Advanced Air Mobility (AAM): Overview and Integration Considerations

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Presentation Outline:
I. Overview of AAM
II. Airspace Integration Considerations
III. Airport/Vertiport Integration Considerations
IV. Closing Thoughts

Disclaimer: any opinions expressed in this presentation are solely those of the presenter and do not necessarily reflect the views of the US Government or NASA.
Overview of AAM
Advanced Air Mobility (AAM) Vision

Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions
Advanced Air Mobility (AAM): Bringing Aviation into Daily Life

• Three primary applications:
  – Urban Air Mobility (UAM)
    • “Local” missions up to ~75 miles around metropolitan areas
    • Largely novel “vertiport” infrastructure
    • eVTOL, potentially eSTOL or eCTOL aircraft
    • Up to ~6 passengers or equivalent cargo
  – Small Unmanned Aircraft Systems (sUAS)
    • Local missions for aerial work or small cargo delivery (e.g., food, small packages)
    • Range of required takeoff/landing infrastructure from none to specialized
    • Typically VTOL-capable aircraft
  – Regional Air Mobility (RAM)
    • “Intraregional” missions up to ~500 miles
    • Primarily utilize existing (smaller) airports
    • eCTOL and eSTOL aircraft
    • Up to 19 passengers or equivalent cargo

• AAM is generally enabled by electrification & automation
• Many potential uses, including
  – Passenger transport
  – Cargo/package delivery
  – Emergency services/public good (e.g., air ambulance, EMT transport, etc.)
  – Aerial work (e.g., infrastructure inspection, photography, etc.)
NASA Role to Address AAM Challenges

Vehicle Development and Operations
Airspace Design and Operations
Community Integration

NASA and key partners are collectively taking on the most difficult mission challenges to enable industry to flourish by 2030

- Research and Development Portfolio
- Robust Ecosystem Partnerships
- AAM National Campaign Series

NASA to deliver long term technical solutions and architecture requirements for industry, regulatory community
AAM Ecosystem Working Groups

Accelerate the development of safe and scalable AAM flight operations by bringing together the broad and diverse ecosystem

- Align on a common vision for AAM
- Learn about NASA’s research and planned transition paths
- Adopt a strategy for engaging the public on AAM
- Collectively identify and investigate key hurdles and associated needs
- Develop AAM system and architecture requirements
- Support regulatory and standards development

Form a connected stakeholder community

Join the conversation! See [https://nari.arc.nasa.gov/aam-portal/](https://nari.arc.nasa.gov/aam-portal/) for more information
Airspace Integration Considerations
AAM Airspace Integration Overview

• Small Unmanned Aircraft Systems
  – UAS Traffic Management (UTM): a service-oriented paradigm for ATM
  – < 400 ft AGL altitude
  – Flight intent sharing and UAS Service Suppliers (USSs)

• Urban Air Mobility
  – Early operations (~2024) under existing rules with novel aircraft
  – Further-future operations (~2028) move toward service-oriented paradigm for ATM
    • Operational intent sharing and Providers of Services for UAM (PSUs)
  – UAM Corridors
    • Airspace structure of defined geometry analogous to SFRAs and helicopter routes
    • Operations follow UAM-specific rules/procedures within Corridors

• Regional Air Mobility
  – Generally leverages existing rules
  – Increases in aircraft automation to require modified rules/procedures (e.g., digital communications, fixed routes, etc.)

*Notional* UAM Corridor design in the Dallas-Ft Worth area, including boundaries of Class B and Class D airspace boundaries.
Airport/Vertiport Integration Considerations
Airport Considerations: Electrification

• Installation of chargers
  – Accessible locations for all operations
  – Consider use also for ground vehicles
  – Ongoing charging standardization discussions
  – How to monetize charging?

• Connectivity to electrical grid
  – Potentially large additional power requirements (multi-MW)
  – Long lead times

• Microgrids/renewables
  – Potentially large available land area
  – Sustainable energy supply for aviation and/or to improve local electricity grid

Note: ongoing NASA-funded research by Georgia Tech assessing potential energy demand for RAM and potential for on-airport renewables to generate needed electricity.
Other Airport Considerations

- Improved multi-modal connectivity for FBOs
  - AAM operations *not* likely to use existing Part 121 passenger terminals
  - Mode change times need to be kept small
  - RAM and some UAM ops likely to utilize existing airport runways
  - FBOs may partner with indirect/direct air carriers

- Consider inclusion of new vertipads at airports
  - Ideally direct passenger access to existing passenger terminals (at larger airports)
  - Enable deconflicted approach/departure paths with existing air traffic
Vertiports

• Many potential locations
  – Greenfield sites
  – Rooftops
  – Parking garages
  – Barges
  – New overpasses / cloverleafs?
  – Etc.

• Many siting considerations
  – Multi-modal connectivity
  – Noise
  – Utilities (electric grid)
  – Proximity of other vertiports/pads
  – Equity
  – Etc.

• Vertiport design guidelines under development
Closing Thoughts
Summary & Closing Thoughts

• AAM is safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions

• Many potential missions under the AAM umbrella
  – Three primary applications: urban air mobility, regional air mobility, small unmanned aircraft systems
  – Common themes: electrification and increased automation

• AAM is a burgeoning field
  – Many details still TBD
    • Still no type certified AAM aircraft!
    • Watch for regulatory guidance and how aircraft/operations evolve
  – Your involvement can shape the future!
    • Get engaged in the AAM Ecosystem Working Groups: https://nari.arc.nasa.gov/aam-portal/
    • Start developing plans and beginning pilot programs

• Many potential opportunities for existing airports
  – Potential for vastly increased passenger/cargo throughput
  – Multi-modal integration is key; airports could be new multi-modal transportation hubs
  – Don’t forget about sUAS operations (inspections, small cargo logistics, etc.)
  – Solar (or other renewable energy generation) hubs for electric aircraft and surrounding communities
BACKUP
Useful References

• FAA UTM ConOps v2.0: 
  https://www.faa.gov/uas/research_development/traffic_management/media/UTM_ConOps_v2. pdf
• Regional Air Mobility White Paper: https://ntrs.nasa.gov/citations/20210014033
• UAM Market Studies
  – BAH (written report, detailed presentation, overview presentation):
    • https://ntrs.nasa.gov/citations/20190001472
    • https://ntrs.nasa.gov/citations/20190000519
    • https://ntrs.nasa.gov/citations/20190000517
  – Crown Consulting (overview presentation, detailed presentation):
    • https://ntrs.nasa.gov/citations/20190002046
    • https://ntrs.nasa.gov/citations/20190026762
• Electrical Infrastructure Study for UAM Aircraft
  – https://nari.arc.nasa.gov/sites/default/files/attachments/UAM_ConOps_v1.0.pdf
• FAA UAM ConOps v1.0: 
  https://nari.arc.nasa.gov/sites/default/files/attachments/UAM_ConOps_v1.0.pdf
• UML-4 Vision ConOps v1.0: https://ntrs.nasa.gov/citations/20205011091
NASA AAM Mission Priorities

Human Response to Noise

Regional M&S Capabilities, & Supply Chain

Community Integration

UAM Supplemental Data Services

In-time Aviation Safety Management System

Source and Fleet Noise

Vehicle Propulsion Reliability

Environmental and Failure conditions

Distributed Electric Propulsion

xtM Architectures

Operational Rules, Roles, & Procedures

Comm, Nav, Surveillance, Information

Vehicle Development & Production

Individual Vehicle Management & Operations

Assured Automated Architectures

High Density Vertiplex

National Campaign

Systems and Architecture Requirements

Automated Flight and Contingency Management

m:N, Pilots to Operators

Aircraft & Aircrew Barriers

Airspace Barriers

Community Integration Barriers
**National Campaign Series Support of the Industry Timeline**

**UML “unlocks”** based on a range of publicly available industry projections and conversations with partners; not a consensus view.

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**Legend**
- NC Series Progression
- X-Series Simulations
- R&D Flight Tests
- NC Series Ops Demonstrations

**NC-1 Operational Safety**
- CY2020
- CY2021
- CY2022
- CY2023
- CY2024
- CY2025
- CY2026
- CY2027
- CY2028
- CY2029
- CY2030

**Help catalyze**
- UML 1, 2…

**NC-2 Complex Operations**
- CY2020
- CY2021
- CY2022
- CY2023
- CY2024
- CY2025
- CY2026
- CY2027
- CY2028
- CY2029
- CY2030

**Key enablers to accelerate the UML 3&4 timeline…**

**NC-3 High Volume Vertiports**
- CY2020
- CY2021
- CY2022
- CY2023
- CY2024
- CY2025
- CY2026
- CY2027
- CY2028
- CY2029
- CY2030

**NC-4 Scaled Urban Demo**
- CY2020
- CY2021
- CY2022
- CY2023
- CY2024
- CY2025
- CY2026
- CY2027
- CY2028
- CY2029
- CY2030

**Remain Agile…**
- Assess and align the AAM strategy with industry needs
HDV Research Flow to National Campaign

**Technology Transfer**
- UAS Automation Reference Architecture
  - ASTM F38, FAA, AFCM, SWS
- BVLOS Safety Case
- Scenarios and Use Cases
- JARUS, UAST, FAA, NC
- Vertiport Automation Reference Architecture
  - FAA, ASTM F38, AFCM, NC

**Automated Aircraft**
- Small UAS
  - CY2021: x3
  - CY2022: x5
  - CY2023: x7
- Representative eVTOL

**Operations**
- Simulation and Multi-Aircraft
  - VLOS Flight Test
- Merging and Spacing
- Contingency Decision Making
- Operational Environment (e.g. Test Range for NC)

**Infrastructure**
- Vertiport Terminal Procedures Design
- Instrumented Vertiport
- Automated Vertiplex

**Development Years**
- CY2021
- CY2022
- CY2023
- CY2024
- CY2025
- CY2026
UAS Traffic Management Architecture

UTM Architecture v2017.10.12

NAS Data Sources
Common data from FAA available to UTM components based on existing access mechanisms

National Airspace System

Color Key:

- ANSP Function
- Operator Function
- Other Stakeholders

NAS state
NAS impacts

Flight Information Management System

Constraints, Directives
Requests, Decisions
Operations, Deviations

Supplemental Data Service Provider
Inter-data provider communication and coordination
Terrain Weather Surveillance Performance

Public Safety
Public

UAS Service Supplier
Operation requests
Real-time information
Operations, Constraints
Notifications, Information

UAS Operators
UAS Operators
UAS Operators

UAS
V2V Comm

Discovery Registration Data/Services Authentication/Authorization
Additional services and components that may have shared or TBD responsibilities
FAA NextGen’s v1.0 UAM Research ConOps: A Quick Overview

• Released June 26, 2020
• Initial state operations (UML-2)
  – Earliest operations occur within existing system/rules/procedures
  – Document focuses on concept for next step of evolution
• Concept **not** coordinated across FAA
• UAM flight contained within corridors
  – Builds off of existing concept of helicopter routes and special flight rules areas
• Community-Based Rules (CBRs) to govern “cooperative traffic management” within corridors
• Providers of Services for UAM (PSUs) enable sharing of information (e.g., intent)

Figure from FAA NextGen’s v1.0 UAM ConOps document: [https://nari.arc.nasa.gov/sites/default/files/attachments/UAM_ConOps_v1.0.pdf](https://nari.arc.nasa.gov/sites/default/files/attachments/UAM_ConOps_v1.0.pdf)
Figure 4-1: Multiple UAM Corridors

Figure 4-2: UAM Corridor with “Tracks”

Figures from FAA NextGen’s v1.0 UAM ConOps document: https://nari.arc.nasa.gov/sites/default/files/attachments/UAM_ConOps_v1.0.pdf
FAA NextGen’s v1.0 UAM Research ConOps

• Slides presented in Airspace AEWG meeting by Steve Bradford (FAA NextGen Chief Scientist):

  UAM Concept Overview
  • UAM leverages a common shared environment for UAS Traffic Management (UTM)
  • A community-based traffic management system in which the operators are responsible for coordination, execution, and management of their operations
    – Community rules approved by the FAA
  • Operations between known locations in volumes of airspace (UAM Corridor) with specified performance requirements
  • Cooperative Separation Environment when within UAM Corridor
    – Operators will be responsible for maintaining proper separation when transiting a UAM Route and staying within the bounds of the UAM Corridor
    – Operations must meet the airspace & performance requirements when not operating within UAM Corridor

  UAM Concept Overview (continued)
  • Leveraging the current model of UTM’s UAS Service supplier (USS) a similar model will be needed to provide services for UAM operations.
  • A Provider of Services for UAM (PSU) assists UAM Operators with meeting UAM operational requirements that enable safe and efficient use of airspace and UAM Routes
    – Shared network environment
      • Same federated UAM/UTM environment
    – Provide operator with information along the route
      • Based on shared intent data
    – Share operator intent with others via a shared network environment

• Recording of Aircraft AEWG meeting discussing slides: https://youtu.be/ohZEt-f0Wqo
• Slides from: https://nari.arc.nasa.gov/sites/default/files/attachments/AAMWG-Airspace%20August4-2020_IL.pdf
Figure 5-1: Notional UAM Architecture

Figure from FAA NextGen’s v1.0 UAM ConOps document: [https://nari.arc.nasa.gov/sites/default/files/attachments/UAM_ConOps_v1.0.pdf](https://nari.arc.nasa.gov/sites/default/files/attachments/UAM_ConOps_v1.0.pdf)
UAM Maturity Level (UML) 4: Medium Density and Complexity Operations with Collaborative and Responsible Automated Systems

- **UAM Operations Environment (UOE)** – Flexible airspace volumes with high UAM activity
- **Provider of Services to UAM (PSU)** – Federated, 3rd party suppliers of services, including air traffic management services
- Advanced automation (aircraft and air traffic management) largely human-over-the-loop
- Aircraft capable of detect and avoid and performance based separation
- UML-4 is characterized by medium density operations between closely-spaced, high throughput UAM aerodromes

Note: Initial (v1.0) UML-4 ConOps document still under review
Intraregional Mission Example: Trip from Hampton Roads to DC

- NASA Langley (Hampton, VA) to DOT HQ

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Intraregional AAM travel saves ~1h 10m (~39%) for this one-way trip
**Combined AAM Mission Example: Trip from Hampton Roads to DC**

- **NASA Langley (Hampton, VA) to DOT HQ**

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AAM travel saves ~1h 25m (~47%) for this one-way trip
Urban Air Mobility Example: Aerial Reach from DC

24 hr weighted average 60 minute driving commute

Any time of day ~30 minute total commute (~40 mi radius)

Any time of day ~60 minute total commute (~100 mi radius)