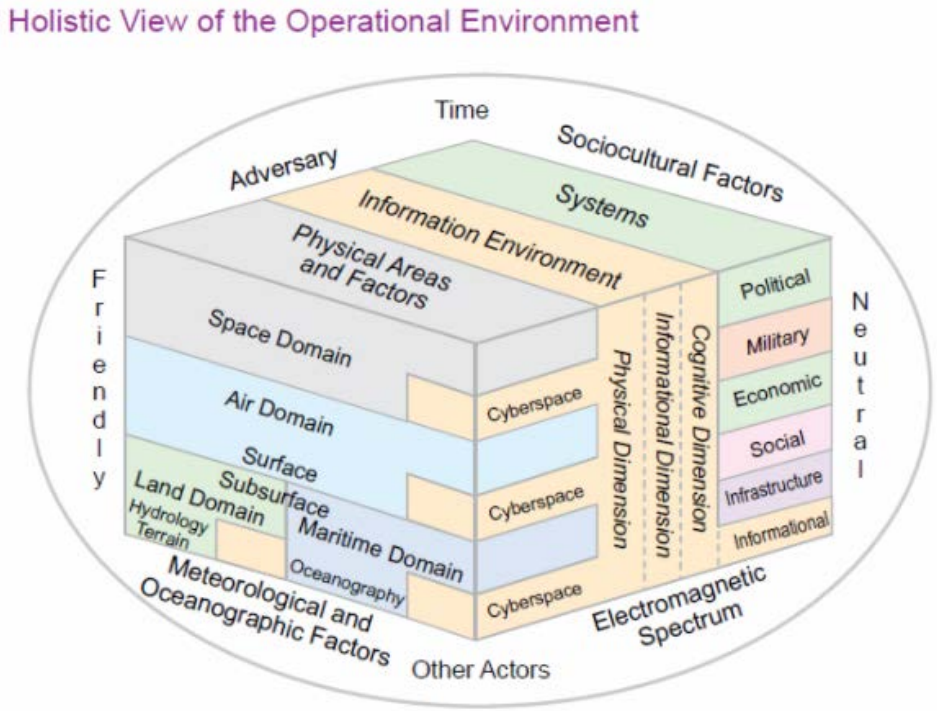
It means sharing data in real time across all domains, all services and the joint force. It means creating the **flexible** capability to **operate disconnected**. It means no more "centers" for accessing all information.

It also means taking more risk.

"What will be very compelling to our adversary is if we develop a technology and a people base, a human capital base, that means that it's going to be almost impossible to cut the head off the snake"

Multi-Domain Operations (MDO)

- Multi-Domain Operations focus in December 2017 US National Security Strategy (NSS) and 2018 National Defense Strategy (NDS)
- NSS directs DoD to "develop new operational concepts and capabilities to win without assured dominance in air, maritime, land, space, and cyberspace domains."
- Joint Pub 5-0 "defines" domains via Operational Environment
  - Physical domains of land, air, maritime, and space
  - Non-physical domains of cyberspace, information environment and the electromagnetic spectrum
- Renamed Joint All-Domain Operations (JADO) in 2020
- Compliments Agile Combat Employment (ACE)



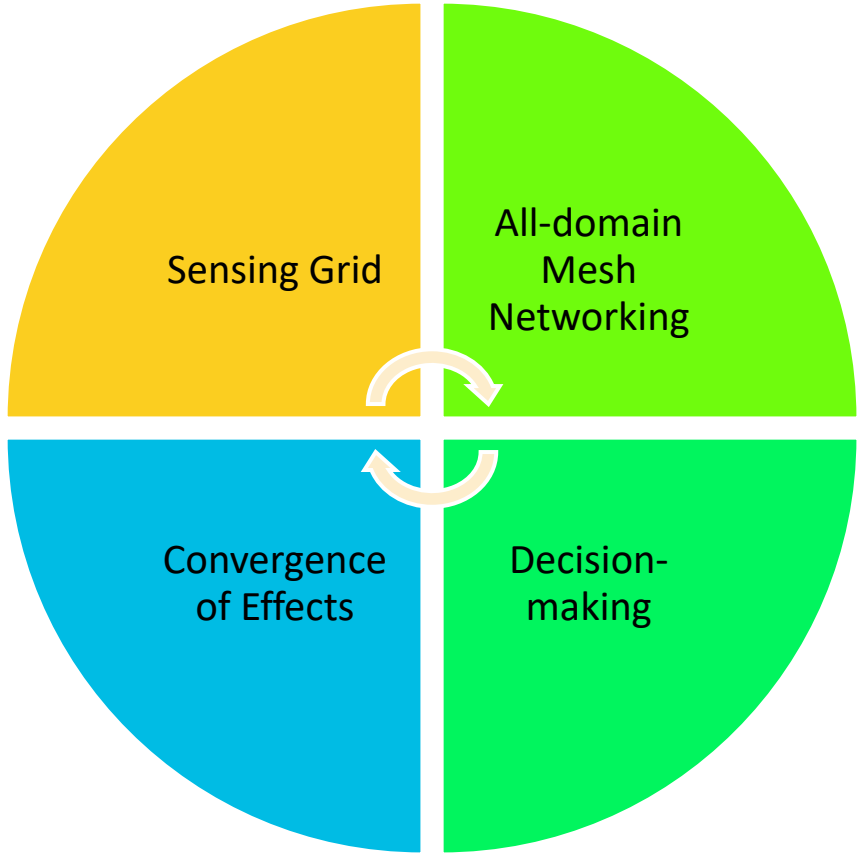
Joint Publication 5-0

Joint All-Domain Command and Control (JADC2)

- Definition: "…concept to **connect sensors** from all of the military services - Air Force, Army, Marine Corps, Navy, and Space Force - into a **single network**." In Focus 11493, Congressional Research Service, Library of Congress, 04 JUN 2021
- Definition: "The art and science of **decision-making** to rapidly translate decisions into action, leveraging capabilities across all domains with mission partners to achieve **operational and informational advantage** in both competition and conflict." Air Force Doctrine Publication 3-99; Department of Air Force (DAF) Role in Joint All-Domain Operations 08 OCT 2020
- Leverages a cloud-like environment of many communication networks
- Data (intelligence, surveillance, and reconnaissance) may be processed with artificial intelligence (AI) algorithms for optimized pairings or targets and effects
- Information (results of AI processing) will be shared with decision makers to support efficient and effective planning and execution
- Current C2 structure must change
  - Vulnerable (adversary anti-access/area denial capabilities)
  - Not optimized for speed, complexity, and lethality of future conflicts

JADC2 Supporting Concept

Network of sensors to collect vast amounts of source-agnostic all-domain data



Agile and resilient network to transport data in real-time across service, domain, and classification boundaries

Translate decision advantage through a convergence of effects from all domains

Accelerate human decision making at a pace and scale necessary for future warfare

JAD “Unique” Features

- Planning and execution requires broad **understanding of many domains** and how they interact
  - Breadth versus Depth
  - Authorities
- **Cyber is the ubiquitous**, offering both capabilities and vulnerabilities
  - Defensive cyber ops are critical as adversaries become proficient in using cyber to effect all of our systems
  - Offensive cyber effects (exploitation and attack) should be considered as instruments of power in JADO
- Planning and execution must be conducted in a **distributed fashion** to overcome network vulnerabilities
- The **sheer amount of data being collected** from the sensing grid will require advanced analytics, automation, and **AI algorithms** for sensemaking
  - Processing
  - Presentation of information
- Decision makers will need to be able to **independently adjudicate** recommendations derived from the application of AI algorithms
  - Data integrity, uncertainty, transparency
  - Confidence/trust/reliability
  - Value system

Concerns

- Incorporating CYBER effects in JADO
- Rapidly forming & operating as (multiple) distributed, heterogeneous teams
- Understanding massively aggregated JAD information/datasets across the sensing grid
- Maintaining human as viable/valuable teammember for key decision making
- Authority issues
- JAD Wargaming/M&S
- Risks from using the agile/DevSecOps process

Notional/Generic Examples of Potential HAI in “Envisioned JADO”

1. AI to actively manage the operation/orchestration of the “sensing grid”, tailoring its many heterogeneous sensing capabilities towards the latest intel & targeting prioritized requirements (including data from publically available info)
2. AI to continually attempt to aggregate data from cross-domain sources into a unified battlespace picture/patterns of life/change detection capability, indicating potential uncertainties & data integrity concerns.
3. AI to generate & prioritize candidate JAD COAs (i.e., COAs that are cross-domain capable and not limited to a single domain of operations); AI to assist in JAD COA comparisons against current context/needs
4. AI to dynamically assess communications between all Blue forces, including unmanned, to prevent spoofing, jamming, miscommunications, etc
5. AI to monitor networks for cyber vulnerabilities (blue) and/or opportunities (grey/red); possibly offer tactics resulting from assessments

Requests & Expectations for this Esteemed Committee

Many Lists of HAT Challenges Already Exist….

- Calibrated trust and transparency
- Common understanding and shared perception
- Human-agent communications/interaction
- Collaboration

DoD Autonomy Community of Interest
Subgroup on Human/Autonomous System Interaction & Collab

- Human-autonomy function division & relationships
- Human-autonomy interaction/communication
- Human-autonomy comprehension

ONR Science of Autonomy Workshops

- Human-Autonomy Interaction/Communications
- Functional Division & Teaming Relationship
- Shared Comprehension/Understanding
- Team Decision-making
- Team Learning/Training
- Trust-based Effects
- Team Performance/Effectiveness Metrics

NATO-HFM-RTG-247 Final Report

Requests & Expectations

1. If formulating a new list of challenges, attempt to go “one step deeper”
   - Aim to be maximally “specific & tactical”
   - Prioritize key needs with supporting rationale for prioritization
   - What unique aspects of HAT should the AF/DoD focus on relative to academia
2. Consider conceptualizing “potential solutions” to key HAT challenge areas (i.e., methods/ideas to maintain meaningful human control in future systems)
3. Propose methods to assure that the human remains an independent & creative assessor/adjudicator of AI-enabled system plans/recommendations
4. What human-human teaming knowledge is most applicable to HAT? Why? What are the pros & cons of applying human-human team metaphor to HAT?
5. Ponder refinements to the current “agile design process” to best include the HF needed to assure that the overall system interface remains cohesive/optimally designed

To aid in obtaining specificity & tactical inputs, consider JADC2 envisioned capability as a unifying framework for discussions & recommendations

Questions?