Studying human-system interaction with the UTM system

Lynne Martin

NASA Ames Research Center, CA
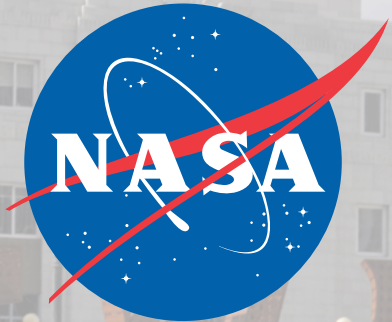
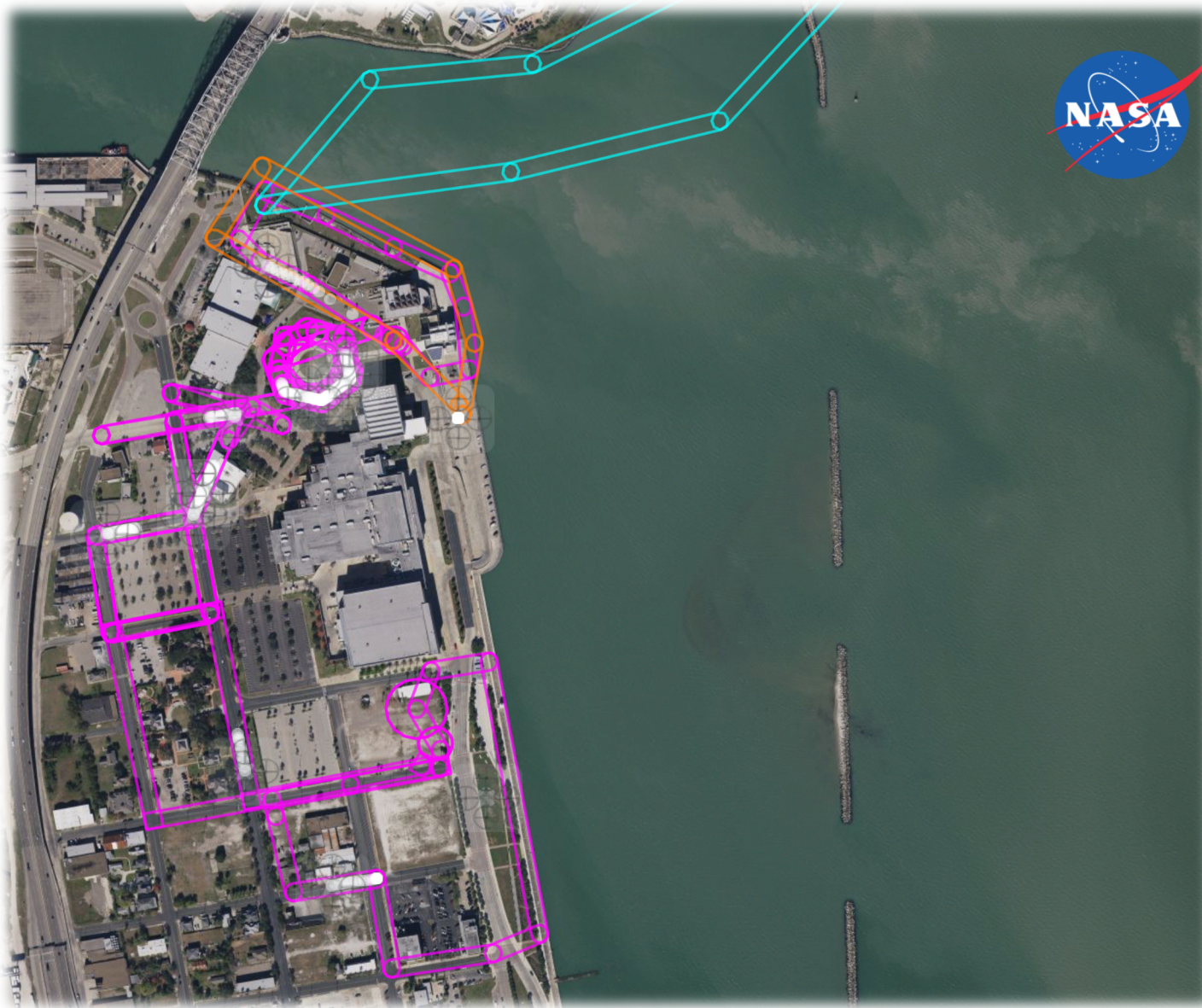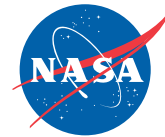# Studying human-system interaction with the UTM system

Lynne Martin and the AOL HF Team:

Joey Mercer, Jeffrey Homola, Faisal Omar, Lauren Claudatos, Cynthia Wolter, Yasmin Arbab, Madison Goodyear, Michele Cencetti, Vimmy Gujral, Kim Jobe, and Abhay Borade
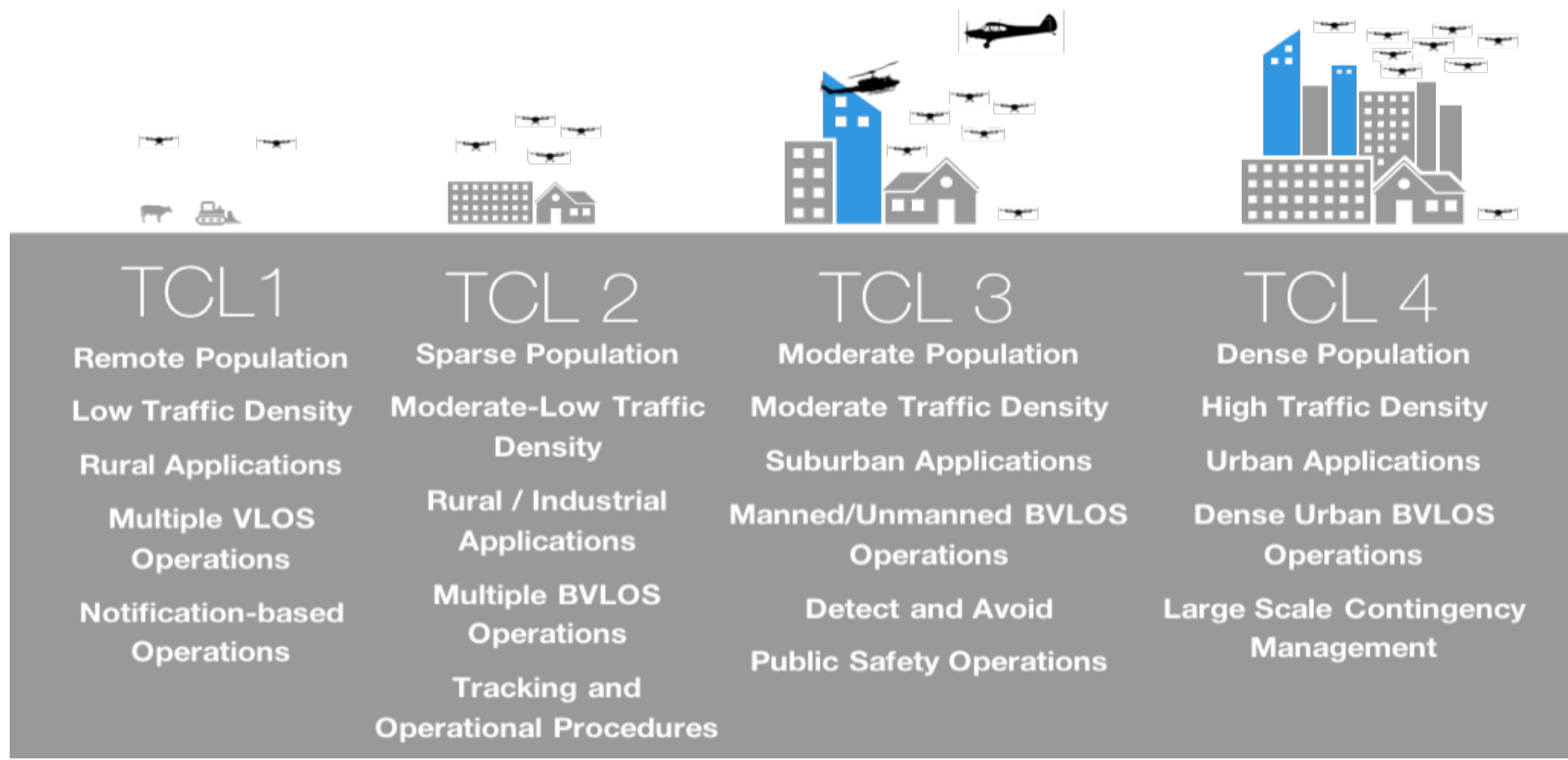
UAS Traffic Management (UTM)

Technical Capability Level (TCL) and risk association

TCL 1	TCL 2	TCL 3	TCL 4
Remote Population	Sparse Population	Moderate Population	Dense Population
Low Traffic Density	Moderate-Low Traffic Density	Moderate Traffic Density	High Traffic Density
Rural Applications	Rural / Industrial Applications	Suburban Applications	Urban Applications
Multiple VLOS Operations	Multiple BVLOS Operations	Manned/Unmanned BVLOS Operations	Dense Urban BVLOS Operations
Notification-based Operations	Tracking and Operational Procedures	Detect and Avoid	Large Scale Contingency Management
		Public Safety Operations	

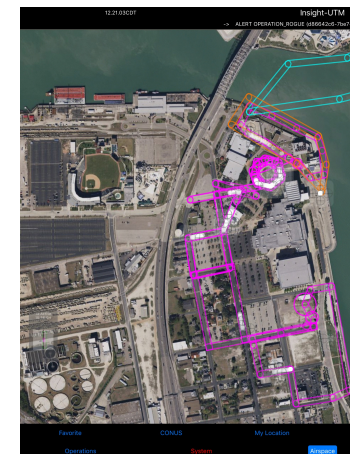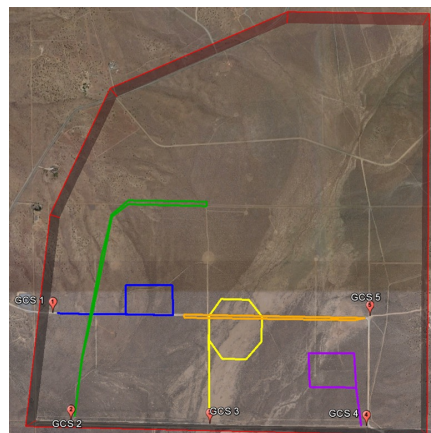Increasing risk
Increasing capability ➝

TCL and HSI considerations

Increasing capability
Increasing complexity of interactions

TCL1   TCL2   TCL3   TCL4

Simple interface   More complex interface

Few functions   Many functions

Developer-user   Crew member

Pre-plan whole area   Pre-plan own flight

HSI =
Human-
System
Interaction

Simple questions &
observations   Detailed questions

Demonstration parameters

	Flight demonstration details				
	Test 1	**Test 2**	**Test 3**	**Test 4**	**Test 5**
Technical Capability Level (TCL)	TCL1	TCL2	TCL2	TCL3	TCL4
Date	2015-16	2016	2017	2018	2019
Locations	1	1	7	7	5
Flying organizations	8	11	18	17	18
Vehicles	10	7	27	28	21
Flight days	8	5	17	50	20
UAS Service Supplier (USS)	3	8	7	9	7
Scenarios	3	4	17	20	5

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HF data collected across the UTM project

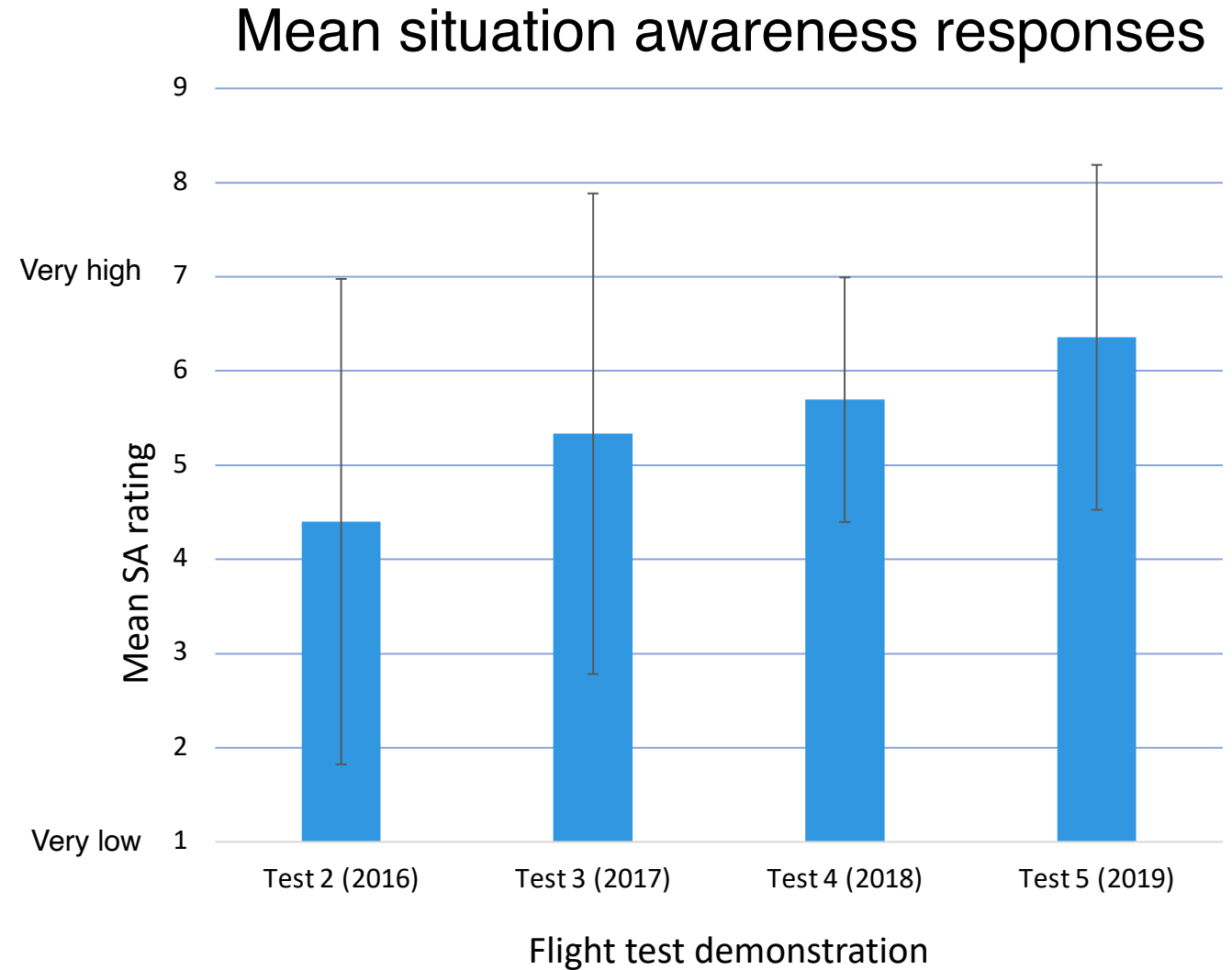|	Flight demonstration level and year				
	Test 1	**Test 2**	**Test 3**	**Test 4**	**Test 5**
Technical Capability Level	TCL1	TCL2	TCL2	TCL3	TCL4
Date	2015-16	2016	2017	2018	2019
Data collected					
Participant surveys	N/A	72	141	274	149
Interviews & debriefs	N/A	5	18	22	19
Hours of debrief	N/A	Approx. 5 hours	Approx. 9 hours	Approx. 8.5 hours	Approx. 9 hours
Flight sessions observed	N/A	24	34	50	75

Flight test demonstrations – Summary

- Successful demonstration that UTM is a viable method for communication and coordination between sUAS operations

- Successful HSI demonstration of:
  - Data exchange through the system, bringing information from one party to another for situation awareness
  - sUAS enacting contingency maneuvers, showing alerting and demonstrating, and what information would be needed for real time decision making
  - Complex operations, e.g., multiple, altitude-stratified operations, that gave us a window into the types of procedures crews needed to have in place

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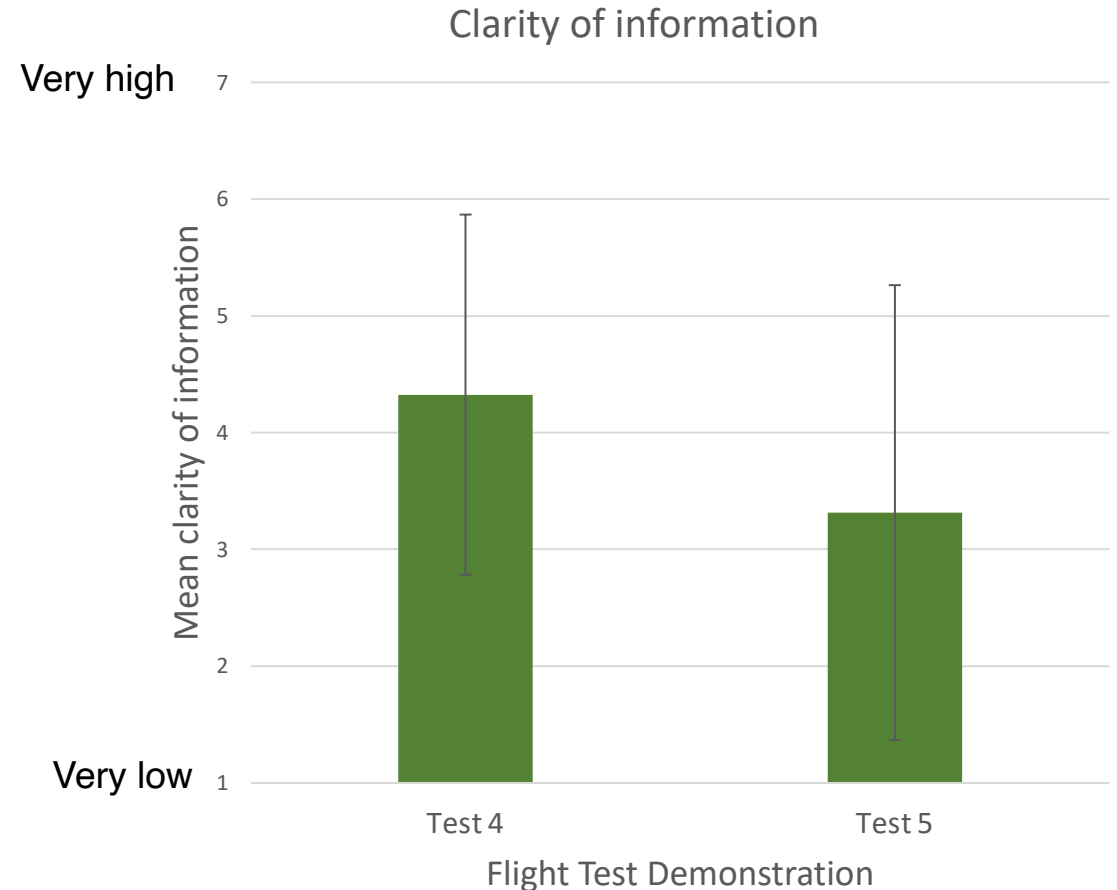# General HSI findings – Information quantity

- In earlier tests
  - Details missing in UTM information that made it more difficult for crews to establish SA
- In later tests
  - USS interfaces matured and much more detailed information was available for broader SA
  - Information need to be clear and timely

HSI = human system interaction

Mean situation awareness responses

Mean SA rating vs Flight test demonstration

Test 2 (2016)	
Test 3 (2017)	
Test 4 (2018)	
Test 5 (2019)	

Very high (7)
Very low (1)

Response scale was 1 to 7, extended in chart to show standard deviations

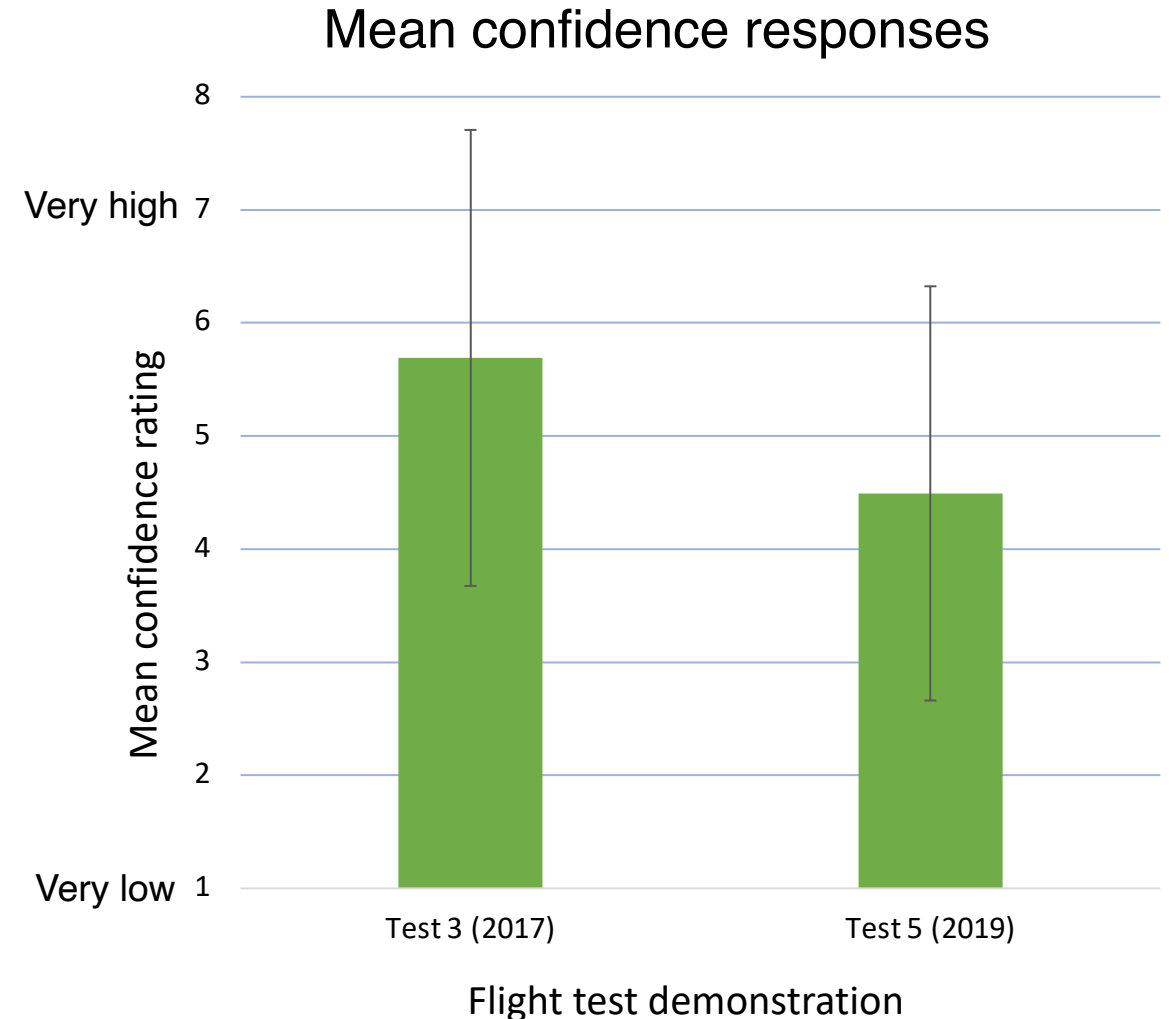# General HSI findings – Increasing complexity

- ## In later tests
  - ## Clutter
  - ## More complex environments required more information to be presented
  - ## Too many messages for crew to read
  - ## Message labels not informative for crew

Clarity of information

Very high

Mean clarity of information

Very low

Test 4   Test 5

Flight Test Demonstration

HSI = human system interaction

Response scale was 1 to 7

General HSI findings - Standardization

- Unfamiliar terminology

  - Information was hard for some users to interpret

- Measurement consistency

  - Use of different units required crews to manually resolve issues

- Undefined procedures

  - UAS an infant industry – no standard approaches to guide the users

  - Too little time for users to make complex contingency decisions

Mean confidence responses

HSI = human system interaction

Response scale was 1 to 7, extended in chart to show standard deviations

UTM as a human-automation system

- While the end-state of the system is fully automated, the interim nearer-term states will still require manual interaction

- Challenges for near-term usage :
  - Designing displays that are easily understandable in a TCL4 environment
    - E.g., Messages that are filtered by criticality
  - Creating UTM training for users

- Challenges for mid-term usage :
  - Automating functions in a manner that keeps remaining manual tasks as coherent activities

Moving to UAM – Urban Air Mobility

UAM concept image courtesy of K. Witzberger, UAM sub-project lead

Do UTM HSI findings translate?

- Yes and no!

- No: UAM is more complex
  - E.g., will require changes in the way airspace is used
  - E.g., PF-PNF team are probably distributed, many more different types of user
  - E.g., many more airworthiness & certification requirements

- Yes: Users have the same basic needs
  - E.g., Interfaces need to be easily usable
    - Understandable displays (to foster SA)
    - Straightforward in-flight input sequences (to reduce distraction)
  - E.g., Function allocation is important
    - Procedures with clear flows & task allocation

- **Operations**
  - Urban operations in all weather conditions

- **Aircraft Performance**
  - Diverse aircraft concepts

- **Automated Systems**
  - Full authority envelope protection, auto takeoff, auto land

- **Pilot Requirements**
  - Reduced skill, expertise and proficiency

- **Command and Control Interaction**
  - Inceptors, Displays, Interfaces

Images and categories courtesy of M. Feary (2020) HFES UAM-HF-issues panel
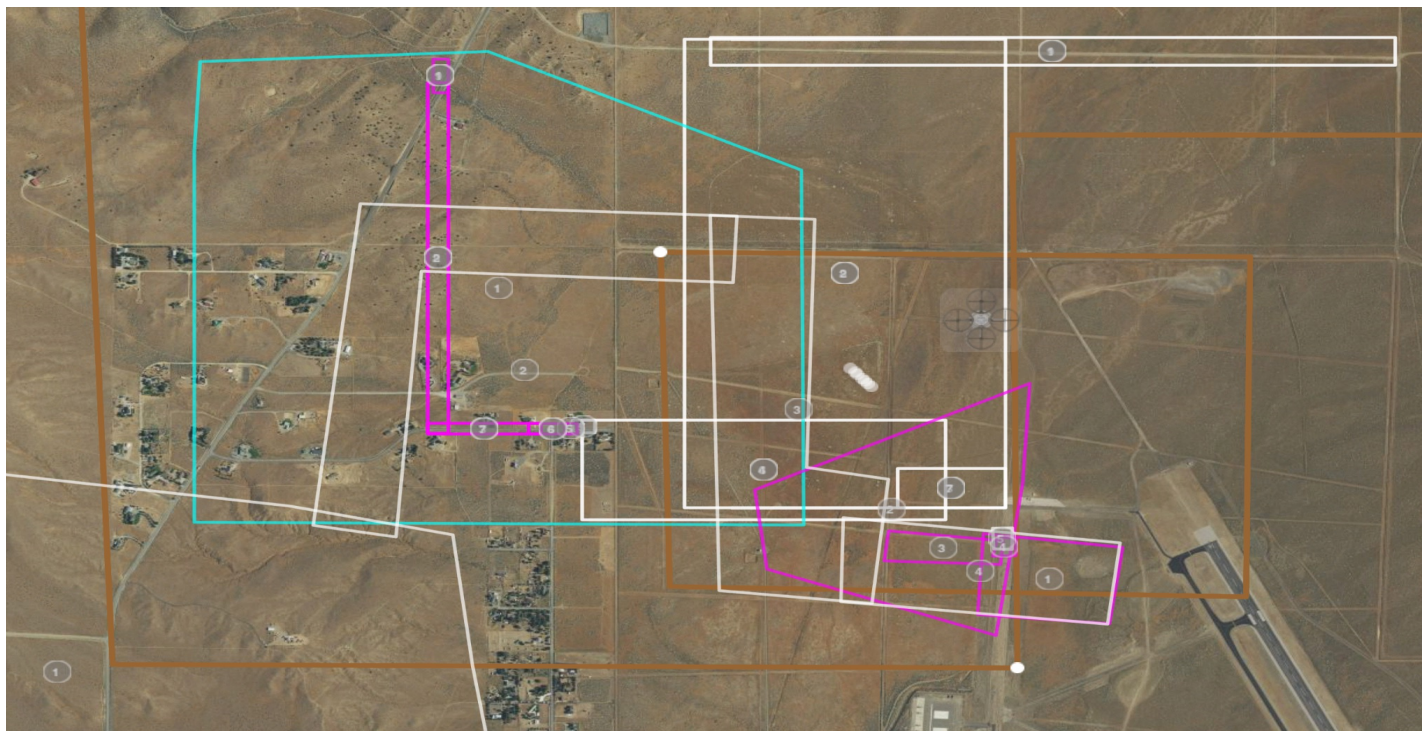
Thank you!

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Questions?

Back up

Summary

- Successful demonstration that UTM is a viable method for communication and coordination between sUAS operations

- But also to provide enough information to operators for them to have awareness and coordinate actions

- Future work should spotlight human-automation system interaction to scope nearer-term evolutions of the UTM system

General HSI findings – Using information

Effciency of USS interaction
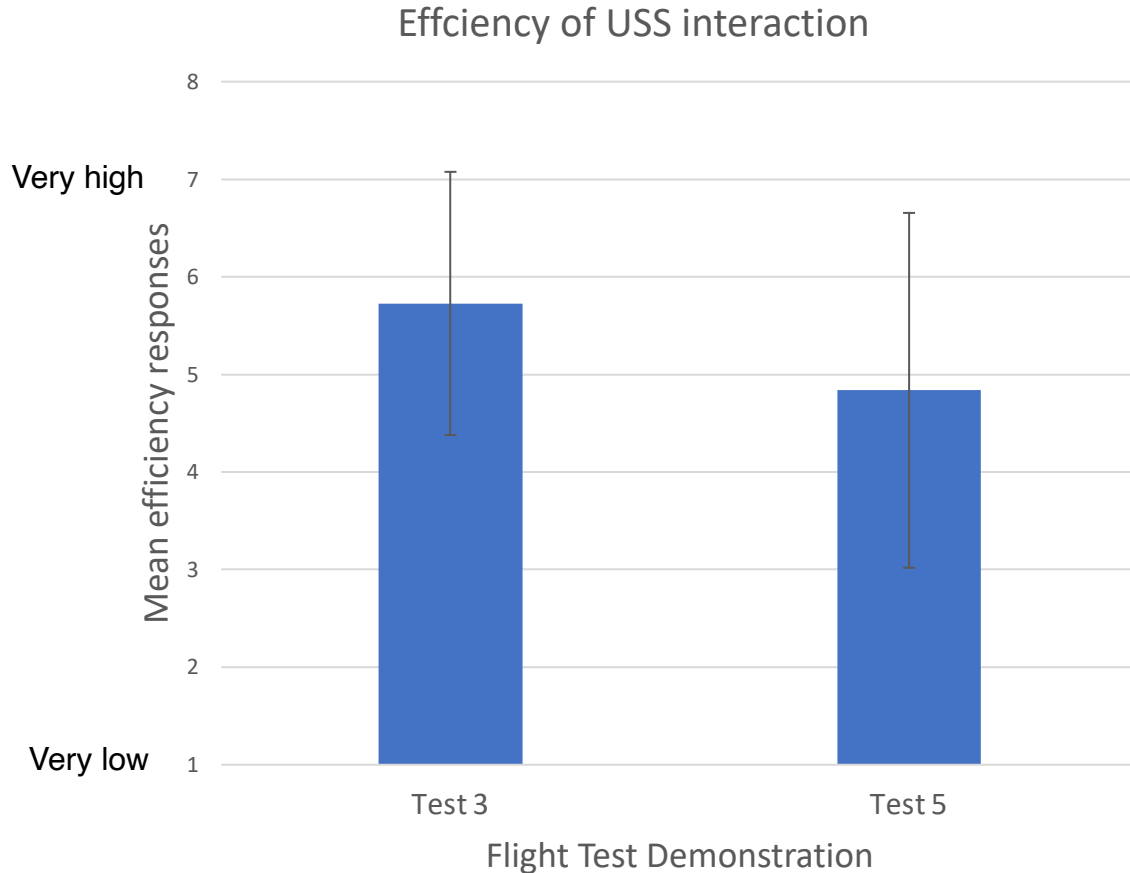
- **In earlier tests**
  - Less information (& more external planning) in UTM made crew decision making more straightforward

- **In later tests**
  - USS interfaces matured and more detailed information was available but it was needed more quickly

HSI = human system interaction

Response scale was 1 to 7, extended in chart to show standard deviations

Simplified Piloting Requirements for AAM

- **Operations**
  - Urban operations in all weather conditions

- **Aircraft Performance**
  - Diverse aircraft concepts

- **Automated Systems**
  - Full authority envelope protection, auto takeoff, auto land

- **Pilot Requirements**
  - Reduced skill, expertise and proficiency

- **Command and Control Interaction**
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Original slide from Feary, 2020