Potential Aviation Use Cases of Autonomy

- Simplified Vehicle Operations / Unified Flight Controls **[1]**
- Automatic aircraft safety systems (e.g., Auto-GCAS, Garmin Autonomi-Autoland) **[1]**
- In-time Aviation Safety Management Systems **[4]**
- Proactive / Preemptive maintenance planning **[4]**
- Digital flight operations (automated operator-responsible separation capabilities) **[3]**
- Flight deck digital assistance (e.g., Digital Co-pilot) **[1]**
- Reduce crew civil passenger air transport **[1]**
- Beyond Visual Line of Sight Operations by Unmanned Aircraft – Uncontrolled airspace **[1]**
- Unmanned Aircraft Operations – Remotely Piloted – Controlled Airspace **[1]**
- Multi-aircraft operations (m:N) – Shifting from Remotely Piloted to Remotely Managed flights **[3]**
- High-Altitude Long Endurance (HALE) aka HAPS **[1]**
- Automated flight management for unmanned aircraft contingencies (e.g., lost c2 link) **[3]**

Uniquely Military

- Loyal Wingman **[2]**
- Collaborative mission management for multiple agents **[2]**
- ISR to find objects without direct supervision and pre-programmed flight paths. **[2]**
- Forward area small package resupply (e.g. think of zipline) **[2]**
- Collaborative platforms as a force multiplier for many mission types. **[2]**

AIAA SHAPING THE FUTURE OF AEROSPACE

Proposed Breakouts For Transformational Engineering Workshop on Aviation Use Cases

1. Commercial Flight Operations
   - Facilitator: Lesley Weitz or Craig Wanke (MITRE)
   - Discussion Capture: Fred Wieland (Mosaic ATM)
2. Military Flight Operations
   - Facilitator: Jim Paunicka (Boeing)
   - Discussion Capture: David Maroney (MITRE)
3. Airspace and Operational Control
   - Facilitator: Andy Lacher (NASA LaRC)
   - Discussion Capture: Alex Cundiff (NASA LaRC)
4. Support Functions (safety data analytics, maintenance, training, etc.)
   - Facilitator: Louis Alvarez (MIT-Lincoln Lab)
   - Discussion Capture: Nipa Phojanamongkolkij (NASA-LaRC)

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Flight Deck Digital Assistance

- **Key Stakeholder(s)**: OEMs, Avionics Manufacturers, Commercial Operators, Defense Operators, General Aviation, Regulators
- **Short Description**: The use of a variety of decision aids both integrated and non-integrated (e.g., Electronic Flight Bags) that assist flight crews with performance of their tasks which will reduce cognitive workload, catch errors, and improve decision-making (e.g., speed of decisions, expansion of options considered) resulting in increased safety and efficiency of flight operations. Could include memory aids/reminders, anticipatory information retrieval, monitors/alerts, calculators, warnings, etc. leveraging intuitive interfaces including voice recognition.
- **Main Assumptions**: Appropriate information can be stored, and voice recognition capabilities can meet performance requirements.
- **Driving Needs/Requirements**: Voice recognition, real-time connectivity to necessary information, integration with aircraft telemetry and systems information, processing power
- **Dynamic Requirements:**
- **Related Metrics**: Cognitive workload reduction, Improvements in the quality of decisions (how much safer are the decisions), Error reductions
- **References:**

Kevin Burns, Craig Bonaceto, Steven Estes, John Helleberg; *Evaluating the Operational Safety of a Digital Copilot*; Cognitive Assistance in Government and Public Sector Applications AAAI Technical Report FS-17-02; https://cdn.aaai.org/ocs/15983/15983-69873-1-PB.pdf

Steinfeld, A., Quinones, P., Zimmerman, J., Bennett, S., and Siewiorek, D.2007. Survey Measures for Evaluation of Cognitive Assistants. Proceedings of the NIST Performance Metrics for Intelligent Systems Workshop, 189-193. Washington, DC.

Multi-Aircraft Operations

- **Key Stakeholder(s)**: New Entrants (Urban Air Mobility, Drone Delivery, Regional Air Mobility), Regulators
- **Short Description**: Through the use of remote pilots of unmanned aircraft, it is now potentially possible for a single pilot to be responsible for multiple simultaneous operations. To improve economies of scale and to ensure reliable flight operations, many of the Advanced Air Mobility new entrants have a future vision where a small team of pilots (i.e., 'm') can be operating multiple simultaneous flights (i.e., 'N'). Often referred to as m:N operations.
- **Main Assumptions**: Automation can be reliable enough to increase the "neglect time" and enable human operators to be in an oversight / supervisory role and not be required to have situation awareness to assume direct control in the event of an off-nominal event.
- **Driving Needs/Requirements**: Automation is capable of appropriately responding to all nominal and off-nominal events
- **Dynamic Requirements:**
- **Related Metrics**: Cognitive workload, Neglect time, Effectiveness of decision-making for off-nominal events
- **References:**

Boeing/Wisk; *Concept of Operations for Uncrewed Urban Air Mobility*; https://wisk.aero/wp-content/uploads/2022/09/Concept-of-Operations-for-Uncrewed-Urban-Air-Mobility.pdf

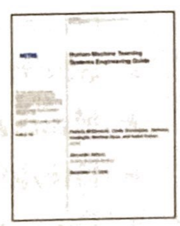
Characteristics of a Trustworthy AI System

Safe	Secure & Resilient	Explainable & Interpretable	Privacy-Enhanced	Fair - With Harmful Bias Managed	Accountable & Transparent
Valid & Reliable					

NIST Artificial Intelligence Risk Management Framework (AI RMF 1.0)
https://nvlpubs.nist.gov/nistpubs/ai/NIST.AI.100-1.pdf

Metric Classes for Human Machine Teaming

- Observability – Human transparency into what automation is doing
- Predictability – Human able to observe and understand intentions and activities of automation
- Attention Directing – Automation is able to direct human attention appropriately
- Solution Space Exploration – Ensures joint exploration of the appropriate solution space
- Adaptability – Automation recognizes and adapts to unexpected situations
- Operator Directability – Humans can direct and redirect automation priorities/activities
- Calibrated Trust – Human is able to understand when and how much to depend on automation partner based upon demonstrated competency
- Common Ground – Human's beliefs, assumptions and intentions are appropriately reflected in the automation
- Understandability/Simplicity – Human is able to understand what the automation is doing by the information presented.



https://www.mitre.org/sites/default/files/2021-11/prs-17-4208-human-machine-teaming-systems-engineering-guide.pdf

Another Thought on Metrics

- **Functional -ilities** – Reliability, Availability, Accuracy, Trustworthiness, Resiliency
- **Cyber-resistance** – How well the system handles cyber threats (data corruption, malicious or adversarial injection of bad training data, jamming, etc.)
- **Temperament** - Measure of gradual failure with degraded function vs. abrupt failure and loss of function
- **Human/machine teaming** – clear role for normal, degraded, off nominal.
- **Training** – level of skill required by the user and how to measure that "skill"
- **Operational resiliency** – how well the autonomy adapts to mission changes, Operational Design Domain (ODD) changes. Flexibility in design and ops assumptions – narrow or broad ODD
- **Fragility – Brittleness** – How robust is the system in a real-world environment?
- **Complexity of info** feeding the function for proper behavior – data for AI, sensors, corrections/changes to tasking
- **Portability/Agility** – How easily can the system be deployed in different scenarios – does it require a large re-work for small changes in mission/ODD, etc.?
- **Collaboration** – How easily can the system be integrated with existing systems, tactics, cross-force collaboration, sharing of data, standard or unique protocols?

Template for describing use cases

Title

- **Key Stakeholder(s):**
- **Category:** [Commercial Flight Operations; Military Flight Operations; Airspace and Operational Control; Support Functions]
- **Short Description:**
- **Main Assumptions:**
- **Driving Needs/Requirements:**
- **Dynamic Requirements:** Requirements that may change after deployment.
- **Related Metrics:**
- **References:**