

Identifying Human Factors (HF) Research for Unmanned Aircraft Systems (UAS) and Advanced Air Mobility (AAM)

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Why?

- **UAS/AAM changes ripple throughout aviation HF**
- **One can argue HF needs are almost everywhere**
 - Responsibilities
 - Tasks
 - Procedures
 - Training
 - Equipment
 - ...in aircraft, traffic mgmt., etc.



- **There is another way to think about HF Research...**

What?

- Focus on *fundamental* differentiating aspects of UAS/AAM
- Differentiate from conventional aviation
 - What is the delta?



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- Leverage existing guidance, policy, standards, regulations, etc.
- Focus on HF and safety

How?

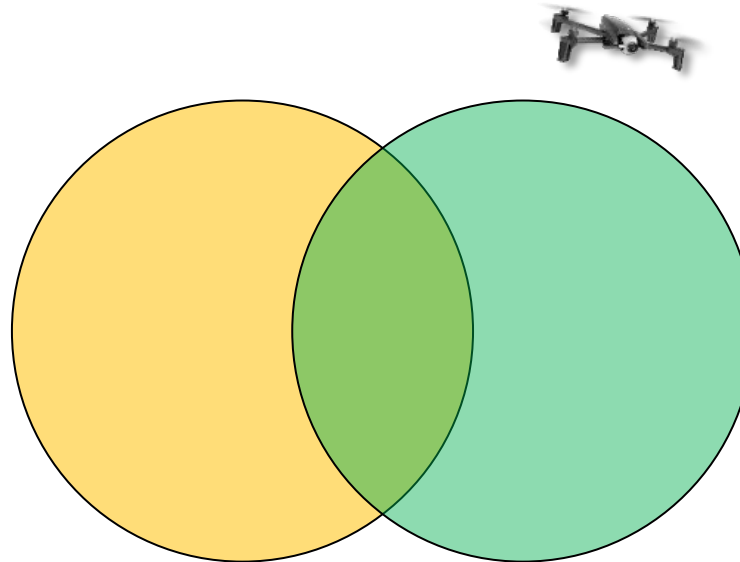
- **Identify HF research that meets the following criteria:**
 - Derived from key characteristics of UAS/AAM
 - Existing guidance is insufficient
 - Research so far is insufficient
- **Use of illustrative example topics (8)**
 - Sustained low-altitude ops (3)
 - Loss of natural sensing
 - Novel aircraft
 - Novel ops
 - Link mgmt. and lost link
 - Link performance (2)
 - Distributed pilot teams (2)
 - Increased automation
- **Not intended to be exhaustive, prescriptive or prioritized**

Working Descriptions and Scope



AAM

- **Advanced Technologies, such as:**
 - Distributed propulsion
 - eVTOL
 - Increasingly autonomous technologies



UAS

- **No onboard pilot**
- **Aircraft plus control station, link, etc.**

eVTOL = electric vertical takeoff and landing

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Union
(not intersection)
of
AAM and UAS

8 HF topics presented (no particular order) ...

eVTOL = electric vertical takeoff and landing

Sustained low altitude operations (1 of 4)

Example HF Topics

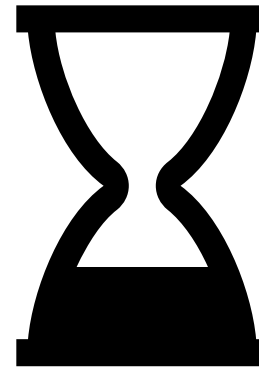
- Response times
- Traffic/terrain integration and use
- Microweather integration and use



Sustained low altitude operations (2 of 4)

- **Response times**

- Increased ops complexity and info density combined with time pressure
- E.g., alt. landing sites (urban)



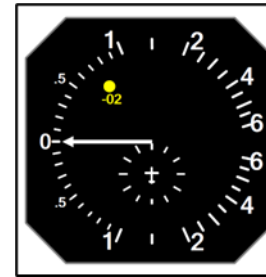
Sustained low altitude operations (3 of 4)

- Response times

- **Traffic/terrain**

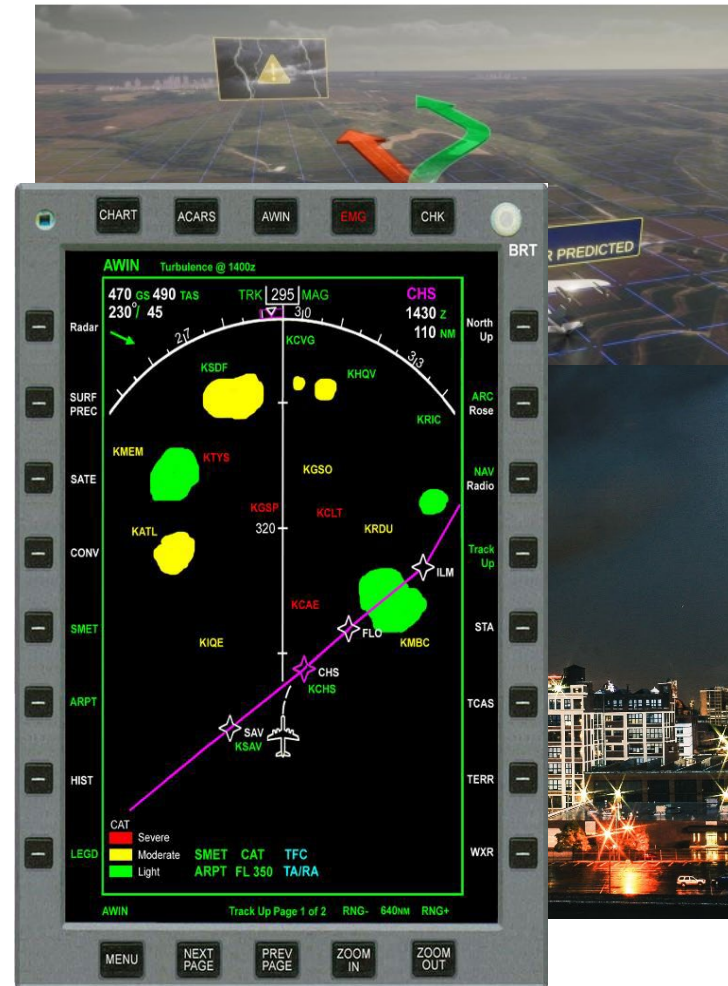
- Diverse traffic (aircraft and ops)
- Diverse traffic avoidance systems
- Combined traffic and terrain guidance and procedures

- Microweather



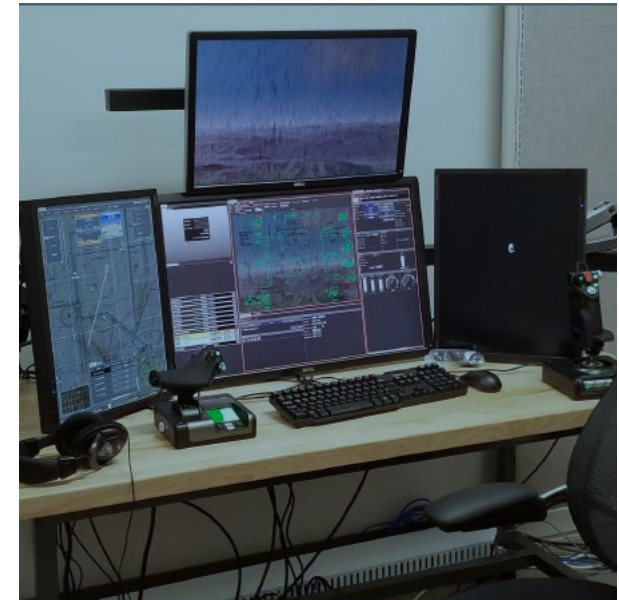
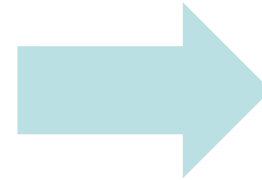
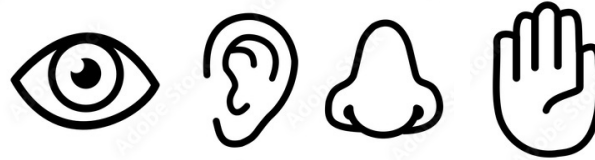
Sustained low altitude operations (4 of 4)

- Response times
- Traffic/terrain
- **Microweather**
 - High density info
 - Local variance
 - Topographic and structure dependencies
 - More uncertainty and faster change
 - Susceptibility of aircraft



Loss of natural sensing

- UAS pilot not collocated with aircraft and its environment
- What are all the consequences of this, related to sensed information?
 - Esp. low altitude



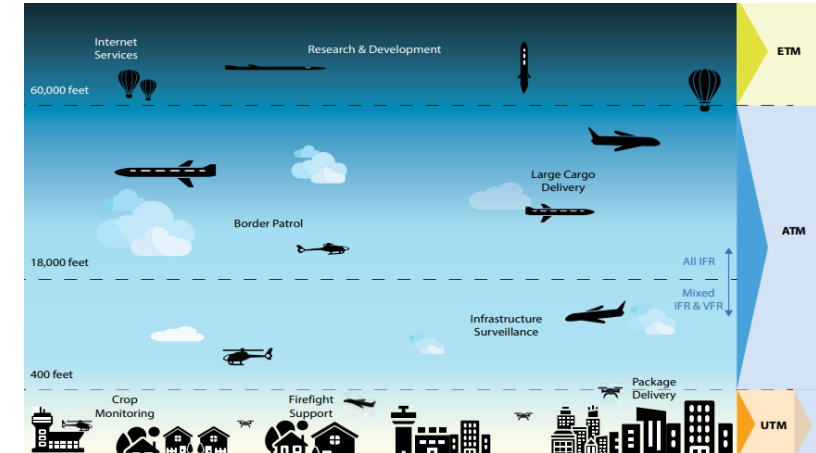
Novel aircraft

- **UAS increasingly automated inner-loop control, due to:**
 - Link performance
 - Dynamics of control
 - Safety vs economic reasons
- **Small size of UAS**
 - No onboard cockpit
- **Electric energy management**
- **New power and flight control**
 - Distributed power
 - Vertical/horizontal transitions
 - Novel primary flight controls



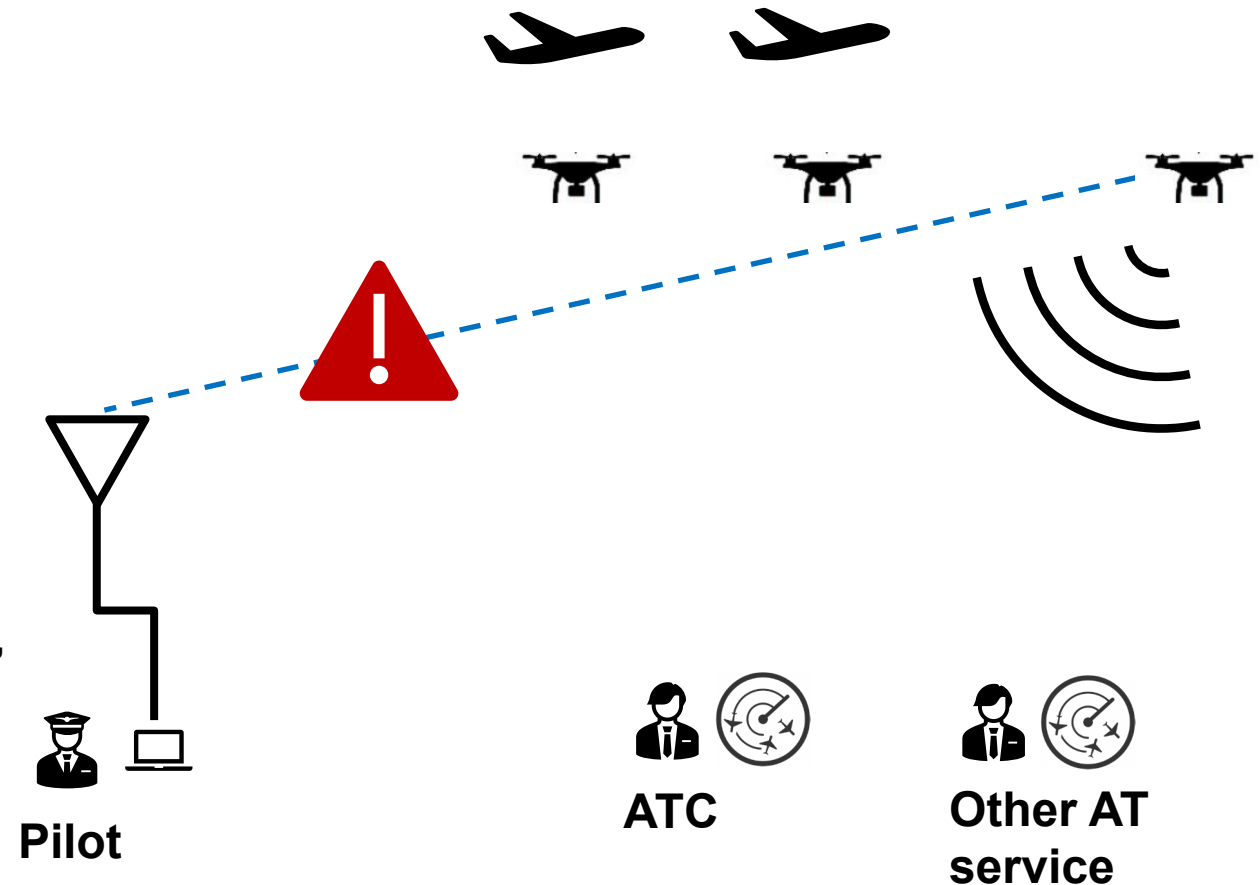
Novel operations

- **Operational diversity and complexity**
 - Aircraft performance, equipment, pilot location, automation, termination points
 - Impacts pilots, air traffic services, etc.
- **UAS ops novelty**
 - Ditching on land
 - Swarm control and behavior
 - Shielded operations
 - etc.



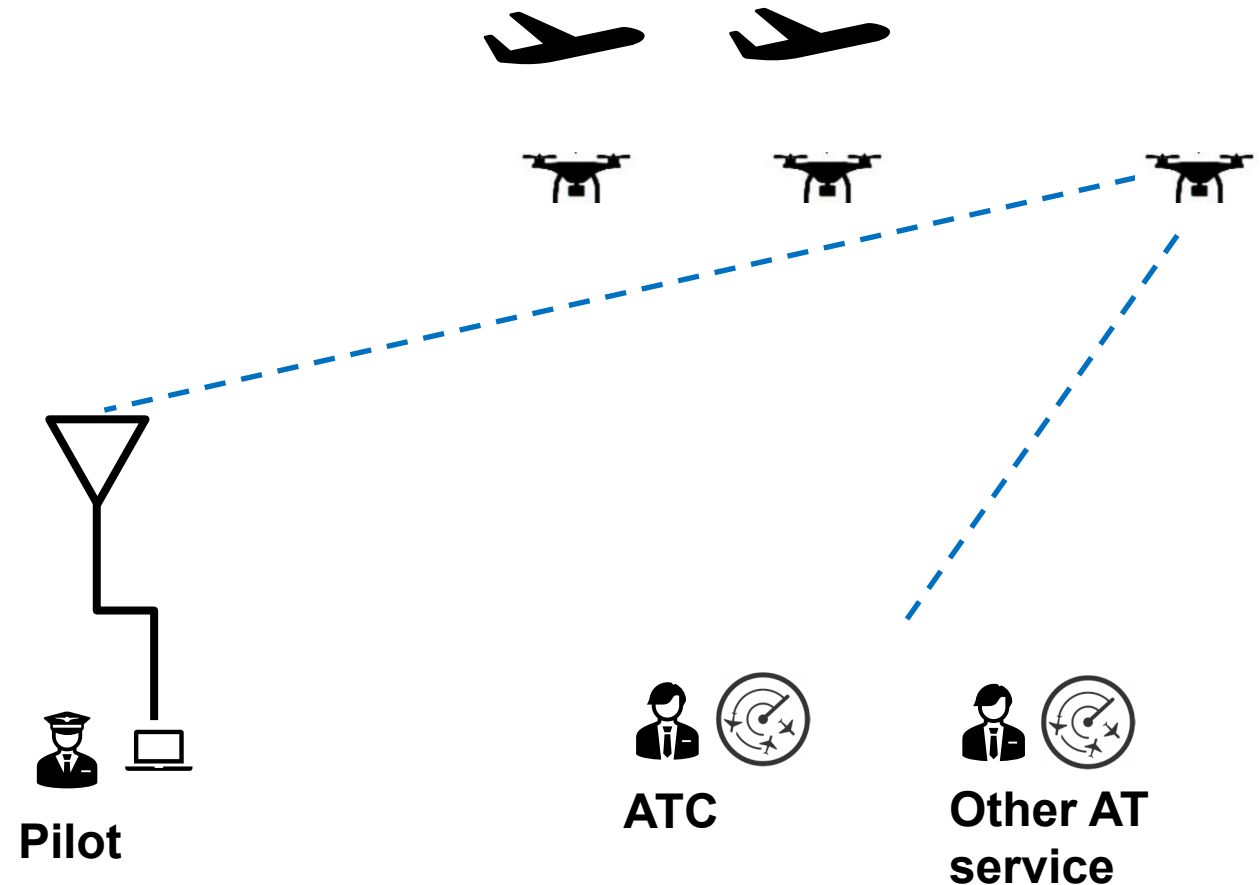
UAS Link management and lost link

- New flight crew tasks
- Crew link monitoring and alerts
- Crew awareness of degradation factors (pilots)
 - Coverage area
 - Obstructions
 - Aircraft orientation
- “Lost link” (air traffic mgmt)
 - Binary determination of lost link state
 - Standard and custom procedures (e.g., continue, return, holding area)



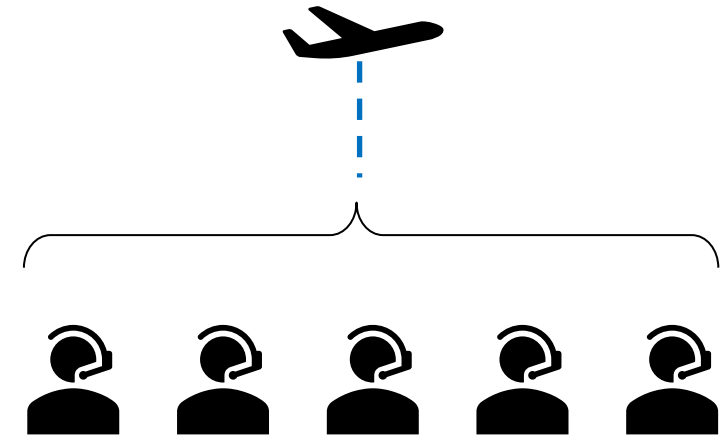
UAS Link performance

- **Required link performance (RLP) dependent on**
 - Human operator needs
 - Aircraft automation
- **Voice relay considerations**
 - Party line
 - Latency



Distributed pilot teams (UAS)

- No cockpit physical constraint
- Flight crew teams can be distributed and dynamic
- Control handoff
 - Handovers and switchovers
 - Sequence, timing, and flight phase tradeoffs
- Multi-aircraft control
 - More complex question than “how many aircraft?”
 - Strong dependence on team size, team roles, team distribution, and supporting procedures/automation
 - What can be generalized (e.g., towards a standard)?



Air traffic controllers shown, to illustrate a team

Increased automation

- Assumed to be key enabler of UAS/AAM
- **Specific research** often needed to understand rippling human/automation effects for **specific functions** of systems (i.e., hardware/software)
 - New system failure modes
 - Workflow, tasks, and errors
 - Human contributions to safety
 - Workload and engagement
 - Supporting displayed information
 - Knowledge dependencies
 - Proficiency and training
 - Control authority and responsibility
 - System behavior that is predictable and unambiguous
 - V&V* of system functions that are traditionally human tasks

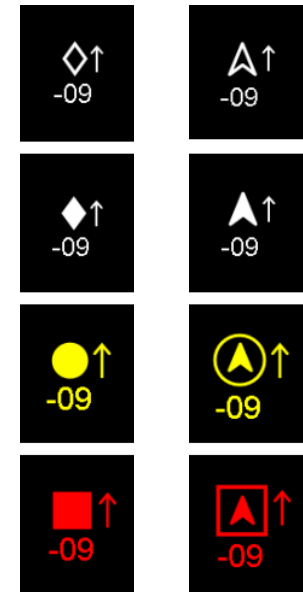
* verification and validation



All that, in contrast to...

- **Examples**

- Alert colors and symbols (guidance exists)
- Information clutter and legibility (guidance exists)
- System controls (guidance exists)
- Speech recognition for pilot controls (not unique to UAS/AAM)
- Use of AI/ML vs conventional algorithms (not unique to UAS/AAM)



Example: Cockpit Display of Traffic Information (CDTI)

Summary

- HF research needs are fundamental to UAS and AAM
- HF research landscape is complex to understand
- This paper provides criteria and examples to improve understanding of HF research needs

