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

• Three task demand scenarios:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Temporal spacing (seconds)</th>
<th>Distance spacing (miles)</th>
<th>Vehicle Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1: Low UAM density</td>
<td>90</td>
<td>3.75</td>
<td>115</td>
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<tr>
<td>Scenario 2: Medium UAM density</td>
<td>60</td>
<td>2.5</td>
<td>167</td>
</tr>
<tr>
<td>Scenario 3: High UAM density</td>
<td>45</td>
<td>1.88</td>
<td>225</td>
</tr>
</tbody>
</table>

• Pilot studies confirmed task demand variation associated with workload variation
• 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
Experimental conditions overview
- Did not use full-factorial design

<table>
<thead>
<tr>
<th>Level of UAM traffic</th>
<th>Helicopter Routes</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Current Routes Communications w/o LOA and ATIS (Baseline)</td>
</tr>
<tr>
<td>Low</td>
<td>Scenario C1</td>
</tr>
<tr>
<td>Medium</td>
<td>Scenario C2</td>
</tr>
<tr>
<td>High</td>
<td>Scenario C3</td>
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</tbody>
</table>

Measures
- Workload
- Efficiency-related performance

Participants
- 6 retired controllers
- Experience with Dallas metropolis control
Result 1: Reduced communication is associated with lower workload

Current routes

Current routes, LOA

Modified routes, LOA

Average Workload (1-Low; 5-High)

Low
Medium
High

UAM density
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.