Advanced Air Mobility: Overview & Integration into the NAS
For the Aeronautics and Space Engineering Board
Oct 19, 2021
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Advanced Air Mobility (AAM) Mission

UAM Maturity Levels (UMLs)
- UML-4 Medium Density/Complexity, collaborative and responsible automated systems
- UML-3 Low Density, Medium Complexity, comprehensive safety assurance automation
- UML-2 Low Density/Complexity, assistive automation
- UML-1 Conforming prototypes

Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions
Urban Air Mobility (UAM) Ecosystem Goals

1 Based on a range of publicly available industry projections; not a consensus view; aggressive

- **CY2020**: Initial UAM ConOps Development
  - Early adopter locations
- **CY2021**: Piloted UAM aircraft cert. basis
  - Conforming prototypes
- **CY2022**: Initial UAM ConOps Development
  - 1st Type Cert awarded
  - Initial pilot training & licensing
  - Initial operational approvals
  - Low volume airspace operations
- **CY2023**: High-capacity corridors in early adopter cities
  - Initial operational approvals
- **CY2024**: Overarching Goals
  - Integration of Automated Systems
  - Automated Flight and Contingency Management
  - Scaled vehicle production
- **CY2025**: UAM Airspace Architectures and 3rd Party Services
  - Procedures for high-capacity corridors
  - CNSi Architectures
- **CY2026**: Local regulations enacted
  - Initial Infrastructure Deployment
  - Advanced urban capable aircraft
  - UAM Airspace Architectures and 3rd Party Services
- **CY2027**: Secured Systems Architectures
  - Integrated Weather Tolerant Airspace Operations
- **CY2028**: Integrated system-wide safety tools & methods
  - Separation Standards
  - Procedures for high-capacity corridors
  - CNSi Architectures
- **CY2029**: Multi-Modal Integration
  - Scalable weather-tolerant urban ops
- **CY2030**: Overarching Goals
  - High Capacity UAM Ports
  - Secured Systems Architectures
  - Integration of Automated Systems
  - Automated Flight and Contingency Management
  - Scaled vehicle production

CNSi: Communication, Navigation, Surveillance, Information
UML: UAM Maturity Level
NASA Role to Address AAM Challenges

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

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

Vehicle Development and Operations
Airspace Design and Operations
Community Integration

NASA to deliver long term technical solutions and architecture requirements for the industry and regulatory communities
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

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

NC-1 Operational Safety
- Help catalyze UML 1, 2...

NC-2 Complex Operations
- Key enablers to accelerate the UML 3 & 4 timeline...

NC-3 High Volume Vertiports
- Remain Agile... Assess and align the AAM strategy with industry needs

NC-4 Scaled Urban Demo

CY2020 CY2021 CY2022 CY2023 CY2024 CY2025 CY2026 CY2027 CY2028 CY2029 CY2030
NASA AAM Mission Priorities

Human Response to Noise
Regional M&S Capabilities & Supply Chain
Community Integration

UAM Airspace Architectures
Operational Rules, Roles, & Procedures
Comm, Nav, Surveillance, Information

Source and Fleet Noise
Vehicle Propulsion Reliability
Environmental and Failure Conditions
Distributed Electric Propulsion

Airspace System Design & Implementation
Community Integration
Airspace & Fleet Operations Management

Vehicle Development & Production
Individual Vehicle Management & Operations

Automated Flight and Contingency Management
m:N, Pilots to Operators

Assured Automated Architectures
High Density Vertiplex
National Campaign
Systems and Architecture Requirements

UAM Supplemental Data Services
In-time Aviation Safety Management System

Community Integration

Aircraft & Aircrew
Airspace
Community Integration
Automated Flight and Contingency Management (AFCM)

** automated flight and contingency management (afcm)**

- Develop and evaluate an initial, integrated suite of key vehicle automation functions to enable simplified piloting in urban environments and propose recommendations to enable certification and approvals for the selected concepts.

<table>
<thead>
<tr>
<th>Community state of the art</th>
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<tbody>
<tr>
<td>• Approaches to enable UML-4 automation architectures include piloted, remotely piloted, and “automated”</td>
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<tr>
<td>• Working groups targeted at developing standards for simplified vehicle operations (SVO) and Assured Vehicle Automation architectures</td>
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<tr>
<td>- FAA EZ-Fly, ASTM F44.50, and GAMA EPIC</td>
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<td>- ASTM SAE, and RTCA working groups established around automated aviation technologies</td>
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<table>
<thead>
<tr>
<th>Community challenges</th>
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<tr>
<td>• Technology development, standards, and training to enable automated nominal and contingency operations</td>
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<tr>
<td>• VV&amp;C procedures and standards for all automated vehicle and airspace architectures</td>
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<tr>
<td>• Security and public trust for automated aviation systems</td>
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<th>NASA Role</th>
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<tr>
<td>• Leverage NASA expertise and facilities to develop and test complex vehicle automation architectures</td>
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<tr>
<td>• Collaboration partnerships with industry and OGAs to advance critical vehicle automation technologies</td>
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High Capacity UAM Ports

Develop requirements and architectures for integrated High Capacity UAM Ports in a Vertiplex environment; with an emphasis on vertiport automation, including its interactions with the UAM broader system, to accelerate safe and efficient vertiport operations as part of a scalable UML-4 system.

Community state of the art

- sUAS community progressing towards efficient Part 107 and Part 135 approvals, via technology enabled BVLOS operations.
- The maturity of automation in sUAS operations is low and limits the scalability and complexity of operations.
- Limited community understanding of procedures and interoperability of automated systems

Community challenges

- Receiving safety credit for integrated automation technologies that holistically address operational hazards and safety cases
- Vehicle-airspace-infrastructure interfaces that support effective data exchange for situation awareness and decision making
- Airspace technologies, services, and interoperability supporting high throughput operation in dense airspace

NASA Role

- Demonstrate prototypes focused on integrating NASA technology capabilities to advance automated sUAS operations
- Leverage sUAS to development concepts, architectures, procedures, and technologies to enable NC-3 High Volume Vertiports
- Leverage lessons from UTM integration for mission to advance sUAS across all NASA centers
**UAM Airspace Architectures and Services**

Collaborate with Industry and the FAA to evolve the notional UAM architecture towards a secure prototype airspace UML-4 architecture to identify and validate airspace UML-4 requirements.

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<td>• Technologies and procedures in the NAS today will support initial commercial UAM operations</td>
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<tr>
<td>• FAA enterprise systems are foundations for air traffic management</td>
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<td>• FAA provides key services, such as separation assurance with ATC</td>
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<table>
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<th>Some Key Community challenges</th>
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<tr>
<td>• Initial commercial UAM operations cannot scale using current technologies and procedures in the NAS</td>
</tr>
<tr>
<td>• Researching and developing a federated approach to air traffic management, relying on 3rd-party services (i.e., services not provided by FAA)</td>
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<td>• Identifying community-based rules</td>
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<tr>
<td>Lead industry to continue building framework for UAM airspace management through research and testing</td>
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<tr>
<td>• Prototype scalable systems</td>
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<tr>
<td>• Community based rules (CBRs) and recommended requirements to the FAA, standards bodies, and working groups</td>
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<td>• Technology transfers to the FAA</td>
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<tr>
<td>• Industry-built UAM services as airspace provider for vehicle OEM in NC-1 flight test</td>
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**Pathfinding for Airspace with Autonomous Vehicles (PAAV)**

Develop concepts, procedures, and technology to enable airspace access for air cargo operations with targeted autonomy in lower complexity airspace shared with conventional aircraft.

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<td>• Large UAS flights are possible with special accommodations</td>
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<tr>
<td>• Current air traffic management system is not able to support routine “file and fly” of increasingly autonomous aircraft integrated with current airspace operations</td>
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<tr>
<td>• Acceptance of large-scale usage of autonomous aircraft</td>
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<tr>
<td>• Airspace integration at a systems level</td>
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<tr>
<td>• Balance viability for Unmanned Aircraft operators and safety and efficiency for ATC and all airspace users</td>
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<tr>
<td>• <strong>Development of algorithms and services</strong> for flow, trajectory, and contingency management</td>
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<tr>
<td>• <strong>Defining requirements</strong> for integrating airspace management services with vehicle technology, and infrastructure</td>
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<tr>
<td>• <strong>Documenting system performance requirements</strong> informed by simulation and field activities</td>
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m:N Fleet Management

Enable scalable operations to achieve the full vision and potential of advanced air mobility through development of targeted tools and techniques critical for m:N operation of autonomous fleets

Community State of the Art

- m:N is a path to scalable, more profitable industry
- Robust m:N tech development underway in multiple industries, including package delivery and passenger operations
- US regulations limit m:N operations to outside the NAS (e.g., BNSF), under protected programs (e.g., FAA’s IPP, PSP) or in other countries (e.g., Wing, Zipline)
- NASA’s m:N WG is coordinating the community beginning with joint identification of barriers

Supporting NASA capabilities

Human-Autonomy Teaming:
Develop tools and techniques to enable a small number of humans (m) to manage many autonomous vehicles (N) across disparate scenarios and dynamic relationships; Coordinate m:N WG

Autonomous vehicle technology:
Develop a capability description of a UML 5 autonomous vehicle through characterization of realistic Intelligent Contingency Management and Perception functions
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

See https://nari.arc.nasa.gov/aam-portal/ for more information
AAM Mission Critical Commitment:

Based on NASA research and activities, the AAM Mission will deliver validated system architectures and recommended requirements for aircraft, airspace, and infrastructure systems to enable sustainable and scalable medium density advanced air mobility operations.
Questions?