NASA's Simulation Activities for Evaluating UAM Concept of Operations

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HorizonUAM Symposium
September 22-23, 2021
ATM-X Urban Air Mobility (UAM) Subproject

• **Motivation:** Today’s air traffic management system cannot accommodate UAM operations that will scale over time

• **Goal:** Evolve the airspace towards UML-4

• **Objectives:**
  – Develop UAM airspace roadmap to guide research towards UML-4
  – Test advanced airspace management services with partners to address foundational issues to enabling mature UML operations
  – Define requirements towards UML-4 airspace management system in support of standards-making organizations to ensure a consistent system architecture
Advanced Air Mobility (AAM) National Campaign (NC)

• Advanced Air Mobility (AAM)
  – Safe, sustainable, affordable, and accessible aviation for various local and intraregional missions
  – NASA’s vision for AAM is to help emerging aviation markets to safely develop an air transportation system that moves people and cargo between places using new aircraft

• NASA’s National Campaign (NC)
  – **Goal**: Ensure AAM safety and accelerate scalability through integrated demonstrations of candidate operational concepts and scenarios
  – **Objectives** for the first NC tests (NC-1)
    1. Accelerate certification and approval
    2. Develop flight procedure guidelines
    3. Evaluate the CNS trade-space
    4. Demonstrate Airspace Operations Management (AOM) architecture
    5. Characterize community concerns

https://www.nasa.gov/aamnationalcampaign
AAM National Campaign Schedule

Legend

- Research and Capability Development
- Integration of Automated Systems (IAS) Flight Testing
- Airspace Simulation Series (X Series with ATM-X UAM)
- NC Series Development
- NC Series Operational Demonstrations

Dry Run
NC Developmental Test (DT)
NC-1 Operational Safety
NC-2 Complex Operations
NC-3 High Volume Vertiports
NC-4 Scaled Urban Demo

we’re here
FAA’s UAM Concept of Operations (ConOps)

- Air traffic management vision for near-term UAM operations
- FAA-defined **UAM corridors** with specific performance requirements
- UAM vehicles: electric Vertical Take-Off and Landing (eVTOL)
- Require UAM operator connection to a Provider of Services for UAM (PSU)
- Separation within corridors assigned to pilots, operators, and PSUs, not ATC
- UAM operations will start with today’s rules and procedures and evolve to incorporate Community-Based Rules (CBRs)

Source: [FAA UAM ConOps v1.0](#)
## Previous Simulations to Inform UAM Operations

<table>
<thead>
<tr>
<th>X1 (FY18)</th>
<th>X2 (FY19)</th>
<th>X3 (FY20)</th>
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<tbody>
<tr>
<td><strong>Description</strong></td>
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<tr>
<td>Examined ATC communications using DFW helicopter routes for initial UAM operations</td>
<td>Examined UTM airspace volumes for UAM operations using UTM TCL-4 based data exchange protocols</td>
<td>Partner PSUs tested; NASA PSU integrated into NC flight test infrastructure and flown in dry runs</td>
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<td><strong>Partnerships</strong></td>
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<tr>
<td>None</td>
<td>Uber Elevate (now Joby Aviation)</td>
<td>National Campaign &amp; 11 Airspace Industry Partners</td>
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<td><strong>Approach</strong></td>
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<td>Tabletop discussions with SMEs; Simulation with NASA technologies and human participants</td>
<td>Simulation with NASA and Uber Elevate technologies</td>
<td>NASA/Industry cohort used to simulate NC-1 scenarios 1-3</td>
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<td><strong>Output Papers / Reports</strong></td>
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<td>Letter of Agreement can reduce ATC-pilot communications, but is not scalable</td>
<td>Volumes may need to be standardized and 4D trajectories should be explored</td>
<td>&quot;X3 Simulation with National Campaign-Developmental Test (NC-DT) Airspace Partners&quot;</td>
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<tr>
<td>&quot;Exploration of Near-term Potential Routes and Procedures for Urban Air Mobility&quot;</td>
<td>&quot;Lessons Learned: Using UTM Paradigm for Urban Air Mobility Operations&quot;</td>
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<td>&quot;Investigation of communications involved in near-term UAM operations&quot;</td>
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<td><strong>Relationship to X4</strong></td>
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<td>Informed airspace structure design</td>
<td>Informed intent sharing; Informed strategic deconfliction</td>
<td>First NC-1 simulation (X4 is second); 100% virtual due to COVID-19</td>
</tr>
</tbody>
</table>

UTM: Unmanned Aircraft System Traffic Management

TCL: Technical Capability Levels
**X4 Objectives**

**Collaborate**
Collaborate with Industry to establish, develop, and test the Minimum Viable Product (MVP) for the PSU needed to ensure scalable UAM operations
- Testing in simulation
- Testing in NC-1 flight demonstrations with vehicle developers where applicable

**Test**
- Identify required PSU capabilities vs. value-added UAM services
- Advance the prototype interface to expected FAA data
- Identify, implement and test Community-Based Rules (CBRs) for strategic conflict management
- NASA to develop a PSU reference implementation to stand-in for airspace in NC-1 flights for vehicle developers without an industry airspace provider
- NASA to implement and test a prototype In-Time Aviation Safety Management Service

**Inform**
- Assess and inform key elements of current and future FAA ConOps and Use-Cases such as airspace constructs (e.g., corridors)
- Use results to inform standards bodies
Preliminary X4 Assumptions

- UML-2 traffic density and complexity (10s of simultaneous operations)
- DFW/DAL in south flow only
- UAM airspace structures include corridors that are shared among UAM Operators
- VMC conditions under VFR
- Weather conditions not simulated (i.e., no wind)
- Airspace authorization for UAM operations obtained via PSU
- Operational intent submitted by the UAM Operator to the PSU, for controlled and uncontrolled airspace
- PSUs operating simultaneously in the same airspace, sharing operation intent with each other
- UAM Operator interaction with ATC not simulated
- Vertiports are available for public use
- Piloted UAM vehicle, assume "see and avoid"
- Pilot communication with UAM Operator assumed, but not simulated
- eVTOL aircraft are considered rotorcraft according to JO 7110.65 for minimum altitude requirements (500' AGL)
Initial PSU Minimum Viable Product (MVP)

- Operates with novel airspace constructs provided by Airspace Structure Definition Service (ASDS)
- Enables UAM Operator to submit 4D Operational Intent, and share on PSU Network
- Monitors for conformance against filed 4D Operational Intent
- Implements initial strategic deconfliction
- Announces flight plan modifications to PSU network during off-nominal and contingency conditions

Source: FAA UAM ConOps v1.0
Scenarios

Scenario 1: Trajectory Planning & Compliance

Scenario 2: Re-routing around Airspace Constraint

Scenario 3: Vertiport Operations (Go-around)
• Airspace of interest: **Dallas** metropolitan area airspace
• 34 vertiports identified based on a market demand analysis
• Corridor and vertiport volumes are shown in blue and dark green
• The remaining area inside Class B is the "ATM Environment" where ATC services are needed
• **Airspace Structure and Definition Service (ASDS)** provides airspace structure information to the airspace partners for planning their operations
Preliminary X4 Schedule

NASA PSU Airspace Capabilities Supporting Scenario 1

Potential Updates to NASA PSU Airspace Capabilities; Identify initial CBRs

Software development and testing: 5 sprints for Scenario 1

Scenario 2 s/w dev: 2 sprints

Scenario 3 s/w dev: 1 sprint

Negotiate MVP with Partners

Collaborative Sims

Kickoff
Test Plan Review
Test Readiness Review

Initial APIs

Start Data Collection
Complete Data Collection

MVP: Minimum Viable Product for PSU
API: Application Programming Interface
Expected Outcomes from X4 Simulations

• Collaboratively developed and tested UAM airspace capabilities
• Artifacts such as Community-Based Rules (CBRs) informing standards bodies and working groups
• Identified PSU requirements vs. value-added UAM services
• Sense of level of effort needed for future UAM airspace capabilities
• PSU(s) ready for field demonstration opportunities

UAM airspace capabilities and lessons learned from X4 simulations will be used in AAM National Campaign flight demonstrations.
QUESTIONS?

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