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

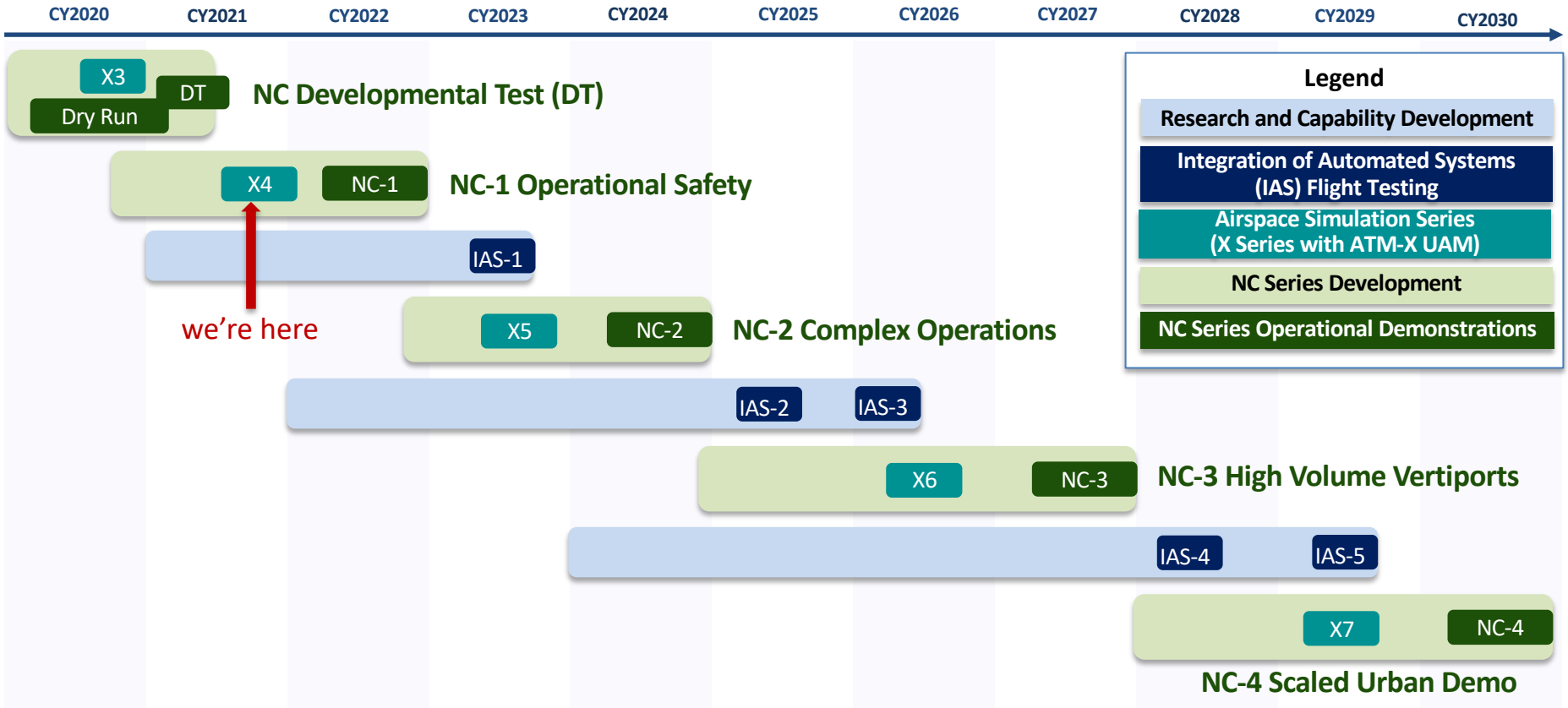
- **Goal**: Evolve the airspace towards UML-4
- **Objectives**:
  - Develop UAM airspace roadmap to guide research towards UML-4
  - Test advanced airspace management services with partners to address foundational issues to enabling mature UML operations
  - Define requirements towards UML-4 airspace 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

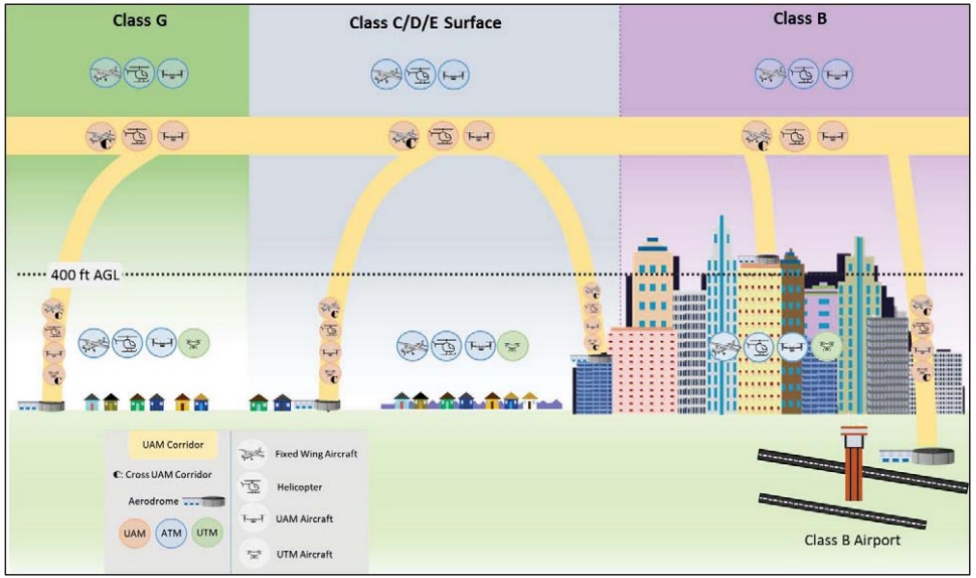
https://www.nasa.gov/aamnationalcampaign

AAM National Campaign Schedule



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

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

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

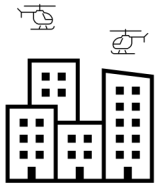
- Identify required PSU capabilities vs. value-added UAM services
- Advance the prototype interface to expected FAA data
- Identify, implement and test Community-Based Rules (CBRs) for strategic conflict management

- 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

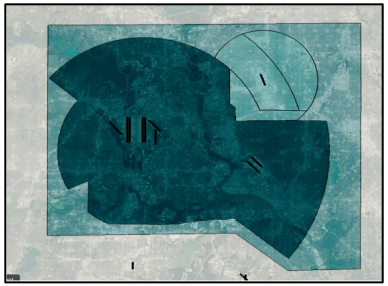
Inform

- 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

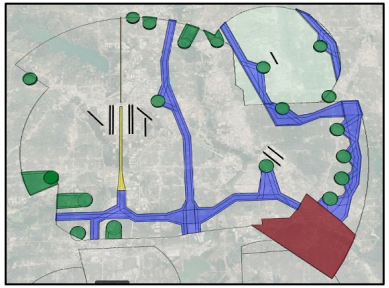
Preliminary X4 Assumptions



- 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

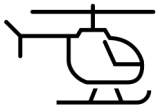


Dallas Area Airspace



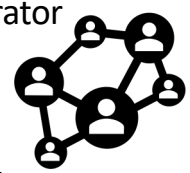
Corridors in Dallas Area Airspace

- 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)



- VMC conditions under VFR
- Weather conditions not simulated (i.e., no wind)

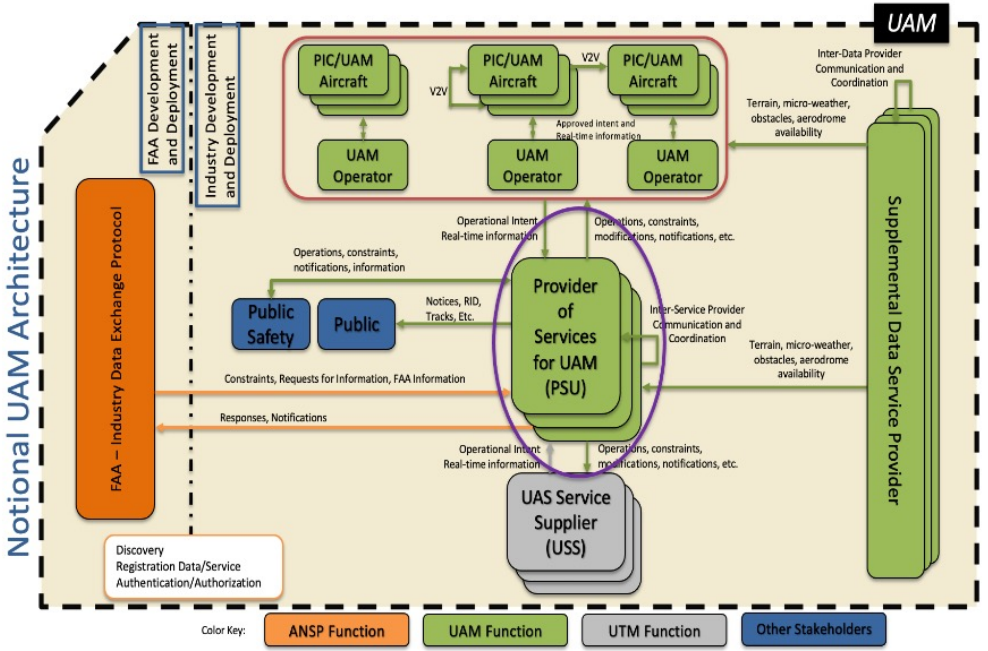
- Airspace authorization for UAM operations obtained via PSU
- Operational intent submitted by the UAM Operator to the PSU, for controlled and uncontrolled airspace
- PSUs operating simultaneously in the same airspace, sharing operation intent with each other
- UAM Operator interaction with ATC not simulated



- Vertiports are available for public use

Initial PSU Minimum Viable Product (MVP)

- Obtains Airspace Authorization for UAM Operator via FAA-Industry Data Exchange Protocol
- 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

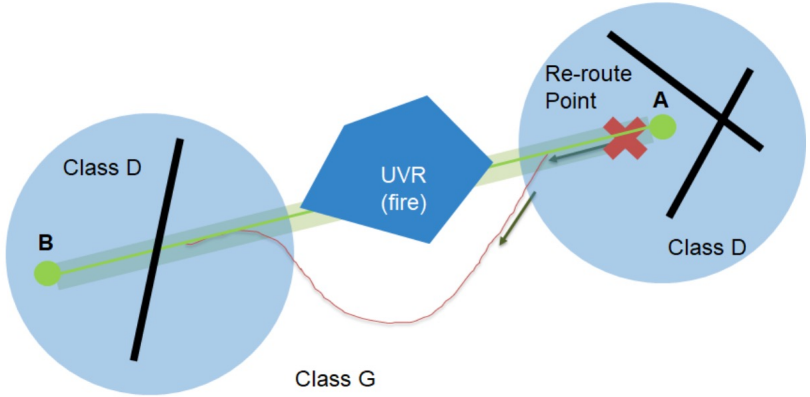


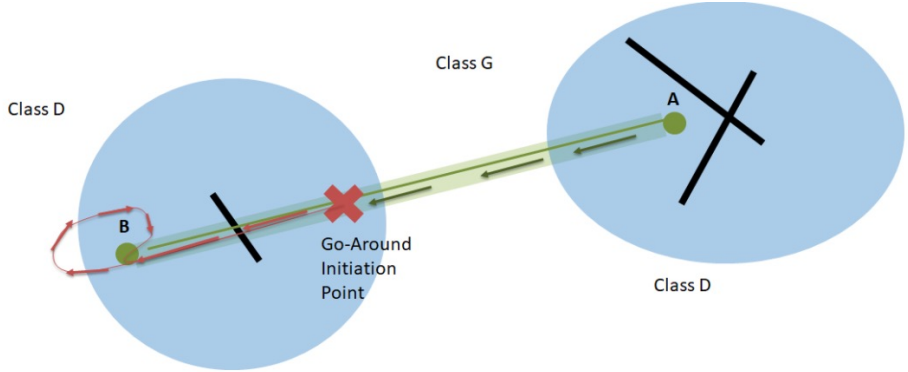
Source: [FAA UAM ConOps v1.0]

Scenarios

Scenario 1:
Trajectory Planning & Compliance

Scenario 2:
Re-routing around Airspace Constraint

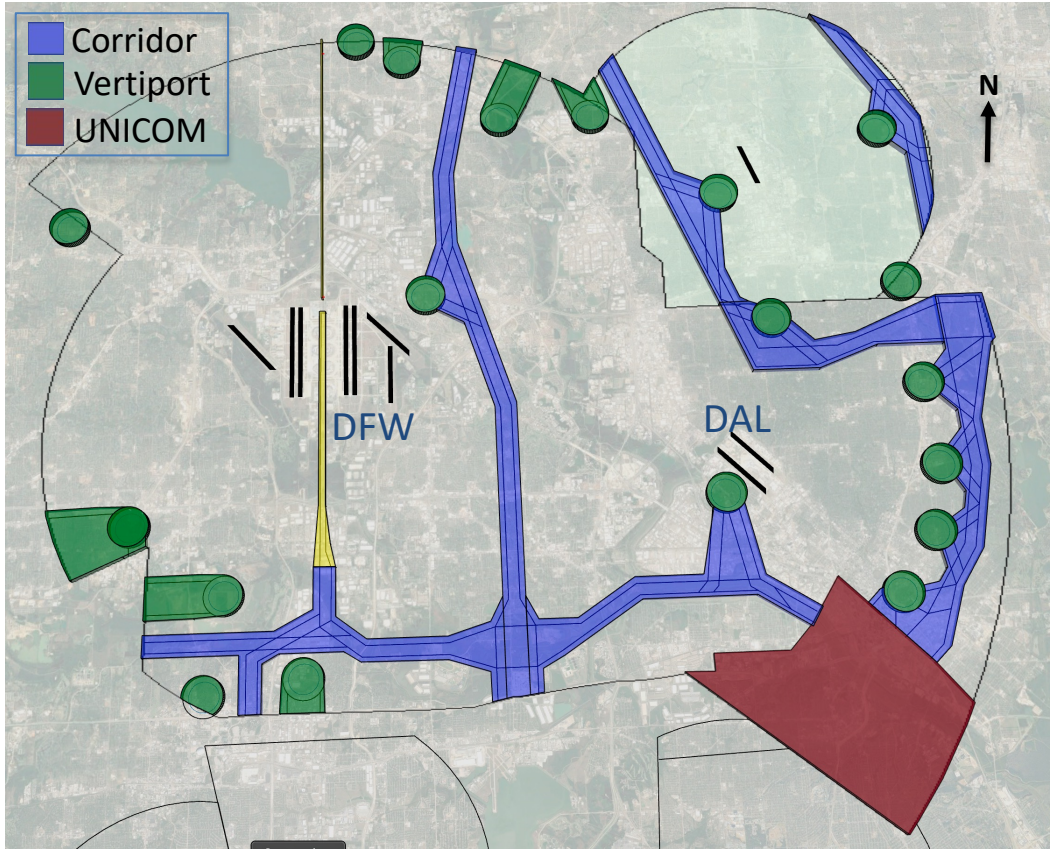




Scenario 3:
Vertiport Operations (Go-around)

X4 Simulated Airspace

- 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 R&D

NASA PSU Airspace Capabilities Supporting Scenario 1

Partner-informed R&D

Negotiate MVP with Partners

Potential Updates to NASA PSU Airspace Capabilities; Identify initial CBRs

NASA-Partner Sprints

Software development and testing: 5 sprints for Scenario 1

Scenario 2 s/w dev: 2 sprints

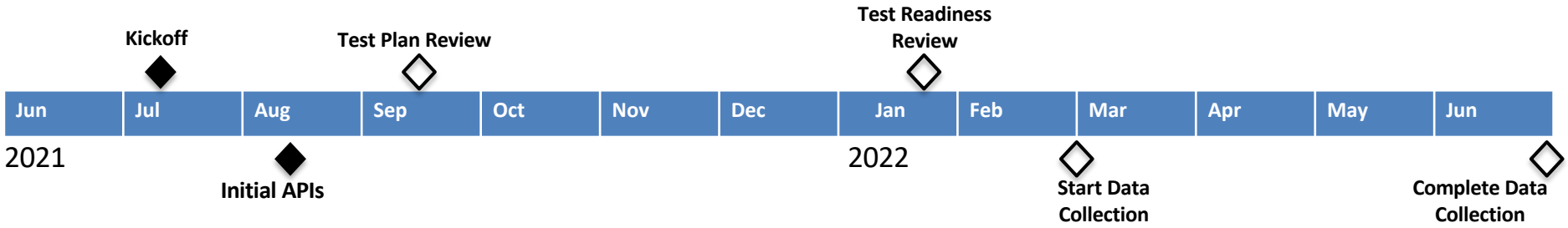
Scenario 3 s/w dev: 1 sprint

Collaborative Sims

Scenario 1 Collab Sim

S2 Sim

S3 Sim



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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