



***Integrity ★ Service ★ Excellence***

# Challenges in Human-Machine Teaming

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# Autonomy Game Changer



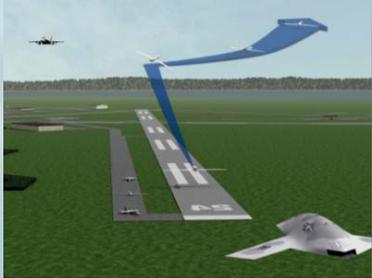
- Ability to operate in highly contested environments
- Increased capability with smaller force structure
- Across air, space & cyber
- Operate inside a sophisticated enemy's OODA loop



## Optimized Airman-Machine Teaming



# AFRL Autonomy Portfolio



**Aircraft**



**Space**



**Command & Control**



**Cyber**



**Weapons**



**ISR Collection**



**ISR Exploitation  
Dissemination**

**Executing Airman's Intent at the Speed of Computing across Domains**

# TODAY

## Machines as Tools

- Non-intuitive interfaces
- One-way information flow
- Uncertainty and limited trust

HUMAN

MACHINE

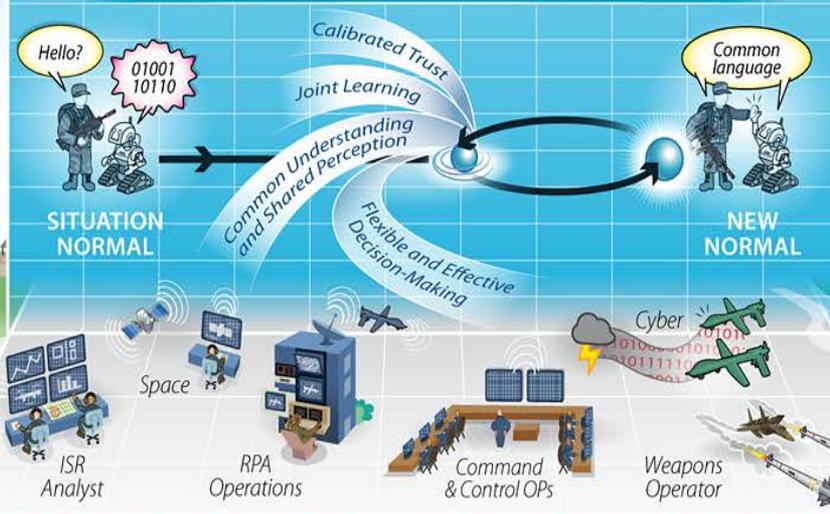
TEAMING

# TODAY

## Machines as Tools

- Non-intuitive interfaces
- One-way information flow
- Uncertainty and limited trust

## ADVANCEMENT OF AUTONOMOUS SYSTEM THROUGH HUMAN-MACHINE TEAMING



# VISION

- BUILDING TRUST AND KNOWLEDGE OVER GENERATIONS
- SHARED DECISION-MAKING
- CAPITALIZES EACH PARTNER'S STRENGTHS
- BI-DIRECTIONAL FLOW OF INFORMATION

## 2030

## SEAMLESS HUMAN-MACHINE PARTNERSHIPS

## Intelligent Machines as Team-Mates

- Natural user interfaces
- Mutual awareness of team-mate condition
- Shared situational understanding

## TECHNOLOGY CHALLENGES

<b>HUMAN STATE SENSING &amp; ASSESSMENT</b>	<b>HUMAN-MACHINE INTERACTION</b>	<b>TASK &amp; COGNITIVE MODELING</b>	<b>HUMAN &amp; MACHINE LEARNING</b>	<b>DATA FUSION &amp; UNDERSTANDING</b>
<ul style="list-style-type: none"> <li>• Objectively measure and assess human's state (physiological, performance, behavioral)</li> </ul>	<ul style="list-style-type: none"> <li>• Enable human and machines to communicate and share information</li> </ul>	<ul style="list-style-type: none"> <li>• Task and function allocation for workload and decision-making balance</li> </ul>	<ul style="list-style-type: none"> <li>• Adaptive, learning and extended mutual training between human and machine</li> </ul>	<ul style="list-style-type: none"> <li>• Integrate human and machine data (context, time, format) for a shared world model</li> </ul>



# Human-Machine Teaming Technology Development Focus Areas



## Human State Sensing & Assessment

- Objectively measure and assess human's state (physiological, performance, behavioral)



## Human-Machine Interaction

- Enable human and machines to communicate and share information



## Task & Cognitive Modeling

- Task and function allocation for workload and decision-making balance



## Human & Machine Learning

- Adaptive, learning and extended mutual training between H & M



## Data Fusion & Understanding

- Integrate human and machine data (context, time, format) for a shared world model

Inter-relationship



## Human State Sensing & Assessment

- Objectively measure and assess human's state (physiological, performance, behavioral)

## •Tech Challenges

- How do we consistently & reliably measure and/or observe the physiological, cognitive, behavioral and emotional 'states' of Airmen?
- How do we use that 'assessed state' and turn it into actionable information that prolongs or increases some measure of system performance (i.e. Sense, Assess & Augment framework)
- The need for appropriate models (both in scale and fidelity) of human performance across a wide realm of mission capabilities



# Human-Machine Interaction



## •Tech Challenges

- Designing in the ‘hooks’ for human state feedback (i.e. the SSA\* paradigm), ‘ease of use’ and adaptable autonomy capabilities
- Designing for trust & transparency into interfaces that will interact with ‘intelligent’ systems that can learn
- Taking advantage of COTS technologies for more intuitive interfaces



### Human-Machine Interaction

- Enable human and machines to communicate and share information



# Task & Cognitive Modeling



## Task & Cognitive Modeling

- Task and function allocation for workload and decision-making balance

## •Tech Challenges

- Analyze the way our work is organized and processed to improve work flow efficiency
- Understand the underlying cognitive capabilities at play and instantiate models on machines, sensors, platforms, etc. for improved mission effectiveness
  - Notion of pushing Airman-like ‘reasoning’ at any moment to any cyber-physical element of the mission environment
- Training for missions using combined cognitive science-based models & LVC capabilities

Inter-relationships



# Human & Machine Learning



## Human & Machine Learning

- Adaptive, learning and extended mutual training between H & M

## •Tech Challenges

- Presenting a unique problem in Airman & intelligent machines jointly learning
  - Both short term & life long learning
  - Unique in the literature space
  - Human teaming currently serves as the model
- More ‘Traditional’ Machine Learning paradigms
  - Deep Learning
  - Neurobiology Connectionist Models



# Data Fusion & Understanding



## Data Fusion & Understanding

- Integrate human and machine data (context, time, format) for a shared world model

## •Tech Challenges

- How to fuse various sources of data in order to present meaningful information to the Airman and the machine
- Will engage at different temporal constraints
  - E.g. NASIC (months); RPA ops (minutes); Cyber Ops (milliseconds)
- Scientific visualization is just the start. Capturing ‘meaning’ from fused data is the goal



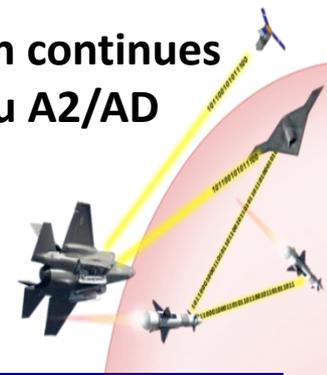
# Overall Roadmap for Autonomy



## Autonomy S&T Challenges

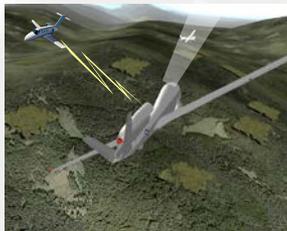
- Airman-Machine Teaming for Efficient Re-coupled, Shared Situational Awareness
- Coordinated Machines that Execute Commander's Intent for Continuous, Integrated Effects

Mission continues thru A2/AD



Machine-assisted ops compressing the kill chain

Operating safely & efficiently



Collision Avoidance



Work-centered PED cell



Unmanned wingman extends effects and reach of manned a/c



Intelligence analytic system fuses INT data & cues analyst of threats

Optimized platform operations delivering integrated ISR and weapon effects

Today

2020

2030+

Executing Airman's Intent at the Speed of Computing across Domains



