Workload considerations in Urban Air Mobility

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Agenda

- Research motivation & aims
- Method
- Results
  - Reduced communication associated with lower workload
  - Current procedures associated with fewer controlled aircraft
  - Route modification associated with increased traffic, not necessarily reduced workload
- Conclusions & Implications
- Future research

Research Motivation

- UAM receiving rapidly increasing attention across academic, research and industry domains
  - E.g. NASA ‘Grand Challenge’
- Offers potential for significant benefits, but also fundamental change
- Human operator involvement remains undefined
  - Dependent on near, medium and far term operations
  - Dependent on airspace location
- UAM operations will interact heavily with traditional airspace and as such, interactions with ATCOs will occur in the near to mid-term future operations
- Investigation of the impact of UAM traffic on ATCOs’ workload and performance needed to identify and mitigate potential risks to human performance and human operator roles

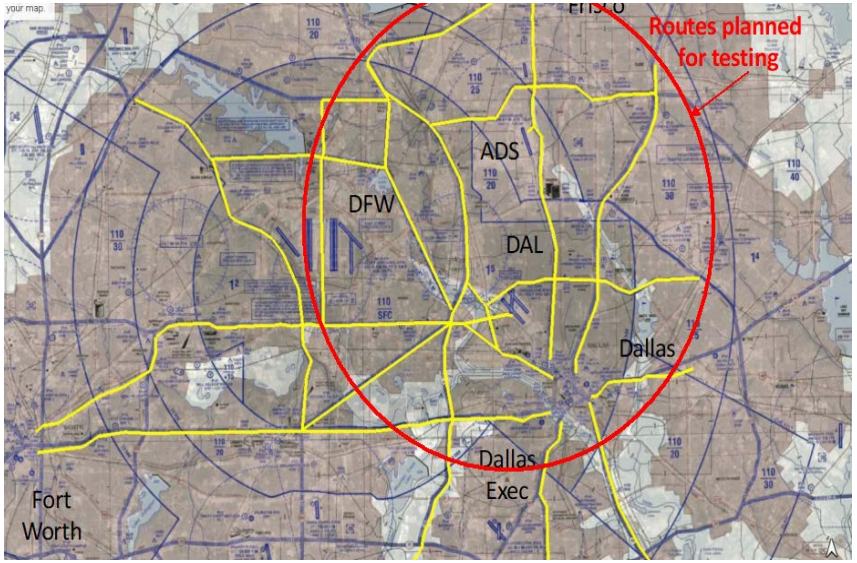
Research overview

- Aim:
  - Investigate the effect of:
    - Task demand
    - Route modification
    - Verbal clearance procedures

  on workload and efficiency-related performance

- Potential Outcomes:
  - Better understanding of human operator roles
  - Contribution to the development of a human-machine interaction paradigm for UAM
  - Inform strategies to support human performance in association with UAM traffic
    - UAM traffic management
    - Interaction with air traffic controllers (ATCOs)

Method: Simulation



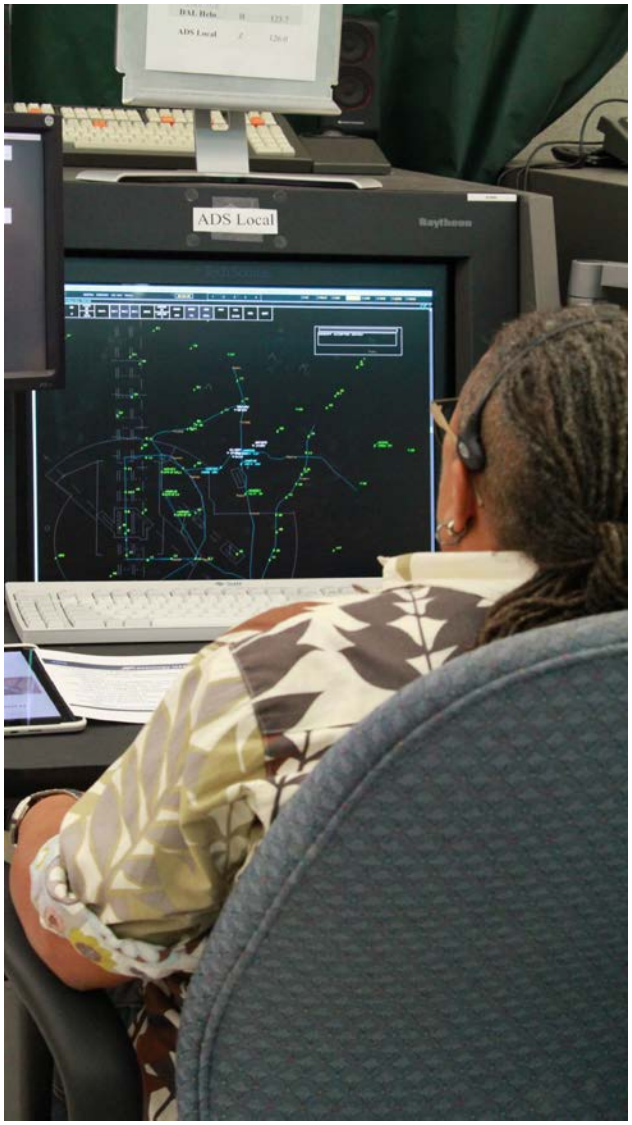
Method: Design(1)

- 3 within-measure variables
  - Task demand
  - Communications procedures
  - Routes

- Three task demand scenarios:

Scenario	Temporal spacing (seconds)	Distance spacing (miles)	Vehicle Count
Scenario 1: Low UAM density	90	3.75	115
Scenario 2: Medium UAM density	60	2.5	167
Scenario 3: High UAM density	45	1.88	225

- Pilot studies confirmed task demand variation associated with workload variation



Method: Design (2)

- Two sets of communication procedure
  - Current day communications

    "UAM942, Love Tower, cleared to enter class bravo. Squawk 4043 [additional instructions]"
  - Simulated letter of agreement – reduced verbal communications

    "UAM173, Love Tower, cleared via [route name]"
- Two sets of routes
  - Current day helicopter routes
  - Modified routes, optimized for UAM vehicles
    - Avoided approach and departure paths for commercial or VFR aircraft
    - Avoided common temporary flight restrictions
    - Avoided heavily populated areas
    - Shorter, more direct
    - Introduced two-way routes

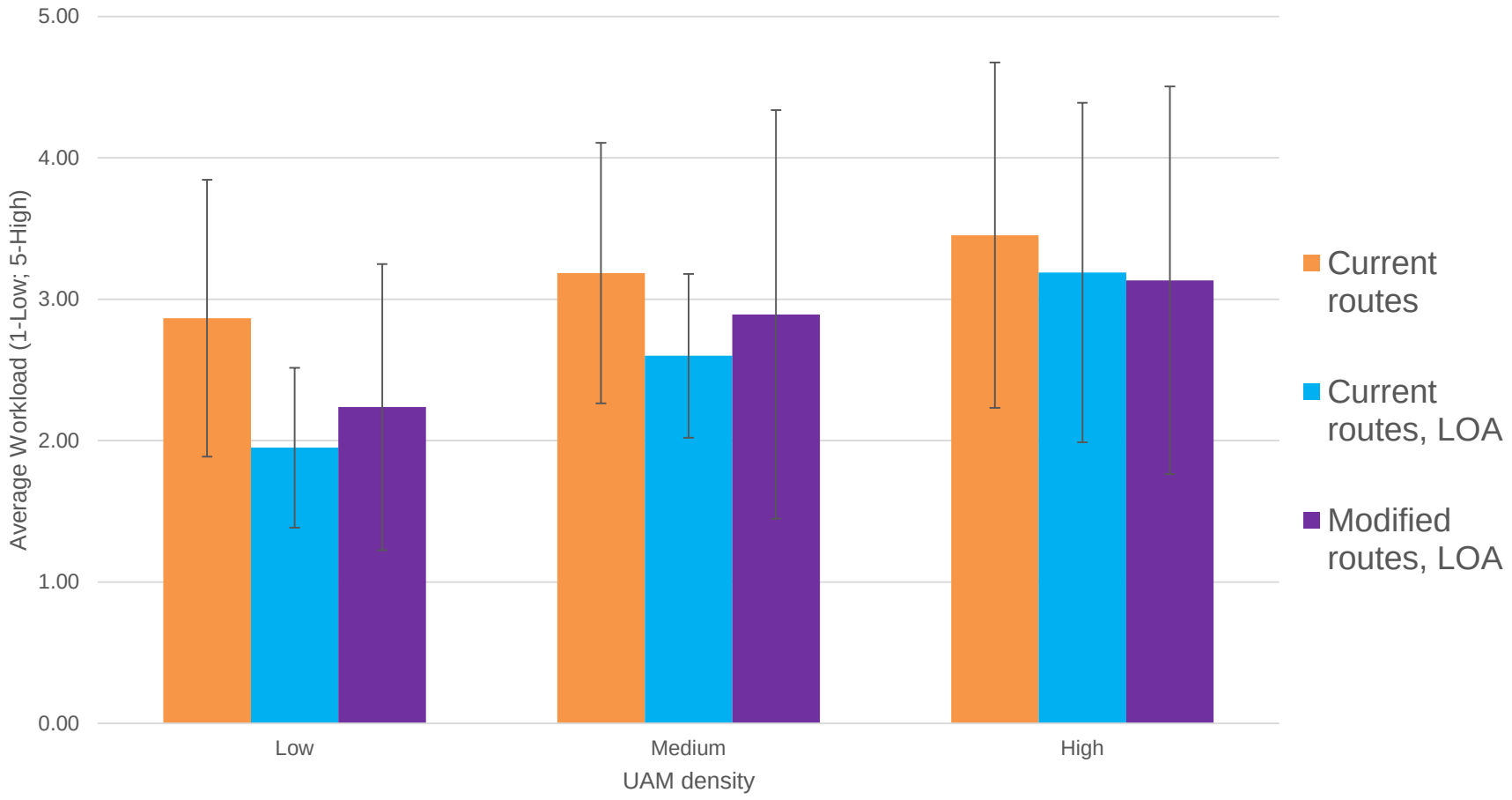
Method: Design (3)

- Experimental conditions overview
  - Did not use full-factorial design

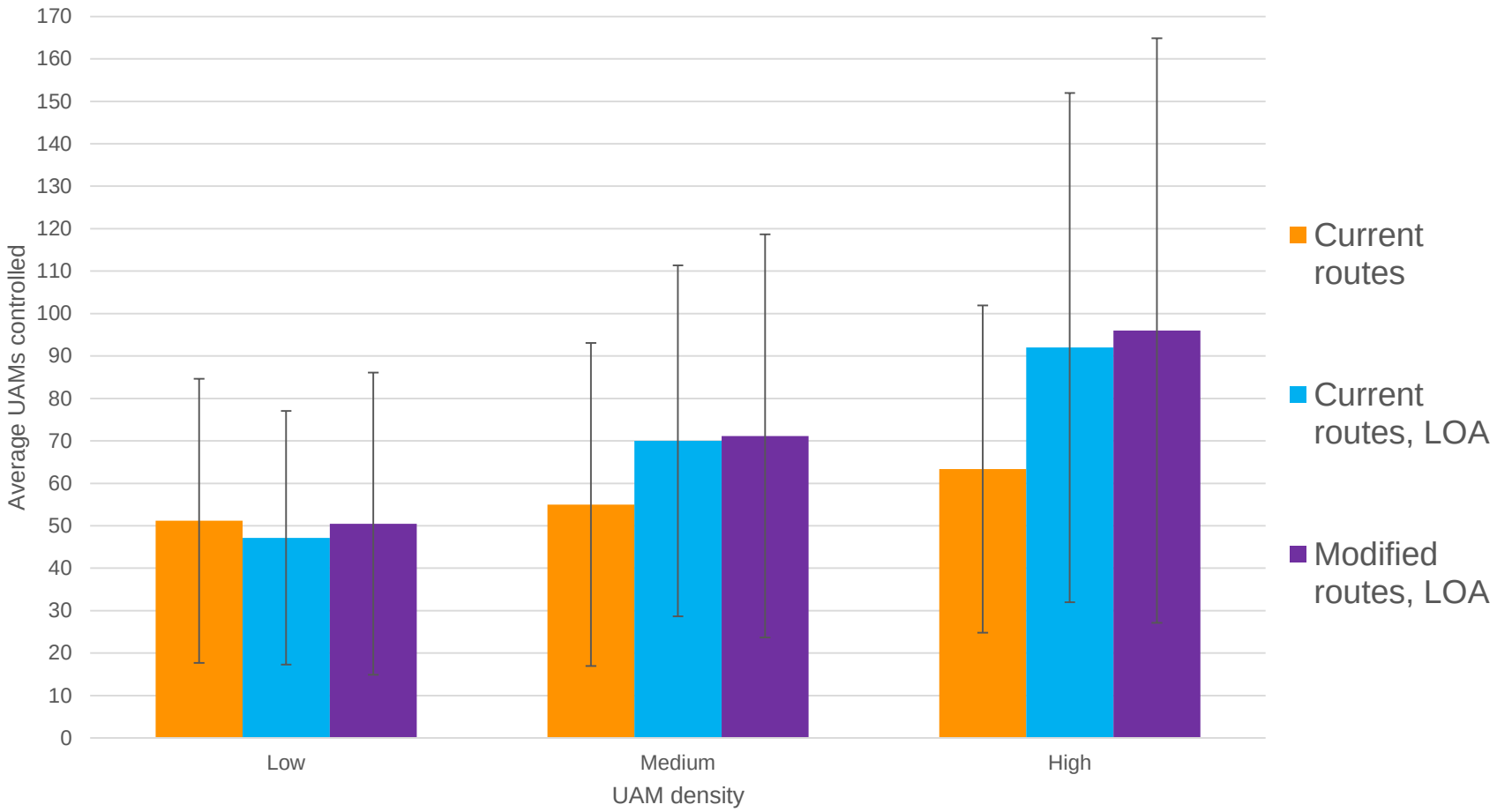
Level of UAM traffic	Helicopter Routes		
	Current Routes *Communications w/o LOA and ATIS* **(Baseline)**	Current Routes *Communications with LOA & ATIS*	Modified Routes *Communications with LOA & ATIS*
[redacted]			
Low	Scenario C1	Scenario CL1	Scenario M1
Medium	Scenario C2	Scenario CL2	Scenario M2
High	Scenario C3	Scenario CL3	Scenario M3

- Measures
  - Workload
  - Efficiency-related performance
- Participants
  - 6 retired controllers
  - Experience with Dallas metroplex control

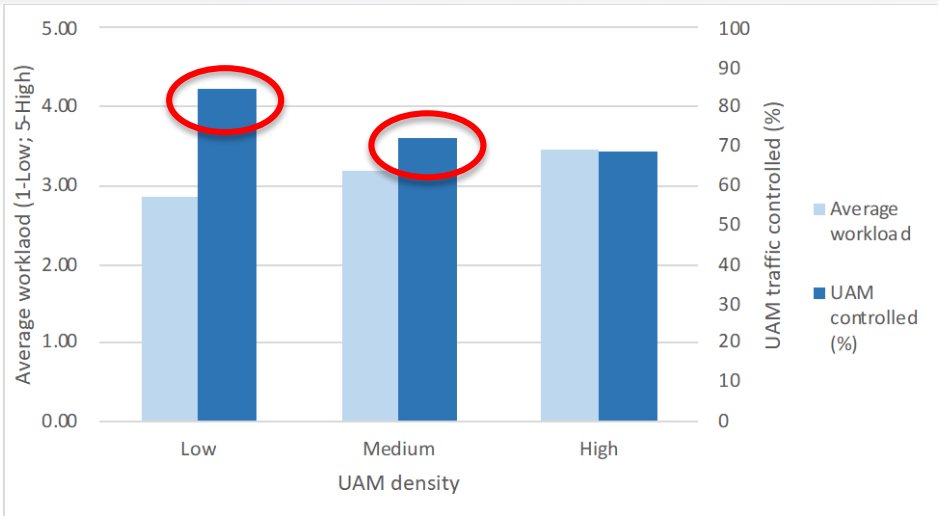
Result 1: Reduced communication is associated with lower workload

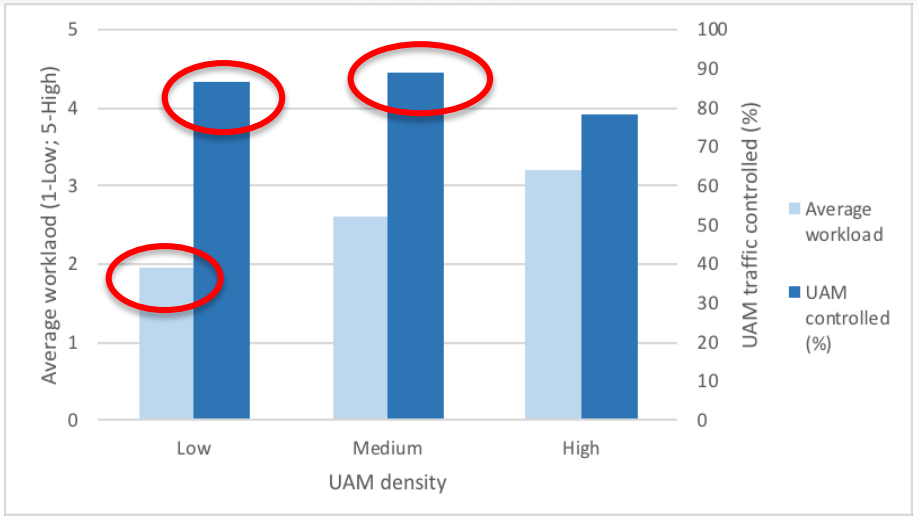


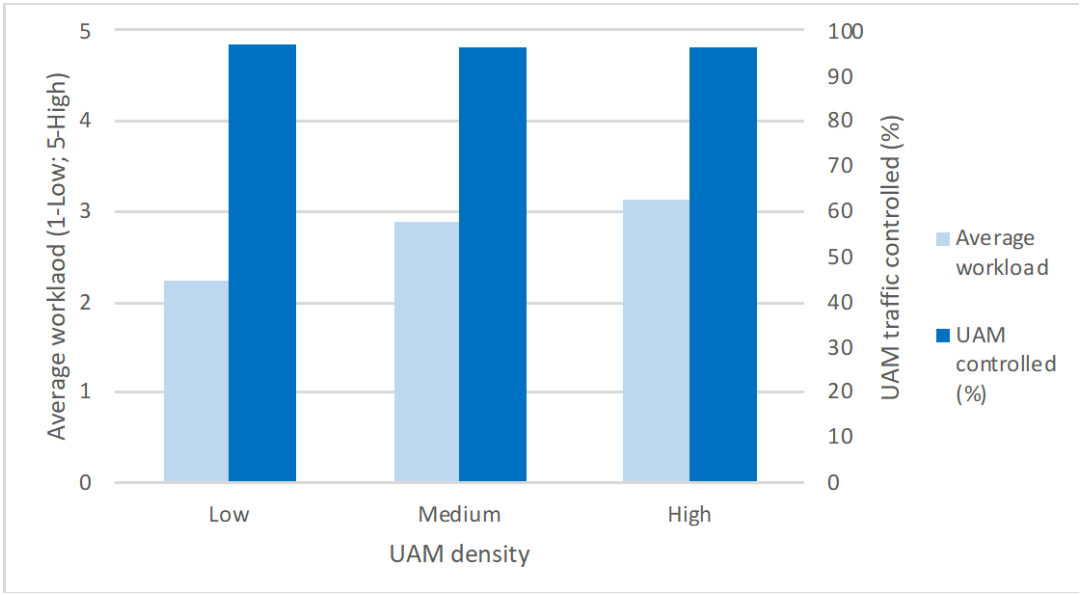
Result 2: Current day routes & procedures are associated with fewer controlled aircraft



Result 2: Route modifications are associated with increased traffic, not necessarily reduced workload







Conclusions & Implications

- Findings are provisional (n=6)
- Reduction of verbal communications associated with reduced workload
- Modification of routes associated with increased throughput
- But may still not be sufficient…
- UAM operations significantly restricted if controlled according to current day regulations

Future research – Human Factors considerations

- Critical focus moves to development of scalable UAM operation that maintains safety
  - In ATC, ATCOs maintain safe operations
- Balance of human operator and automation in UAM traffic management
  - Dynamic response, prevention and mitigation
- Role and responsibilities of human operator
- System resilience, tolerances and graceful degradation

Thank you!

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Result 4: Positioning of UAM routes has implications for workload