Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Project

Studying human-system interaction within the UTM system

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UTM Technical Interchange Meeting
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Outline

- Technical Capability Level (TCL) and Risk Association
- TCL and Human Systems Integration (HSI) Considerations
- Demonstration Parameters
- Human Factors (HF) Data Collected across the UTM Project
- Flight Test Demonstration – Summary
- General HSI Findings
  - Information quantity
  - Using information
  - Increasing complexity
  - Standardization
- UTM as a Human-Automation System

Technical Capability Level (TCL) and Risk Association

TCL1	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

TCL 1	TCL 2	TCL 3	TCL 4
	Simple interface		More complex interface
	Few functions	→	Many functions
	Developer-user		Crew member
	Pre-plan whole area		Pre-plan own flight

Simple questions & observations → Detailed questions

Demonstration Parameters

	Flight Demonstration Details				
	Test 1	**Test 2**	**Test 3**	**Test 4**	**Test 5**
Technical Capability Level (TCL)	TCL 1	TCL 2	TCL 2	TCL 3	TCL 4
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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Human Factors (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	TCL 1	TCL 2	TCL 2	TCL 3	TCL 4
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

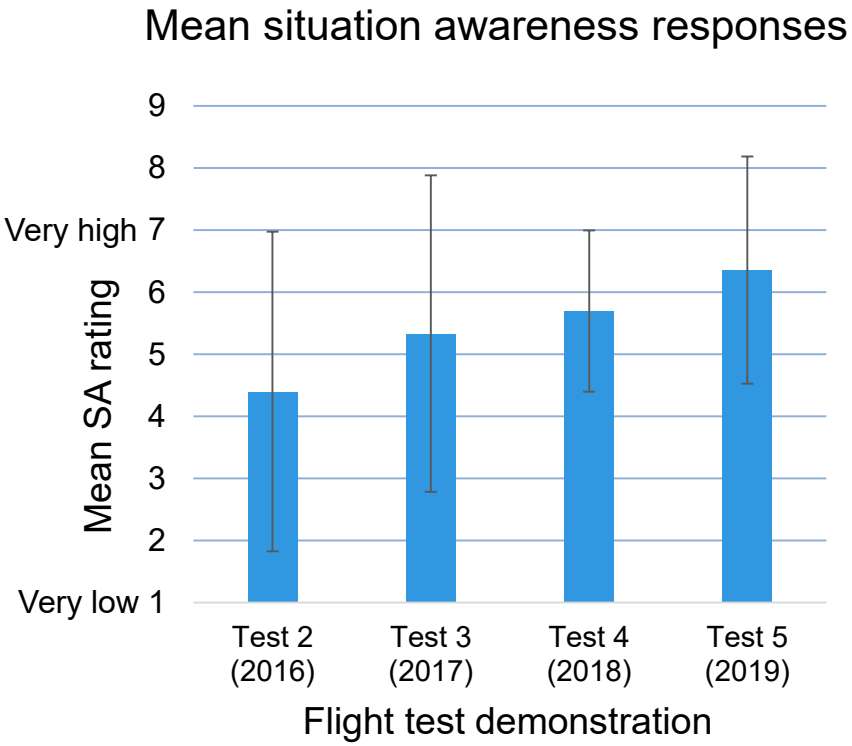
Flight Test Demonstrations - Summary

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

- Successful 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 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

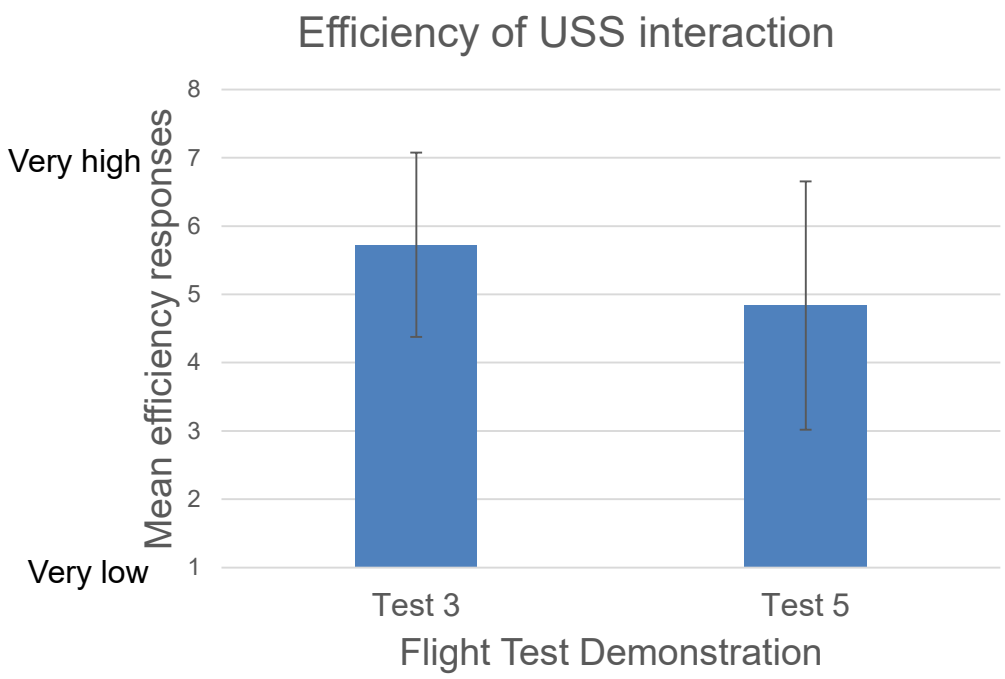
General HSI Findings – Information Quantity

- In earlier tests
  - Details missing in UTM information that made it more difficult for crews to establish situation awareness (SA)
- In later tests
  - USS interfaces matured and much more detailed information was available for broader SA



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

General HSI findings – Using Information

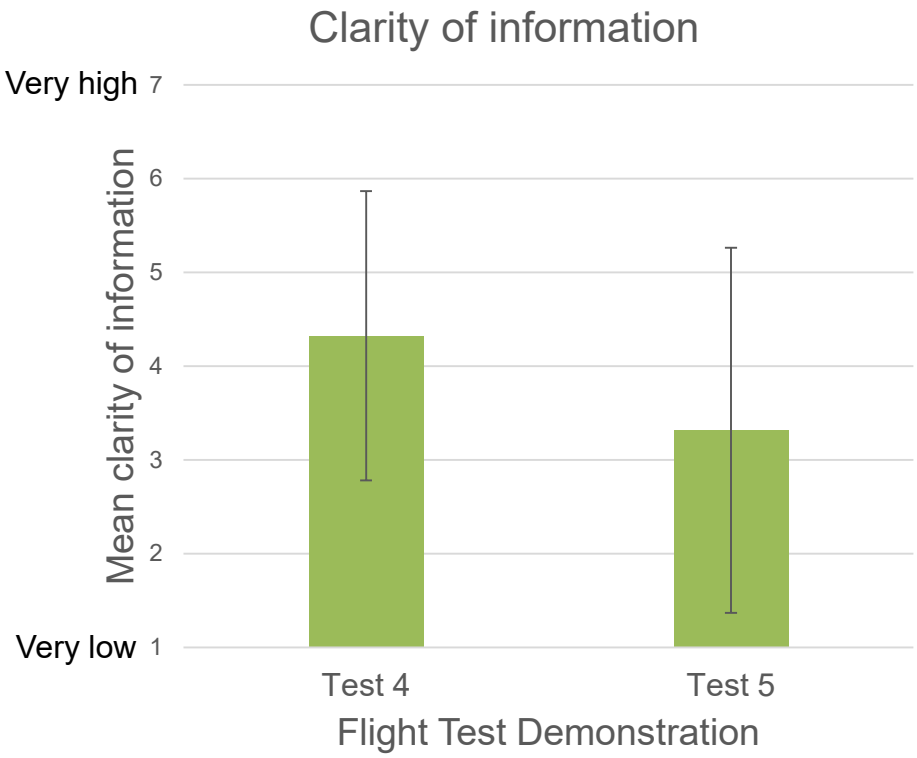


- In earlier tests
  - Less information (& more external planning) in UTM made crew decision making more straightforward
- In later tests
  - USS interfaces matured and more detailed information was available, but it was needed more quickly

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



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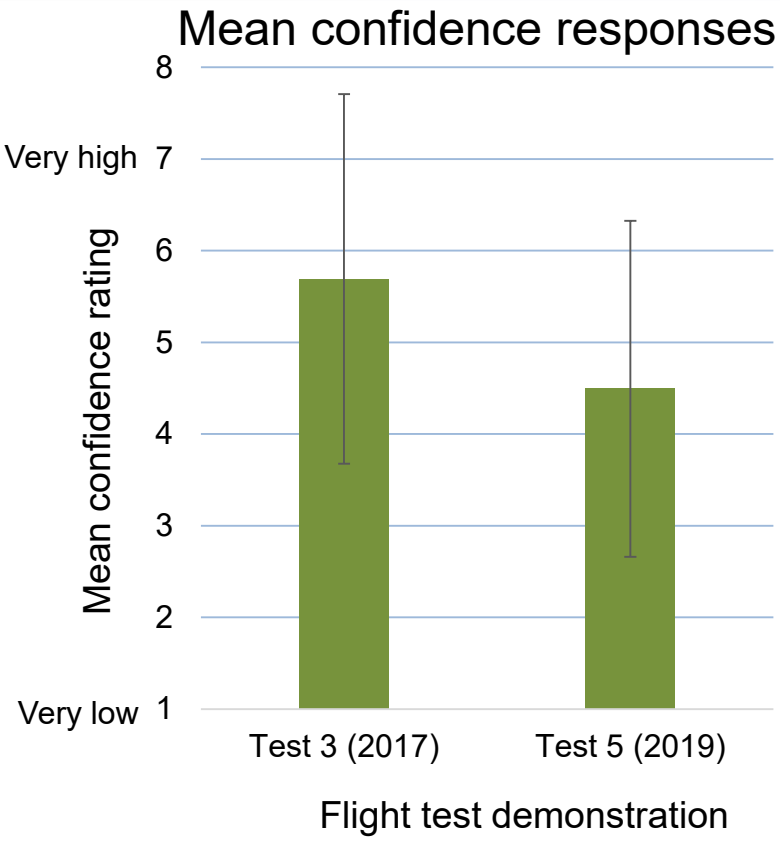
General HSI Findings – Standardization

- 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



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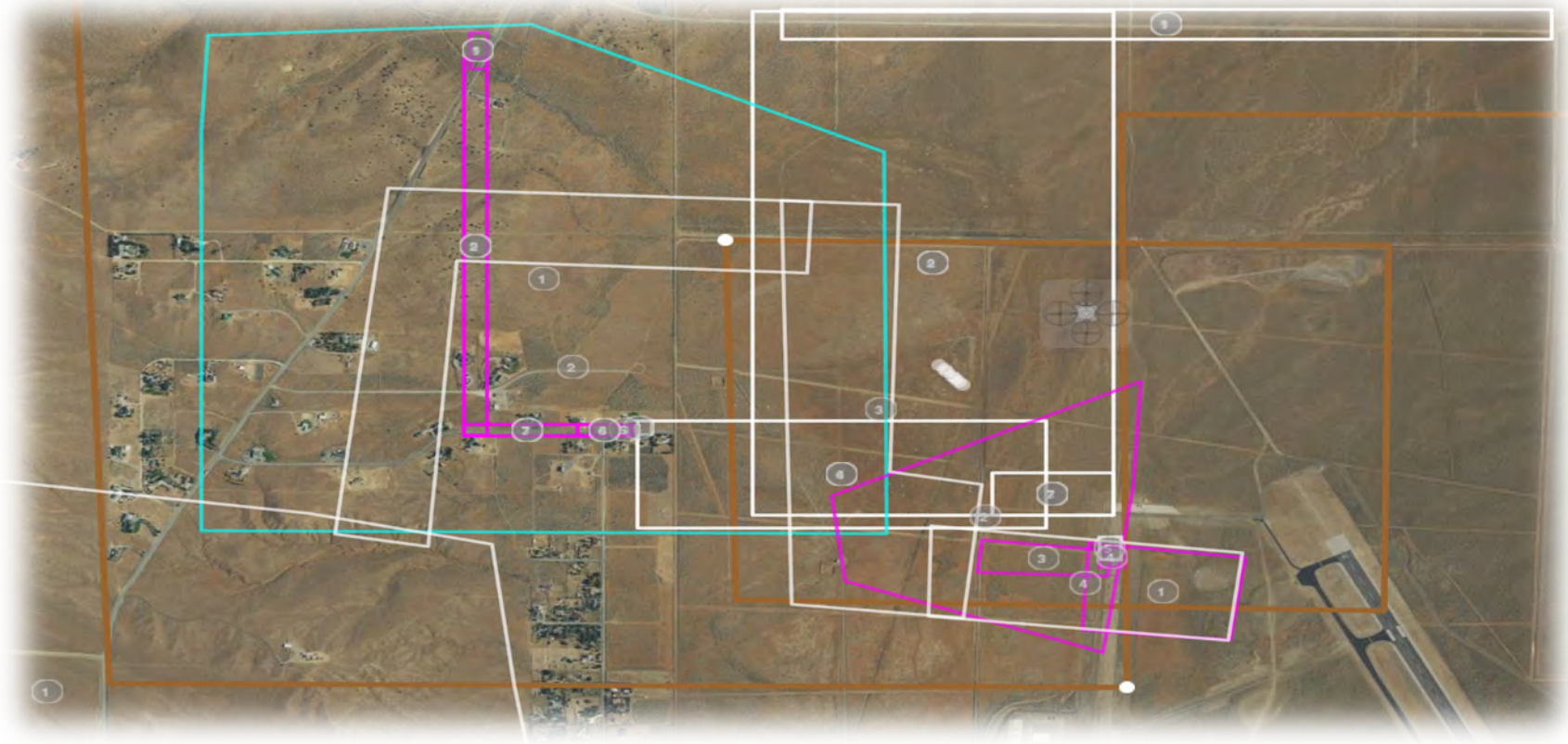
UTM as a Human-Automation System

- 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 usable 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

Summary and Future Work

- 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

Thank you!



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Most Recent Papers and Reports

- Wolter, C., Martin, L. & Jobe, K. (2020). Human-system interaction issues and proposed solutions to promote successful maturation of the UTM system, *39th Digital Avionics Systems Conference (DASC),* IEEE, virtual conference, October 11-16.
- Martin, L., Wolter, C., Jobe, K., Goodyear, M., Manzano, M., Cencetti, M., Mercer, J. & Homola, J. (2020), *TCL4 UTM (UAS Traffic Management) Texas 2019 Flight Tests, Airspace Operations Laboratory (AOL) Report*, NASA/TM-2020-220516, NASA Ames Research Center, Moffett Field, CA.
- Martin, L., Wolter, C., Jobe, K., Manzano, M., Blandin, S., Cencetti, M., Claudatos, L., Mercer, J. & Homola, J. (2020), *TCL4 UTM (UAS Traffic Management) Nevada 2019 Flight Tests, Airspace Operations Laboratory (AOL) Report*, NASA/TM-2020-220466, NASA Ames Research Center, Moffett Field, CA.
- Grossi, C. & Martin, L. (2020). Obtaining public opinion about sUAS activity in an urban environment, *11th International Conference on Applied Human Factors and Ergonomics (AHFE)*, virtual conference, July 16-20.
- Martin, L., Wolter, C., Jobe, K., Homola, J., Cencetti, M., Dao, Q. & Mercer, J. (2019), *TCL3 UTM (UAS Traffic Management) Flight Tests, Airspace Operations Laboratory (AOL) Report*, NASA/TM-2019-220347, NASA Ames Research Center, Moffett Field, CA.