FEDERAL AVIATION ADMINISTRATION

Concept of Operations

v2.0

Foundational Principles

Roles and Responsibilities

Scenarios and Operational Threads

Urban Air Mobility (UAM)

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U.S. Department
of Transportation
Federal Aviation
Administration

Office of NextGen

800 Independence Ave., S.W.
Washington, DC 20591

April 26, 2023

Dear Reader:

We are pleased to share Version 2.0 of the Urban Air Mobility (UAM) Concept of Operations (ConOps) with our Federal Aviation Administration (FAA), National Aeronautics and Space Administration (NASA), and industry partners who have provided feedback to Version 1.0 of this document since its release in 2020. This ConOps documents the outcomes of the joint concept development efforts undertaken to date by the FAA NextGen Office with industry stakeholders as well as interagency coordination.

The UAM ConOps Version 2.0 is an iterative progression of work in the development of the concept that will be continued to mature through ongoing government and industry stakeholder collaboration. Future editions of the UAM ConOps will provide a broader and more comprehensive vision of our shared partnership for UAM operations based on feedback and continued collaboration surrounding this iteration of the UAM ConOps.

This document is key element in maturing the overall Advanced Air Mobility (AAM) concept aimed at developing an air transportation system that moves people and cargo between local, regional, intraregional, and urban locations not previously served or underserved by aviation using innovative aircraft, technologies, infrastructure, and operations. AAM will support a wide range of passenger, cargo, and other operations within and between urban and rural environments using new and innovative aircraft.

Sincerely,

Paul Fontaine
Assistant Administrator for NextGen (A)
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Executive Summary

The Federal Aviation Administration (FAA) NextGen Office released the initial Concept of Operations (ConOps) v1.0 for Urban Air Mobility (UAM) in June 2020 to describe a new, future, operational environment. UAM is a subset of Advanced Air Mobility (AAM), an initiative by the FAA, National Aeronautics and Space Administration (NASA), and industry. The AAM initiative aims to develop an air transportation system that moves people and cargo between local, regional, intraregional, and urban locations not previously served or underserved by aviation using innovative aircraft, technologies, and operations. While AAM supports a wide range of passenger, cargo, and other operations within and between urban and rural environments, UAM focuses on flight operations in and around urban areas. The UAM vision is supported by the introduction of a cooperative operating environment known as Extensible Traffic Management (xTM), which complements the traditional provision of Air Traffic Services (ATS) for future passenger or cargo-carrying operations/flights.

This concept is not a policy statement and is not a prescriptive statement of what the far term integration will be. It is a target description of the evolution of integration from the near-term Innovate 28 environment to a future of high-density urban operations. The concept focuses on a potential longer-term target supporting exploration and validation efforts. Future versions of the ConOps will reflect the outcomes of analyses, trials, concept maturation, and collaboration.

While many of the concept elements are similar across the future cooperative environments (e.g., UAM, Unmanned Aircraft Systems [UAS] Traffic Management [UTM], Upper Class E Traffic Management [ETM]), this ConOps focuses on UAM. The envisioned evolution for UAM operations includes an initial, low-tempo set of operations that leverage the current regulatory framework and rules (e.g., Visual Flight Rules [VFR], Instrument Flight Rules [IFR]) as a platform for increasing operational tempo, greater aircraft performance, and higher levels of autonomy. These are made possible by increased information sharing with operations across a range of environments, including major metropolitan areas and the surrounding suburbs. Resulting from stakeholder input sessions, the mature state operations will be achieved at scale through a crawl-walk-run approach, wherein:

1. Initial UAM operations are conducted using new aircraft types that have been certified to fly within the current regulatory and operational environment.
2. A higher frequency (i.e., tempo) of UAM operations in the future is supported through regulatory evolution and UAM Corridors that leverage collaborative technologies and techniques.
3. New operational rules and infrastructure facilitate highly automated cooperative flow management in defined Cooperative Areas (CAs), enabling remotely piloted and autonomous aircraft to safely operate at increased operational tempos.

This updated UAM ConOps v2.0 reflects the continued maturation of UAM and incorporates feedback received on v1.0, as well as research outcomes and additional input from government and industry stakeholders. Its focus is on clarifying elements from the initial version and providing additional detail in response to the feedback and input.

Language and definitions have been updated to ensure consistency across the cooperative (i.e., xTM) operating environments when applicable and includes an expanded description of Cooperative Operating Practices (COPs) (previously Community Business Rules [CBRs]). However, it does not prescribe specific solutions, detailed operational procedures, or implementation methods except as examples to support a fuller understanding of the elements associated with UAM operations.

Document Change Record

Published Date	Document Version	Section Impacted	Revisions of Particular Merit
6/26/2020	**1.0**	**Baseline Document**	
4/26/2023	**2.0**	Throughout	Expanded document to provide greater detail of selected concept elements (e.g., COPs) and relationship of UAM within the service environments (i.e., ATS and xTM) as well as reconcile use of terms.
		1.3	Updated and expanded service environment descriptions to include ATS and xTM.
		1.4	Incorporated definitions for range of terms used across the cooperative environments (e.g., UTM, UAM, AAM, xTM).
		3.0, 3.1, 3.2, 3.3	Amended to reflect updated terms and provide greater detail on the use of current regulatory framework to support initial UAM operations.
		4.2	Addition of section focused on Cooperative Operating Practices (COPs), which replaces Community Business Rules (CBRs)
		4.3.5	Updated the phrasing/language describing the federated service network supporting UAM operations.
		4.4.1, 4.4.2, 4.4.3, 4.4.4	Provided additional detail for elements of UAM Corridors, including potential evolution over time.
		5.0	Updated architecture with additional details (e.g., data exchanges specific to UAM/PSUs, depiction of vertiports).
		6.0	Updated scenarios to reflect current content in the body of the concept.

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1 Introduction

1.1 Scope

Urban Air Mobility (UAM) enables highly automated, cooperative, passenger or cargo-carrying air transportation services in and around urban areas. UAM is a subset of the Advanced Air Mobility (AAM) concept under development by the Federal Aviation Administration (FAA), National Aeronautics and Space Administration (NASA), and industry. As a subset of AAM, UAM focuses on operations moving people and cargo in metropolitan and urban areas. This Concept of Operations (ConOps) provides an evolving vision that will help facilitate further research on how to best assist UAM operations in the National Airspace System (NAS) if demand and volume exceed current capabilities.

The goal of this ConOps is to provide a common frame of reference to support the FAA, NASA, industry, and other stakeholder discussions and decision-making with a shared understanding of the challenges, technologies, and their potential, as well as examples of areas of applicability to the NAS. No solutions, specific implementation methods, or detailed operational procedures are described in this document except for example purposes (i.e., operational scenarios). This ConOps will be further matured and updated as the concept undergoes validation, stakeholder engagement continues, and additional operational scenarios are developed.

As the follow-on to the UAM ConOps v1.0, this document reflects the outcome of additional stakeholder engagement, exploration, and validation activities. It represents the continued maturation of the vision for UAM operations, airspace considerations, and UAM Cooperative Operating Practices (COPs). The ConOps v2.0 identifies the need for regulatory changes to support operations and collaborative environments with increasing density and complexity.

Current industry projections describe initial UAM operations incorporating a Pilot in Command (PIC) onboard the UAM aircraft with potential evolution to Remote PIC (RPIC). Consistent with the ConOps v1.0 and industry expectations, this document describes operations with an onboard PIC operating within the cooperative environment.

1.2 Background

Transportation is constantly evolving. Each step forward yields new opportunities that fundamentally change the relationship that humankind has with distance and travel. While it may not significantly reduce surface traffic volume, UAM will provide an alternative mode of transportation that should reduce traffic congestion during peak times.

1.2.1 Drivers for Change

For the UAM concept to mature to operational viability, it is important to understand stakeholder business models and operational needs, as well as their impact, for incorporation into the NAS. The FAA has collaborated with NASA and participated in a series of additional industry stakeholder engagements to identify examples of desired operations and environments for UAM aircraft.

The volume of UAM operations may increase substantially. The degree to which some, or all, of these UAM operations will require current Air Traffic Services (ATS) is undefined. To the degree that these operations require current ATS, the increasing number of UAM operations may soon challenge the current capabilities of the ATS workforce resources. Solutions that extend beyond the current paradigm for crewed aircraft operations to those that promote enhanced shared situational awareness and collaboration among operators are needed. As the FAA continues to mature the UAM concept, additional support systems for UAM operators may be introduced.

To the degree that these operations require current ATS, the increasing number of UAM operations could create new challenges for ATS workforce resources. Several industry leaders and stakeholders have invested heavily in this new concept and technology with the goal of eventually being able to provide the public with personal transportation or cargo services. Personal transportation services may be scheduled, on demand, or part of intermodal transportation links within major urban areas. Greater public acceptance of aircraft integrity and automation in the ride sharing economic model will also help enable increased UAM operations.

1.2.2 Aircraft Evolution

The industry vision involves incorporating new aircraft design and system technologies. While some of the new designs may resemble traditional winged aircraft, some are anticipated to include powered lift and Vertical Takeoff and Landing (VTOL) capabilities that facilitate operations between desired locations (e.g., metropolitan commutes). Major aircraft innovations, mainly with the advancement of Distributed Electric Propulsion (DEP) and development of Electric VTOLs (eVTOLs), may allow for these operations to be utilized more frequently and in more locations than are currently performed by conventional aircraft.

1.2.3 Vertiport Considerations

State and local governments are being encouraged to actively plan for UAM infrastructure to ensure transportation equity, market choice, and accommodation of demand for their communities. The vertiports and vertistops should be sited to ensure proper room for growth based on FAA evaluated forecasts and be properly linked to surface transportation (when possible), especially if the facility primarily supports cargo operations. Local governments should also have zoning protections in place to protect airspace in and around vertiports and vertistops.

Metropolitan planning organizations, including state and local governments, may incorporate UAM infrastructure planning into larger transportation and utility planning efforts to ensure seamless coverage and capacity. Community engagement and strategic connectivity to larger transportation planning efforts is key to ensuring UAM provides maximum benefits.

1.3 Operating Environment Perspectives

1.3.1 Overview

NAS operating environments include the airspaces, types of operations, regulations, and procedures necessary to support an operation. Currently, the range of NAS services provided to airspace users are characterized at the highest level under the category of ATS. These include separation (via Air Traffic Control [ATC]), Traffic Flow Management (TFM), advisories, and infrastructure (i.e., Communication, Navigation, and Surveillance [CNS]). Evolving concepts describe the introduction of highly automated, cooperative environments such as Unmanned Aircraft Systems (UAS) Traffic Management (UTM), AAM/UAM, and Upper Class E Traffic Management (ETM) to meet future NAS needs and challenges. These concepts of operations rely on sharing intent information across airspace users. This is governed by the current, evolving regulatory framework as needed to support new types of operations in defined Cooperative Areas (CAs) within which they are conducted.

1.3.2 UAM Cooperative Environment

Recent advances in technology have enabled industry development of new and innovative aircraft types, offering lower operating costs and highly automated functionality that facilitates the introduction of new types of operations. At the same time, advances in real-time information sharing and the distribution of roles and functions over federated service networks are maturing daily. In response to these challenges and opportunities, a highly automated, cooperative environment (with defined CAs) relying on a federated service network has been envisioned and described through multiple operational concepts as an additional aspect of the future service environments and part of the NAS. The term Extensible Traffic Management (xTM) is used to refer to these cooperative service environments in general and is comprised of UTM, AAM/UAM, and ETM. UAM operations, as a subset of AAM, may sometimes be conducted in CAs generally described as UAM Corridors. The evolution of the regulatory framework will provide the needed guidance to allow application of the innovative concepts, technologies, and techniques to support the emerging aircraft types and envisioned operations. Figure 1 provides a depiction of the AAM/UAM environment (outlined in red) relative to the current service delivery environment, as well as the other future cooperative environments.

As part of the future NAS, the complementary service delivery environments (i.e., ATS and xTM) will be evaluated as potential options to assist with scalability to meet future demand challenges and the flexibility to seize opportunities presented by the rapid evolution across the technology horizon (e.g., cloud computing, communications, information management).

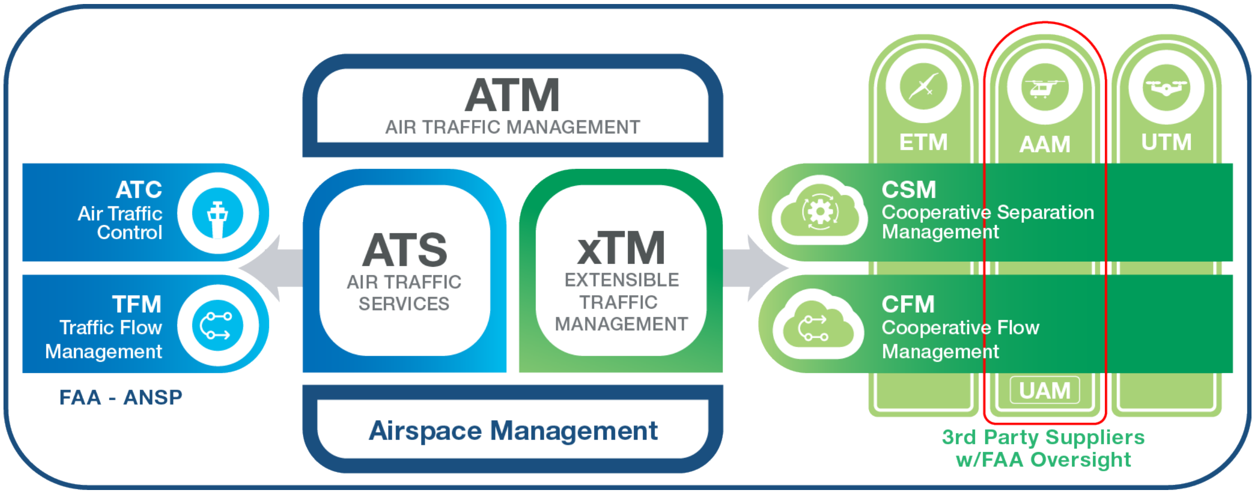

Figure 1: Notional Overview of Future Complementary Service Environments

1.3.3 Operations in the ATS Environment

All aircraft are required to comply with the regulatory requirements of the airspace within which they are conducting operations. A UAM operation is one executed by a UAM aircraft conducted within an airspace volume defined for UAM cooperatively managed operations. When conducting operations in the ATS environment, a UAM aircraft will comply with the ATS requirements of the applicable airspace class.

UAM aircraft will need to comply with applicable ATS regulations regarding VFR and IFR while operating in either Visual Meteorological Conditions (VMC) or Instrument Meteorological Conditions (IMC), like any current NAS operation. Capable aircraft (and operators) may choose to utilize ATS operating outside of a CA or cooperative services if operating in a CA based on whichever is more operationally advantageous to the airspace user. Consistent with today's operations, this choice is subject to the environment and conditions for the flight.

1.4 Definitions

Automated Flight Rules (AFRs) – Refers to rules, applied within UAM Corridors, which reflect the evolution of the current regulatory regime (e.g., VFR/IFR) and take into account advancing technologies and procedures (e.g., Vehicle-to-Vehicle [V2V] and data exchanges). Under defined conditions, the systems/automation may be allocated the role of the "predetermined separator" (see paragraphs 2.7.18–2.7.22 in [1]).

Cooperative Area – An airspace volume (e.g., UAM Corridor) within which cooperatively managed operations can occur. ATC ensures separation of non-participating aircraft from the cooperative operations and/or CA.

Cooperative Operating Practices (COPs) – Industry-defined, FAA-approved practices that address how operators cooperatively manage their operations within the CA (i.e., UAM Corridor), including conflict management, equity of airspace usage, and Demand-Capacity Balancing (DCB).

Cooperative Operation – A term used to describe an operation making use of cooperative services (e.g., separation, flow management) and is sharing/exchanging Operational Intent and other information in compliance with applicable regulations and COPs within a CA.

Federated Service Network – A group of service providers sharing information within a federated network to support operating in a common, agreed manner consistent with the approved COPs.

Fully Integrated Information Environment – Information environment and key attributes necessary to effectively deliver services and facilitate information exchange between stakeholders.

Service Environment(s) – Refers collectively to the distinct regulatory, procedural, and supporting automation mechanisms through which services (e.g., conflict management, flow management) are provided. In the future, the NAS is envisioned to include the current (i.e., traditional) ATS environment as well as incorporate a complementary, cooperative xTM services environment.

UAM Aircraft – An aircraft that chooses to participate in UAM operations.

UAM Corridor – A specific type of CA, as an airspace volume within which cooperatively managed operations can occur. ATC ensures separation of non-participating aircraft from the cooperative operations and/or CA. It is comprised of an airspace volume defining a three-dimensional route, possibly divided into multiple segments, with associated performance requirements.

UAM Operation – A specific type of cooperative operation that occurs within a UAM Corridor and is conducted in compliance with UAM specific rules, procedures, performance requirements, and COPs.

UAM Operator – The person or entity responsible for the overall management and execution of one or more UAM operations. The operator plans operations, shares flight information (e.g., planning, live flight), and ensures infrastructure, equipment, and services are in place to support safe execution of flight. Throughout this document, "UAM operator" is often used to describe the roles and responsibilities of the UAM Code of Federal Regulations (CFR) Title 14, Part 135 carrier, the RPIC/PIC, or conflict management automation to avoid allocating prematurely and allow for evolution of the role.

Vertiports – A collective term for the diverse system of public and private vertiports and vertistops.

- **Vertiport** – An area of land or structure used or intended to be used for electric, hydrogen, and hybrid VTOL landings and takeoffs. A vertiport can include associated buildings and facilities.
- **Vertistop** – A vertistop is a term generally used to describe a minimally developed vertiport for boarding and discharging passengers and cargo (i.e., no fueling, defueling, maintenance, repairs, or storage of aircraft, etc.).

2 Principles and Assumptions

The following principles and assumptions guide the development of the UAM operating environment and mature the UAM concept.

- The FAA retains regulatory authority over NAS airspace and operations.
    - UAM aircraft operate within a regulatory, operational, and technical environment as part of the NAS.
    - Any evolution of the regulatory environment will always maintain safety of the NAS.
- The FAA reserves the right to increase aircraft operational performance requirements to optimize the capacity/utilization of the airspace.
- The FAA has on-demand access to information regarding UAM operations.
- Airspace management will be static where necessary and flexible when possible.
- UAM operators:
    - Are responsible for the coordination, execution, and management of their operations.

  - Conduct operations in compliance with the applicable regulatory framework for the operation, the airspace within which the operation is conducted, and the applicable COPs.
  - Maintain conformance to shared intent and, via Providers of Services for UAM (PSUs), are made aware of the intent of other relevant operations.
  - Cannot optimize their own operations at the expense of sub-optimizing the environment as a whole.
- Cooperative traffic management is conducted in compliance with a set of COPs, which would need to be collaboratively developed by relevant stakeholders and approved by the government.
  - DCB intervention may be required as the number of UAM operations increases.
  - As the operational tempo increases the need for new ATC tactical deconfliction techniques, including the formulation of new separation standards that would rely on enhanced aircraft performance and air traffic management system fidelity may be utilized.
  - The architecture (i.e., technology) for UAM services needs to be flexible and scalable. Operators or third-party service suppliers share information using common standards and messaging protocols to ensure interoperability.
- PSUs may be utilized by operators to receive and exchange information during UAM operations.

3 Evolution of UAM Operations

The evolution of UAM operations is characterized by the following key indicators.

1. **Operational Tempo:** Representation of the density, frequency, and complexity of UAM operations. Tempo evolves from a small number of low-complexity operations to a high-density, high frequency of complex operations.
2. **UAM Structure (Airspace and Procedural):** The level of complexity of infrastructure and services that support the UAM environment.
3. **UAM-Driven Regulatory Changes:** Existing regulations may need to evolve to address the needs for UAM operations' structure and performance.
4. **UAM COPs:** COPs implement the updated regulations to establish the expectations and interactions. See Section 4.2 for additional COP details.
5. **Aircraft Automation Level:** The level of "PIC" engagement with the UAM aircraft enabling systems. The following categories describe the evolution of aircraft automation:
   - Human-Within-the-Loop (HWTL)
     - Human is always in direct control of the automation (i.e., systems)
   - Human-on-the-Loop (HOTL)
     - Human has supervisory control of the automation (i.e., systems)

  - Human actively monitors the systems and can take full control when required or desired
- Human-Over-the-Loop (HOVTL)
  - Human is informed, or engaged, by the automation (i.e., systems) to take action
  - Human passively monitors the systems and is informed by automation if, and what, action is required
  - Human is engaged by the automation either for exceptions that are not reconcilable or as part of rule set escalation

6. **Location of the PIC:** The physical location of the PIC. UAM operations may evolve from a PIC onboard the UAM aircraft to RPICs/remote operators via the advent of additional aircraft automation technologies.

Figure 2 describes the evolution of UAM operations and its relationship with increasing level of operational tempo and the airspace structure and procedures.

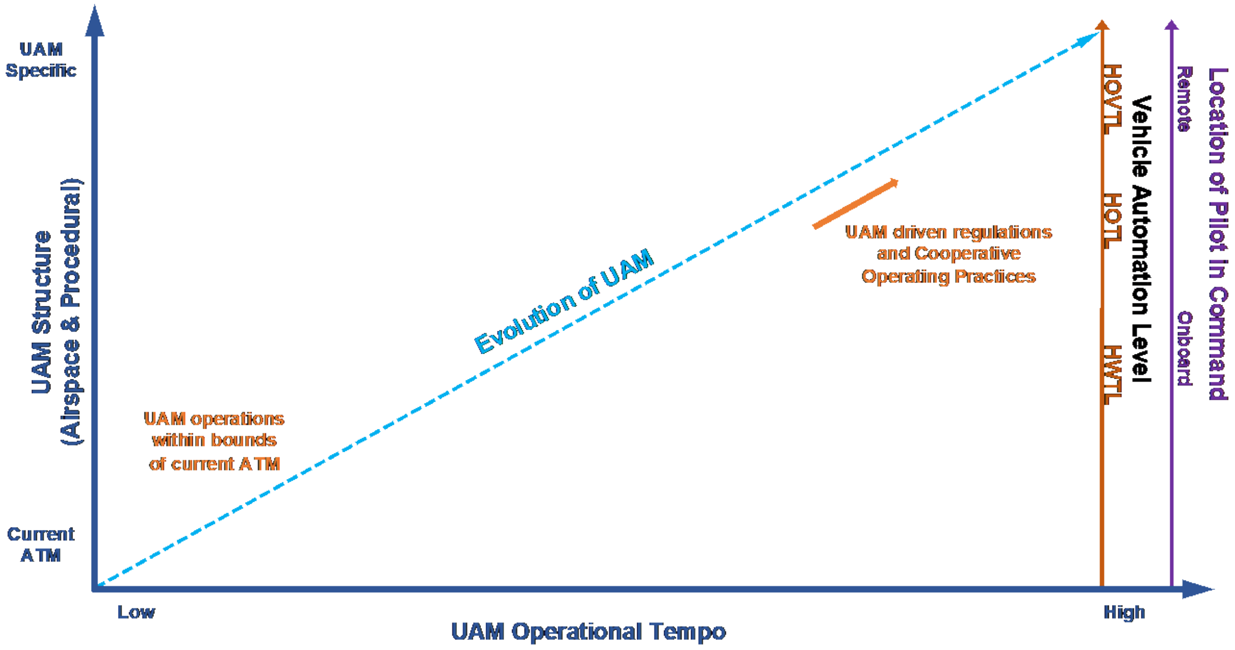

Figure 2: Evolution of the UAM Operational Environment

UAM operational evolutionary stages are described in the following subsections:

- Initial UAM operations
- Midterm operations
- Mature state operations

3.1 Initial UAM Operations

Initial UAM operations are conducted by UAM aircraft leveraging current ATS rules and regulations (e.g., VFR, IFR). Key indicators of initial UAM operations are listed below.

- **Operational Tempo:** Low.
- **UAM Structure (Airspace and Procedural):** No UAM unique structures or procedures exist. Operations will utilize existing ATS and routes but may create new routes as necessary.
- **UAM-Driven Regulatory Changes:** Initial UAM operations are conducted leveraging current rules, regulations, and local agreements.
- **UAM COPs:** There are no COPs, but operational needs may be addressed in agreements such as Letters of Agreement (LOAs).
- **Aircraft Automation Level:** Consistent with current, crewed fixed-wing and helicopter technologies (e.g., autopilots, auto-land).
- **Location of the PIC:** Onboard.

For UAM aircraft that are capable, current operations are supported by existing rules, procedures, and designated routes. As additional operations outside of the current operational paradigms are initiated, LOAs, routes, and other procedural changes may need to be introduced to accommodate the additional demand and location of operations within the regulatory framework of the current ATS system. Since industry anticipates increasing operations to scale cost effectively and meet increased demand for services, the demand for UAM operations may eventually reach the limits of current regulations and ATS services.

3.2 Midterm Operations

With increased tempo, UAM operations will evolve through changes to the governing regulations augmented by COPs, UAM infrastructure, and automation. The evolution to a collaborative, information-rich, data-sharing environment may require new technologies and capabilities. UAM operators and other stakeholders will share information with the FAA, having on-demand access to identified operational information.

Midterm operations are supported by an environment that meets the needs of increased operational tempo. Key indicators of midterm UAM operations are listed below.

- **Operational Tempo:** The operational tempo remains low; however, it may have increased to a point that necessitates changes in the existing regulatory framework and procedures.
- **UAM Structure (Airspace and Procedural):** UAM aircraft are flying within UAM Corridors. UAM operations are enabled through confirmed UAM Operational Intent—operation-specific information including, but not limited to, UAM operation identification, the intended UAM Corridor(s), aerodromes and vertiports, and key operational event times (e.g., departure, arrival) of the UAM operation. Operations are considered UAM participants during the period of operation that exists within the UAM Corridor cooperative environment.

ATC ensures separation of non-participating aircraft from cooperative operations and/or CAs. Deconfliction may be allocated to the UAM operator and/or PIC akin to visual separation.

- **UAM-Driven Regulatory Changes:** Changes to ATS regulations and new UAM regulations that enable operations within UAM Corridors.
- **UAM COPs:** COPs are defined by industry to meet industry standards or FAA guidelines when specified. COPs will require FAA approval.
- **Aircraft Automation Level:** PICs may control the aircraft with emerging capabilities (e.g., simplified vehicle operation).
- **Location of the PIC:** Primarily onboard aircraft but complemented by the introduction of RPIC operations (with one RPIC per operation).

The number and complexity of operations, along with aircraft capabilities and equipage, may increase beyond that effectively supported by leveraging current rules (e.g., VFR, IFR). To support such an increase, a UAM cooperative environment may need to be developed and implemented with new or modified procedures, an updated regulatory framework, and COPs. The UAM cooperative environment (i.e., UAM Corridor) is a performance-based airspace structure with defined parameters that are achievable by the participants. UAM Corridors would be known to airspace users and governed by a set of rules which prescribe access and operations. Where supporting infrastructure and support services meet participation requirements, UAM operations may be conducted. Operators whose aircraft meet performance and participation requirements may conduct operations within the UAM Corridor.

Initially, the number of UAM Corridors may be low or limited in use, but over time, additional UAM Corridors may be introduced as they may be utilized in airspace areas where traffic volume requires their establishment in the interest of safety and efficiency. The UAM Corridors may transit any applicable airspace classes.

Operations within UAM Corridors may be supported by COPs collaboratively developed by the stakeholder community, based on industry standards and/or FAA guidelines, and approved by the FAA, as appropriate, to ensure that the agency’s regulatory authority is maintained (e.g., NAS safety, equitable access, security). The collaborative development of COPs would allow for stakeholders to agree on norms of interactions, which may reduce the need for ATC tactical control of individual flights and management of access. The collaboratively developed, transparent, standard COPs augment the envisioned regulatory foundation for UAM operations.

3.3 Mature State Operations

As the UAM operational tempo increases, UAM operations may further evolve to support operational demand. Key indicators of mature state UAM operations are listed below.

- **Operational Tempo:** The operational tempo increases significantly. Higher operational tempo needs drive the increased maturity for the other indicators.
- **UAM Structure (Airspace and Procedural):** UAM operations continue to occur within UAM Corridors. The UAM Corridors may form a network to optimize paths to support an

increasing number of vertiports; the internal structure of the UAM Corridors is expected to increase in complexity, and the necessary performance parameters for UAM participation may increase. ATC ensures separation of non-participating aircraft from cooperative operations/CAs. Deconfliction may be allocated to the UAM operator, PIC, or operator's automation.

- **UAM-Driven Regulatory Changes:** Extensive UAM-driven regulations will be necessary to enable cooperative operations within UAM Corridors.
- **UAM COPs:** The complexity of COPs and FAA involvement in establishing guidelines and approving COPs may evolve to match the specific topic addressed.
- **Aircraft Automation Level:** Automation improvements may lead to HOVTL capabilities.
- **Location of the PIC:** Remote piloting is more widely available and as frequent as PIC operations.

Additional increases in the tempo of midterm operations could require advances to the UAM environment and aircraft. To overcome the constraints, UAM operations may evolve to UAM mature state operations through advances to data sharing, DCB, UAM structure, and aircraft automation. Mature state operations may also include additional COPs accompanied by UAM-driven regulatory changes.

4 UAM Operational Concept

This section provides an overview of the UAM operational concept and COPs, followed by key definitions and descriptions of roles and responsibilities, UAM Corridor characteristics, weather and other obstacles within the UAM environment, and constraint information and advisories.

4.1 Overview

A UAM operator performing a UAM operation is cooperatively sharing information and engaging cooperative services to assure the safe and efficient conduct of the flight within a UAM Corridor. The UAM Corridor structure, UAM procedures, information sharing, and UAM performance criteria enable increasing operational tempo and minimize impact to ATS. UAM operations are supported by PSUs that comprise a federated service network to enhance the capabilities of individual UAM operators/PICs in all phases of operations through exchange, analysis, and mediation of information among all relevant actors (e.g., UAM operators/PICs, PSUs, the FAA, and public interest stakeholders).

Any aircraft operating within a UAM Corridor must meet the performance and participation requirements of the UAM environment. Within UAM Corridors, deconfliction is allocated by ATC to UAM operators and/or PIC. The UAM community will collaboratively develop and establish COPs as standards for operations. The FAA may contribute to COP guidelines but will approve COPs based on the specific focus, topic, or area addressed by the COP. UAM Corridor design, performance, and participation requirements, as well as UAM COPs, may be designed to reduce ATC involvement with UAM off-nominal events by implementing standardized off-nominal protocols. UAM aircraft operating outside UAM Corridors must follow the operational rules and procedures applicable to the corresponding airspace.

The concept represents an early step in the envisioned evolution of the regulatory framework, development of operating rules and performance requirements commensurate with demands of the operation, and data exchange with information architecture to support UAM operator and FAA responsibilities. UAM leverages a common, shared, technical environment, where the operators are responsible for coordination, execution, and management of operations consistent with the regulatory framework and applicable COPs. This networked information exchange is the cornerstone for stakeholders to plan, manage, execute, and oversee UAM operations. Additional stakeholders can access UAM shared operational information on demand.

4.2 Cooperative Operating Practices (COPs)

Foundational to the success of the envisioned, federated, highly automated, cooperative environment is the establishment of common business rules across relevant stakeholders, referred to as COPs. Development, adoption, and implementation of COPs will require collaboration across multiple stakeholders—including operators, industry, and the FAA as the regulator—to identify and resolve a broad range of questions and challenges. Examples of these questions include "what rules are needed?", "how are they expressed?", and "how will they be managed?"

COPs are characterized as industry-defined, FAA-approved practices that address how operators cooperatively manage their operations within the cooperative UAM environment, including conflict management, equity of airspace usage, and DCB.

They are consistent with and augment updates to the regulatory framework.[1] The development timeframe will be driven by the pace at which operators desire to execute cooperative UAM operations distinct from those conducted under the current regulatory framework (e.g., VFR, IFR). As the tempo and complexity of UAM operations increases, it is anticipated that the complexity and range of topics covered by COPs will also increase. The relationship between industry and government (e.g., FAA, Department of Transportation [DOT]) differs based on the focus of the specific COP. In some instances, the rules or topic area of an individual COP may determine the level of engagement necessary with the regulatory authority. The level of engagement also has implications for the level of involvement that the authority will undertake as part of the applicable coordination for the specific COP. The range of engagement by the regulator may span from minimal to high levels. At higher levels, significant documentation, and testing, as well as formal acceptance, authorization, or qualification, may be necessary prior to operational use by industry.

Another aspect of the relationship between government and industry before a specific COP may be used operationally is "equity interest." This refers to how closely the topic/area covered by the specific COP is related to government responsibilities (i.e., mission) or policies. Some COPs, such as those focused on aviation safety, fall directly under the FAA's regulatory mission. Other COPs, such as avoiding unnecessary anti-competitive technical specifications for participation in the federated service network, may be subject to policies that fall under the purview of regulatory agencies beyond the FAA.

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[1] Significant efforts will be required to review potential rules, regulations, and guidance material that govern UAM operations (e.g., 14 CFR Parts 135, 91, 23, 25, 27, 29) to identify any updates required to enable the implementation and regulation of UAM operations within the NAS.

4.3 Roles and Responsibilities

This section defines the roles and responsibilities for actors associated with UAM operations.

4.3.1 FAA

The FAA performs regulatory, ATC, and NAS data exchange roles for UAM, as detailed in the following subsections.

4.3.1.1 Regulation

The FAA is the federal authority over aircraft operations in all airspace and the regulatory and oversight authority for civil operations in the NAS. The FAA maintains an operating environment that ensures airspace users have access to the resources needed to meet specific operational objectives and that shared use of the airspace can be achieved safely and equitably. The FAA develops or modifies regulations to support UAM operations. The FAA will approve COPs to ensure that the FAA authority is maintained (e.g., NAS safety, equal access to airspace, security). The FAA will define, maintain, and make publicly available UAM Corridor definitions (e.g., routes and altitudes) and manage the performance requirements of UAM Corridors.

4.3.1.2 ATC

The primary purpose of ATC is to maintain safe movement of aircraft operating within the NAS. For high-density UAM operations, this may be accomplished through ATM modernization. ATC will ensure the separation of non-participating aircraft from the cooperative operation and/or CAs. As appropriate, ATC may issue traffic advisories regarding known UAM operations (e.g., active UAM Corridors) to aircraft receiving ATC services. ATC may request information as needed from participating actors and may receive automated notifications in accordance with applicable requirements.

The ATC responsibilities that enable UAM operations are to:

1. Set UAM Corridor availability (e.g., open or closed) based on operational design (e.g., time of day, flow direction of a nearby airport).
2. As appropriate, provide traffic advisories regarding known UAM operations (e.g., active UAM Corridors) to aircraft receiving ATC services.
3. Respond to UAM off-nominal operations as needed.
4. When tactical separation assurance is required, provide current or newly developed services appropriate to the airspace in which the UAM aircraft is operating.

To fulfill their responsibilities, ATC may review any pertinent information from UAM operations.

4.3.1.3 NAS Data Exchange

FAA NAS data sources are available to UAM operations via FAA-industry exchange protocols. This allows for authorized data flow between the UAM community and FAA operational systems.

This interface between the FAA and UAM stakeholders is a gateway such that external entities do not have direct access to FAA systems and data. FAA data sources available via the FAA-industry data exchange include, but are not limited to, flight data, restrictions, charted routes, and active Special Activity Airspaces (SAAs).

4.3.2 UAM Operator

UAM operators may conduct operations as scheduled services or on-demand services via a request from an individual customer or intermodal operator. UAM operators are responsible for regulatory compliance and all aspects of UAM operation execution. Use of the term "UAM operator" in this document indicates airspace users electing to conduct operations via cooperative management within the UAM environment.

The UAM operator obtains current conditions from PSU and Supplemental Data Service Provider (SDSP) services (e.g., environment, situational awareness, strategic operational demand, vertiport availability, supplemental data) to determine the desired UAM Operational Intent information. This may include location of flight (e.g., vertiport locations), route (e.g., specific UAM Corridors), UAM Corridor entry or exit point, and estimated flight time.

UAM operators must have a confirmed UAM Operational Intent to operate in UAM Corridors. UAM Operational Intent data serves the following primary functions.

1. Informs other UAM operators of nearby operations within the UAM Corridor to promote safety and shared awareness
2. Enables strategic deconfliction
3. Enables identification and distribution of known airspace constraints and restrictions for the intended area of operation
4. Enables distribution of spatially and temporally relevant advisories, weather, and supplemental data
5. Supports cooperative separation management services (e.g., conformance monitoring, advisory services)

The UAM operator also plans for off-nominal events. This includes an understanding of alternative landing sites and the airspace classes that border the UAM Corridor(s) for the operation. Upon completion of the operation, the UAM operator notifies the PSU.

4.3.3 Pilot in Command (PIC)

The PIC is the person aboard the UAM aircraft who is ultimately responsible for the operation and safety during flight. This ConOps assumes a pilot onboard the aircraft; however, operations described do not preclude a remote pilot or automated operations.

4.3.4 Provider of Services for UAM (PSU)

A PSU is an entity that supports UAM operators with meeting UAM operational requirements that enable safe, efficient, and secure use of the airspace. A PSU is the primary service and data provider for UAM stakeholders and the interface between the UAM ecosystem and the FAA. A PSU can be a separate entity from the UAM operator, or an operator can act as its own PSU. When confirming the UAM Operational Intent, a PSU may act on behalf of an operator who has subscribed to its offered services within the updated regulatory framework established by the FAA for instances when an operator does not act as its own PSU.

A PSU:

1. Provides a communication bridge between federated UAM actors, from PSU to PSU via the network, to support its subscribing UAM operator's ability to meet the regulatory and operational requirements for UAM operations.
2. Provides its UAM operators with information gathered from the network about planned UAM operations in a UAM Corridor so that UAM operators can ascertain the ability to conduct safe and efficient missions.
3. Analyzes and confirms that a submitted UAM Operational Intent is complete, consistent with current advisories and restrictions, and strategically deconflicted considering previously confirmed UAM Operational Intents, COPs, UAM Corridor capacity, airspace restrictions, vertiport resource availability, and adverse environmental conditions.
4. Provides the confirmed UAM Operational Intent to the federated service network.
5. Distributes notifications (e.g., constraints, restrictions) for the intended area of operation.
6. Distributes FAA operational data and advisories, weather, and supplemental data.
7. Supports cooperative separation management services (e.g., conformance monitoring, advisory services).
    a. Assists with coordinating UAM Corridor use status; UAM Corridor use status (e.g., occupied, unoccupied) is an indication that UAM operations are being conducted or not.
8. Archives operational data in historical databases for analytics, regulatory, and UAM operator accountability purposes.
9. Negotiates airport access through the airport's sponsor.

These key functions allow a PSU to support cooperative management for UAM operations without direct FAA involvement on a per flight basis.

PSU services support operations planning, UAM Operational Intent sharing, deconfliction, airspace management functions, and off-nominal operations that UAM operators may encounter. PSUs may provide value-added services to subscribers that optimize operations or provide SDSP services in support of UAM operations. PSUs exchange information with other PSUs via the federated service network to enable UAM services (e.g., exchange of UAM Operational Intent information, notification of UAM Corridor status, information queries). PSUs also support local municipalities and communities as needed to gather, incorporate, and maintain information that may be accessed by UAM operators.

4.3.5 Federated Service Network

The federated service network is the collection of connected PSUs that share subscriber information, FAA data, supplemental data, and data from other entities (e.g., PSUs, FAA, public interest stakeholders) to provide a fully integrated information environment to support UAM operations. Since multiple PSUs can provide services in the same geographical area, the federated service network facilitates the availability of data to the FAA and other entities as required to ensure safe operation of the NAS and any other information sharing functions including security and identification.

4.3.6 Supplemental Data Service Provider (SDSP)

UAM operators and PSUs use supplemental data services to access supporting data including, but not limited to, terrain, obstacle, and specialized weather. PSUs are also able to serve as SDSPs for subscribed UAM operators. SDSPs may be accessed via the federated service network or directly by UAM operators.

4.3.7 UAM Vertiport

Vertiports, used as a collective term, are expected to be a diverse system of public and private vertiports and vertistops. These facilities are categorized to identify the variety of aircraft they can support based on facility design and operations. Vertiports and vertistops support passenger and cargo operations for aircraft operating in VFR, IFR, and AFR.

UAM operators are expected to utilize whichever vertiport configuration meets their operational needs.

A vertiport is a designated area that meets the capability requirements to support UAM departure and arrival operations. The UAM vertiport provides current and future resource availability information for UAM operations (e.g., open/closed, pad availability) to support UAM operator planning and PSU strategic deconfliction. UAM vertiport information is accessible by the operator via the federated service network and supplemental vertiport information may be available via the SDSP. The vertiport information is used by UAM operators and PSUs for UAM operation planning including strategic deconfliction and DCB; however, the vertiports do not provide strategic deconfliction or DCB services.

4.3.8 UAS Service Supplier (USS)

UAS Service Suppliers (USSs) are entities that support UAS operations under the UTM system (see the UTM ConOps v2.0 [2] for more details). Potential scenarios may exist where USSs and PSUs need to share information to ensure cooperative separation during UAM landing and takeoff phases of flight within UTM environments (i.e., under 400 feet).

From a UAM operational perspective, USSs may interact with PSUs by:

1. Enabling UTM operations to use federated service network services to cross a UAM Corridor.

2. Supporting UAM off-nominal operations as needed (e.g., UAM operations executing emergency landings impacting UTM operation areas).
3. Supporting UTM off-nominal operations as needed (e.g., UTM operation deviating from filed Operational Intent near a UAM vertiport).

4.3.9 Other NAS Airspace Users

Other NAS airspace users are any non-UAM aircraft operation within the NAS. These users would have the responsibility to know about and meet the relevant performance and participation requirements to operate in open UAM Corridors or avoid active UAM Corridors. UAM Corridor definitions and availability will be publicly available for these users to access.

4.3.10 Public Interest Stakeholders

Public interest stakeholders are entities declared by governing processes (e.g., COPs) to be able to access UAM operational information and notifications. This access may support activities including, but not limited to, public right to know, government regulatory, government assured safety and security, and public safety. Examples of public interest stakeholders are local law enforcement and United States federal agencies.

4.4 UAM Corridors

As described earlier, initial UAM operations are expected to make use of the flexibility in the current regulatory framework (e.g., VFR, IFR) to meet their operational and mission needs. Over time, the number of UAM operations are expected to increase, the specific areas/locations where operators desire to conduct the operations may expand, and aircraft capabilities (e.g., equipage, performance) could advance. Corridors may offer the opportunity to respond to what could be new levels and types of service demands while taking advantage of the aircraft's capabilities without adversely impacting current service levels.

The concept of UAM Corridors envisions safe and efficient UAM operations that may not require traditional ATC services in certain situations, are available to any aircraft appropriately equipped to meet the performance requirements, and would be created/implemented when operationally advantageous. The UAM Corridors could help support the increasing operational tempo through increased capabilities (e.g., aircraft performance), UAM Corridor structure, and UAM procedures. At increased UAM traffic levels, UAM Corridors could be a mechanism for distinguishing and keeping separate the different regulatory frameworks—those applicable to UAM operations versus those operating under the current (e.g., IFR, VFR) or UTM regulations.

UAM Corridors would be designed consistent with applicable environmental considerations and may be implemented in areas where it is operationally advantageous. The UAM Corridors may transit all airspace classes. It is anticipated that UAM Corridors may exist simultaneously at locations and in airspace classes with constructs (e.g., VFR flyways/corridors, IFR) leveraged for initial UAM operations.

Operations within UAM Corridors may have operational performance and participation (e.g., UAM Operational Intent sharing, deconfliction within the UAM Corridor) requirements. The performance and participation requirements for a UAM Corridor may vary between UAM Corridors. In addition, performance requirements and UAM Corridor definition (e.g., volume, location) support accommodations for most UAM off-nominal operations where the UAM aircraft can complete the operation safely. Any operator meeting the UAM Corridor performance and participation requirements may operate within or crossing the UAM Corridor. The crossing of a UAM Corridor by an aircraft/operator not participating in the cooperative environment (e.g., general aviation) remains an area of exploration as the UAM Corridor concept, specific features, uses, and requirements mature. As UAM Corridor geometry is better understood, the foundational elements of UAM Corridor crossings may be analyzed by stakeholders.

UAM Corridor definitions are available to stakeholders for planning and operational use. ATC will be involved in the implementation and execution of UAM Corridors for the airspace for which ATC is responsible. Other NAS users will be aware of UAM Corridors through airspace familiarization associated with flight planning or ATC flight plan approval or advisories. UAM Corridor design considerations should include:

1. Minimal impact to existing ATS and UTM operations while maintaining equity for all operators.
2. Public interest stakeholder needs (e.g., local environmental and noise, safety, security).
3. Stakeholder utility (e.g., customer need).

UAM Corridor availability (e.g., open, closed) would be in accordance with ATC operational design (e.g., nearby airport configurations/change). UAM Corridor availability may be communicated through the federated service network to PSUs and UAM operators. In addition to UAM Corridor availability established by ATC, PSUs determine UAM Corridor status that identifies if one or more UAM operations are occurring somewhere within the UAM Corridor. UAM Corridor usage information may be used by the FAA or other stakeholders for situational awareness.

Initially, the UAM Corridors may support point-to-point UAM operations. As UAM operations evolve, UAM Corridors may be segmented and connected to form more complex and efficient networks of available routing between points (e.g., vertiports). Figure 3 shows a small number of point-to-point UAM Corridors.

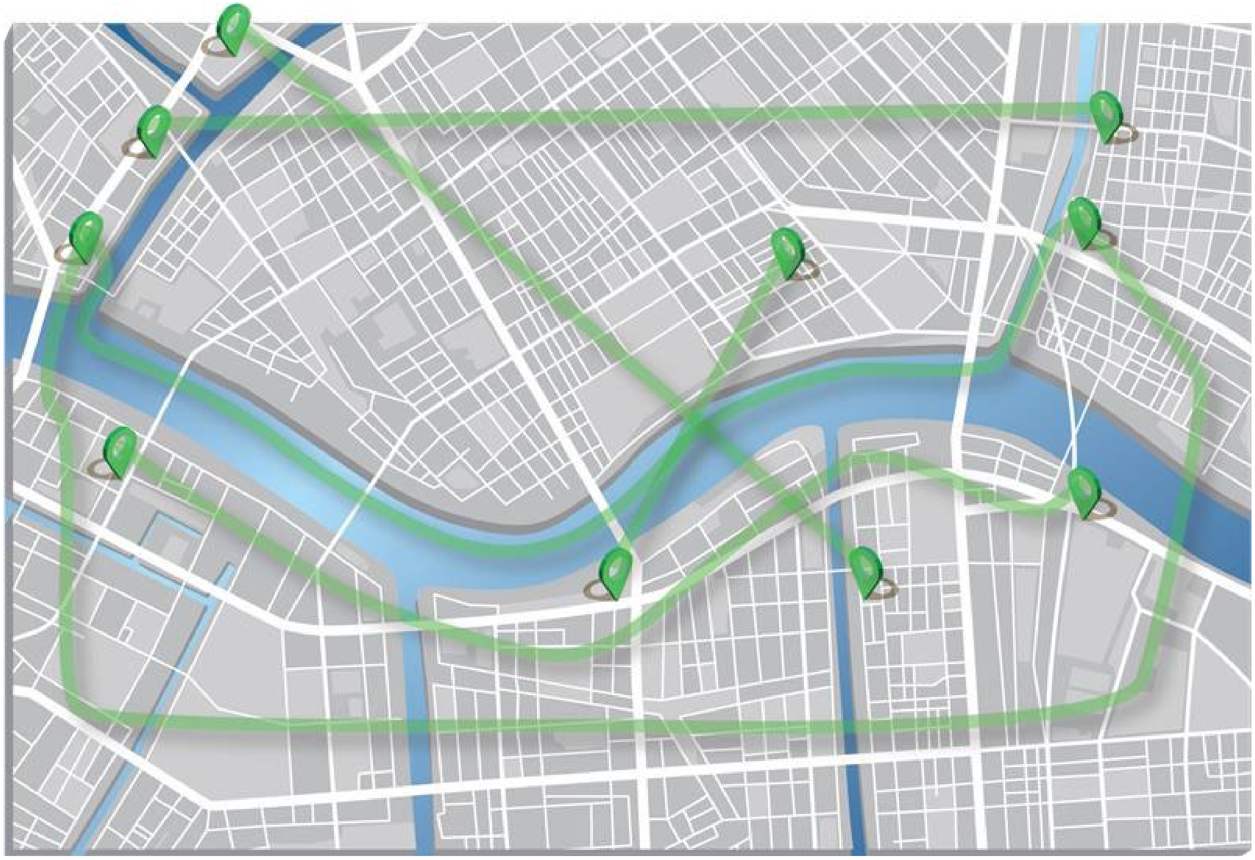

Figure 3: Notional Multiple UAM Corridors

4.4.1 UAM Corridor Entry/Exit Points (CEPs)

Some UAM operations may be conducted wholly within the cooperative environment. However, most operations are anticipated to transit both service environments (i.e., ATS and xTM [UAM]). Corridor Entry/Exit Points (CEPs) refer to the defined points in space at which an aircraft crosses from one environment to another.

CEPs may be "established" in that they are defined as part of the UAM Corridor itself. An example would be established points at either end of a UAM Corridor that are defined and disseminated as part of the UAM Corridor definition/description. They may also be "operation-defined," which are those points in space on the boundary between the service environments (i.e., ATS and xTM [UAM]) along an accepted intent or trajectory that has not already been established.

Specific requirements or limitations regarding the use of CEPs may be addressed in applicable COPs and regulatory framework. Aircraft entering or exiting a UAM Corridor must meet the requirements of the airspace (e.g., Class B, C, D, E) they intended to use external to the UAM Corridor.

4.4.2 Conflict Management and Separation

Conflict management across the NAS includes the strategic activity of airspace organization and management. In certain situations, when operationally advantageous, UAM Corridors may enable UAM operations without traditional ATC services. Separation of operations within UAM Corridors may be provided through a layered approach of strategic and tactical deconfliction methods. Strategic deconfliction envisions the sharing of flight intent and the collaborative execution of the COPs relevant to deconfliction. In later stages, capabilities relying on V2V data exchanges guiding the execution of aircraft separation may also mature sufficiently for implementation.

When operating within a UAM Corridor, FAA regulations and COPs direct the manner of interactions across relevant actors for strategic and tactical deconfliction. UAM operators remain responsible for the safe conduct of operations, including operating relative to other aircraft, weather, terrain, and hazards and avoiding unsafe conditions. UAM separation is achieved via shared UAM Operational Intent, shared awareness, strategic deconfliction of flight intent, and the establishment of procedural rules.

While strategic deconfliction within UAM Corridors could occur during UAM Operational Intent planning, the need may remain for in-flight coordination, sharing, and tactical deconfliction. Initial analysis indicates strategic deconfliction in the planning phase may not be sufficient to support the operational tempo described as desired by industry. In the event a UAM aircraft operates outside of the bounds of shared UAM Operational Intent, notifications of the off-nominal event and updates to the UAM Operational Intent, if applicable, would be shared via the federated service network. Initial separation in UAM Corridors may leverage applicable VFR/IFR mechanisms (e.g., “see-and-avoid”). If aircraft technology and capabilities (e.g., equipage) evolve and mature, separation minima and AFRs may be introduced to provide higher capacity and support the projected increase in demand (i.e., operational tempo). The regulatory framework governing UAM operations would need to evolve significantly to account for the increasing levels of performance and automation. The maturation and implementation of both the advanced technologies and updated regulatory framework are coupled to changes in the separation minima and, by extension, the available throughput of a given UAM Corridor. The need for DCB capabilities or initiatives will be coupled to the pace at which the operational tempo increases and the envisioned advances in aircraft performance (e.g., equipage, capabilities) are realized.

4.4.3 Demand-Capacity Balancing (DCB)

DCB is applied when the requested resources cannot support the collective UAM Operational Intent demand. In certain circumstances, the excessive demand may not be due to UAM Corridor capacity but due to other factors such as congestion at origin or destination. Initial analysis of strategic deconfliction to eliminate tactical maneuvering identified that the operational tempo desired by UAM operators cannot be supported solely through strategic planning/deconfliction. The “buffer” necessary to account for uncertainty as the operational tempo increases leads to the eventual need for tactical deconfliction and DCB capabilities to optimize efficiency.

Within the UAM Corridor, flow management functions, including DCB, will be provided through Cooperative Flow Management (CFM) services. The business rules governing the execution of

CFM are included in relevant COPs, which are consistent with FAA authority including access, equity, safety, and security.

4.4.4 UAM Corridor Evolution

Initial UAM operations, characterized by low tempo and low complexity, will be executed using the current regulatory framework. As the tempo and complexity of operations increases, options available in the current regulatory framework (e.g., VFR corridors/flyways, T-routes) may accommodate the growth. As the operations continue to increase in volume and complexity, the implementation of simple UAM Corridors may become operationally advantageous for the airspace users and/or the ATS service providers. Initial UAM Corridors are expected to be "simple" in design (e.g., one-way UAM Corridors or single track in each direction), as illustrated in Figure 4. As UAM Corridors become more defined, AFR will likely be available, consistent with the evolving regulatory framework.

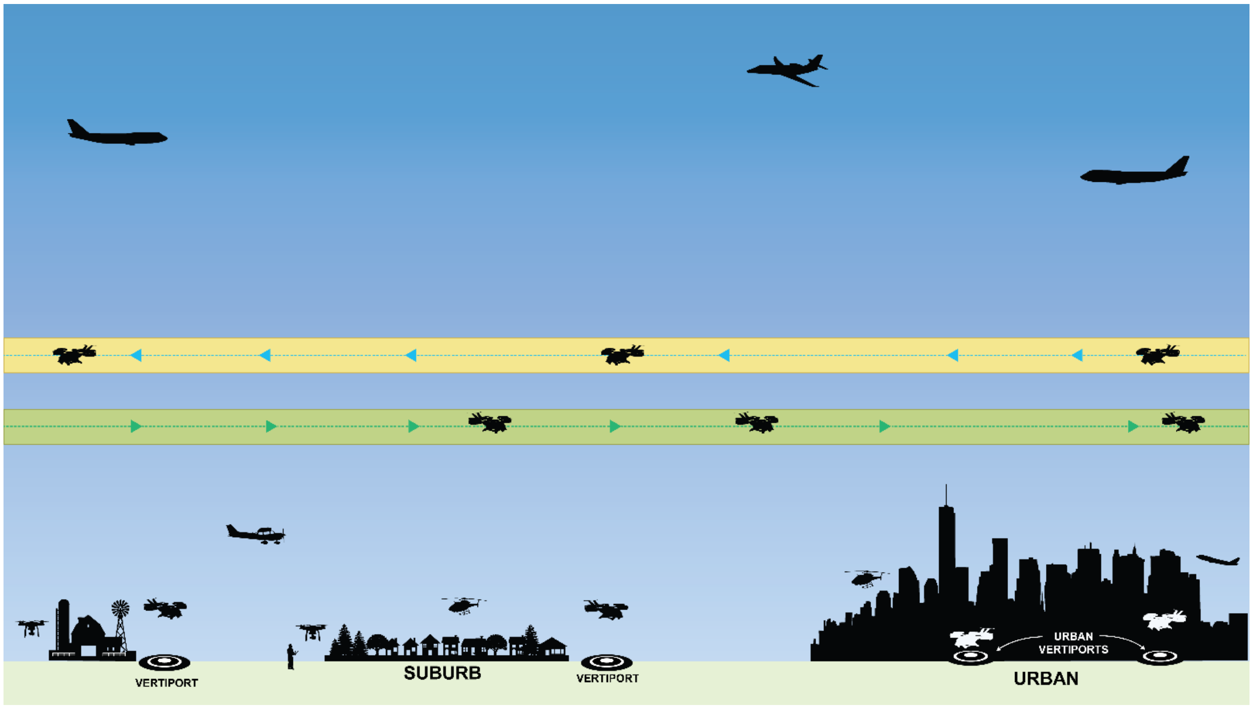

Figure 4: Early UAM Corridor Concept

With continued growth, UAM operational demand may result in exceeding a UAM Corridor's initial design capacity, at which point increased capacity may be gained through additional structure including tracks and increased performance capabilities (e.g., ability to safely reduce separation minima within the UAM Corridor through improvements in navigation and/or other technologies). Additional options include variations in UAM Corridor topology to meet specific challenges such as "passing zones" as shown in Figure 5 and Figure 6. *Note:* An aircraft (and operator) meeting the performance requirements of a UAM Corridor as well as those of the surrounding airspace class (i.e., ATS environment) may elect to operate in whichever service environment they determine to be operationally advantageous.

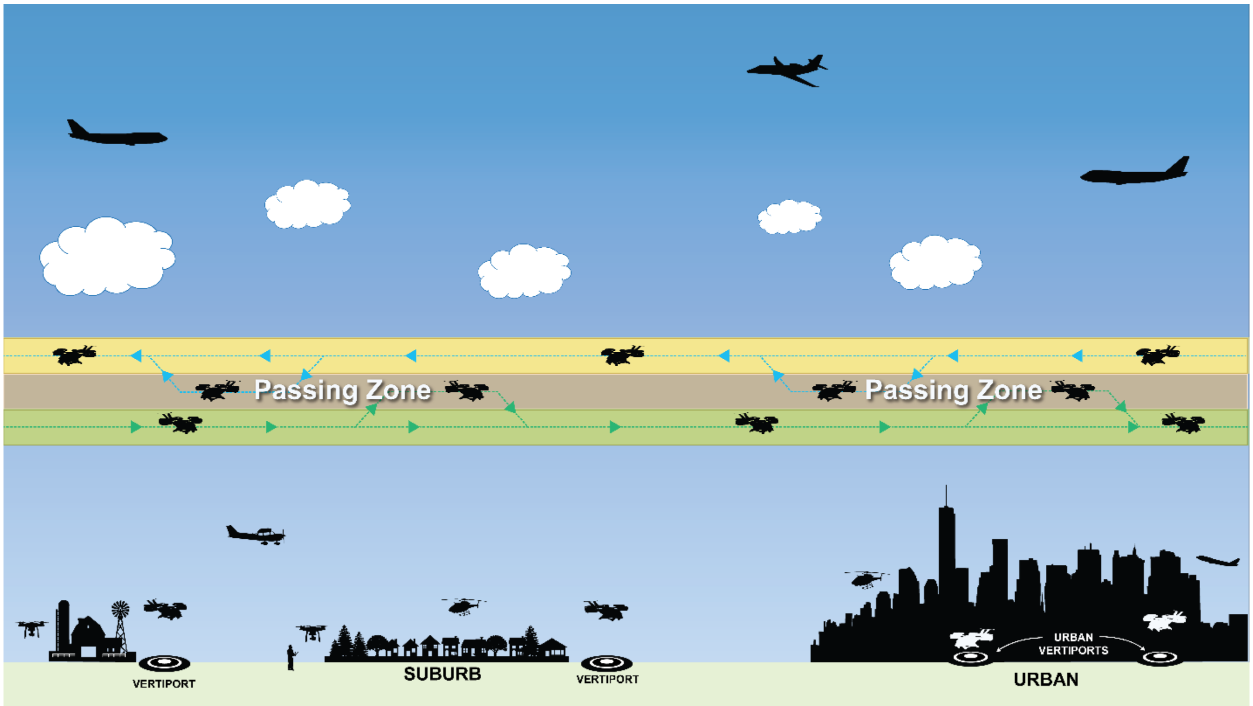

Figure 5: Use of a Vertical Common Passing Zone

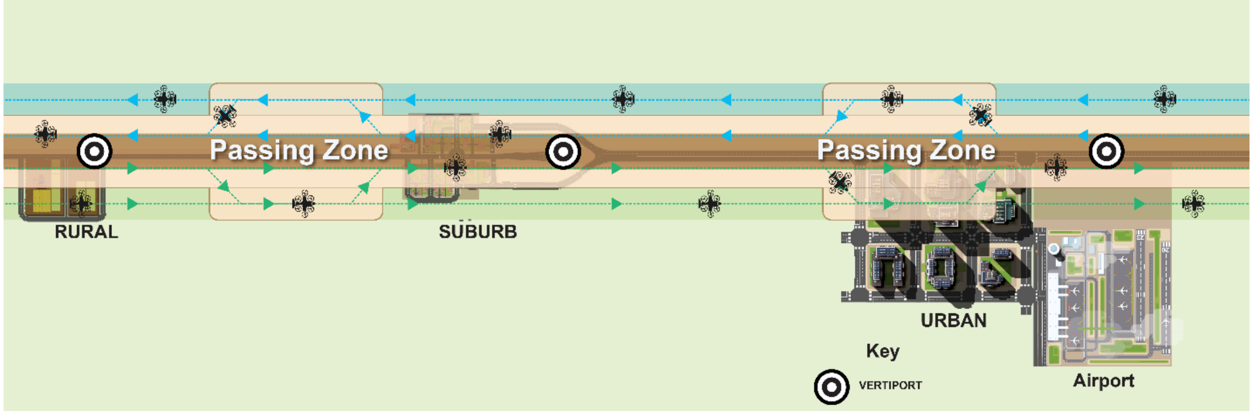

Figure 6: Use of Lateral Passing Zones

As the operational tempo and breadth of UAM aircraft physical performance (e.g., speed) continue to increase, Figure 7 depicts a notional internal UAM Corridor structure comprised of multiple “tracks.” The tracks reflect additional internal structure, which may also require increased performance requirements that support an increased operational tempo within the same UAM Corridor.

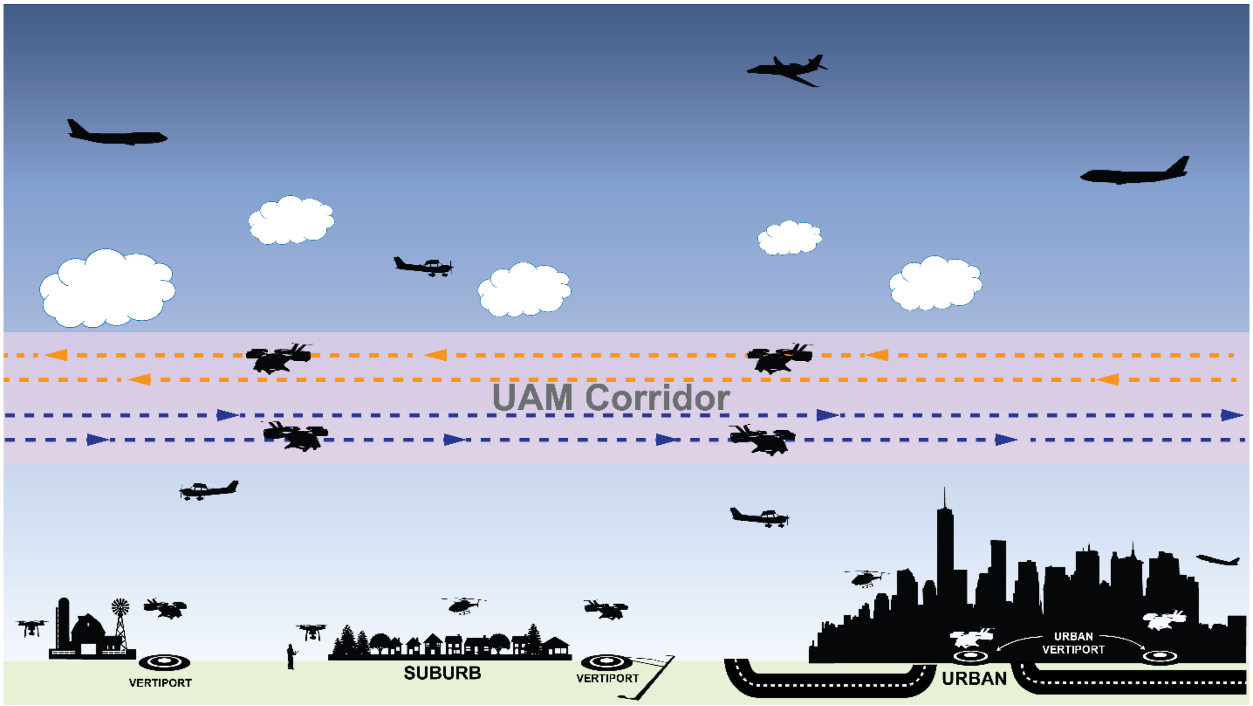

Figure 7: UAM Corridor with Multiple Tracks

4.5 Weather and Obstacles Within the UAM Environment

PSUs or SDSPs support the UAM operator by supplying weather, terrain, and obstacle clearance data specific to the UAM operation. This data is accessed in the UAM Operational Intent planning phase to ensure strategic management of a UAM operation and updated in-flight, as appropriate. UAM operators monitor weather and winds prior to and throughout flight. If aircraft performance is inadequate to maintain required separation within the UAM Corridor, UAM operators are responsible to take appropriate action to ensure separation is maintained (e.g., do not take off, exit the UAM Corridor, operate per appropriate airspace rules).

4.6 Constraint Information and Advisories

UAM operators are responsible for identifying operational conditions or flight hazards that may affect an operation. This information is collected and assessed both prior to and during flight to ensure the safe conduct of the flight. PSUs support this UAM operator responsibility by supplying information and advisories including, but not limited to:

- Other airborne traffic including operations within and crossing UAM Corridors.
- Weather and winds.
- Other hazards pertinent to low-altitude flight (e.g., obstacles such as a crane or powerline Notice to Air Missions (NOTAM), bird activity, local restrictions).
- SAA status.
- UAM Corridor availability.

The sharing of projected demand and available capacity information between ATS and federated service network supports the applicable flow management function (e.g., TFM, CFM). Constraints may be shared from one environment to be complied with by the other, consistent with applicable procedures, COPs, and regulations.

5 Notional Architecture

Within the UAM cooperative management environment, the FAA would maintain regulatory and operational authority for airspace and traffic operations. UAM operations may be organized, coordinated, and managed by a federated set of actors through a distributed network that leverages interoperable information systems. Figure 8 depicts a notional architecture of the UAM actors and contextual relationships and information flows. This architecture is based on patterns established within the UTM architecture described in the UTM ConOps [2] and is consistent with the architecture described in the ETM ConOps [3].

The federated service network, comprised of individual PSUs operating as a collective, lies at the center of the UAM notional architecture and exchanges data with UAM operators, USSs, SDSPs, the FAA, and public interest stakeholders. PSUs receive supplemental data supporting UAM operation management from the SDSPs and provide relevant UAM operational data to the public. PSUs communicate and coordinate via the federated service network. This allows other UAM stakeholders (e.g., UAM operators, ATC, law enforcement) connected to a PSU to access data shared across the federated service network.

PSUs and USSs may exchange operational information about UAM and UTM operations in airspace under 400 feet where there is a potential need for cooperative separation (e.g., vertiports). Notionally, a USS can expand their service offerings to become a PSU and vice versa. Combined service providers may support operations in both the UAM and UTM environments. The architecture depicts the connectivity of the federated service network to USSs for information exchange while retaining a UAM-centric architectural view.

Vertiports exchange information with the federated service network to facilitate the communication of situational awareness and resourcing information to UAM operators. The PSUs make the aggregate vertiport information available for the operator to be aware of capacity and situational constraints present at the time of respective departure and arrival time. PSUs could potentially provide additional services with this information (e.g., suggested alternate vertiports, suggested alternate departure/arrival times).

The vertical dashed line in Figure 8 represents the demarcation between the FAA and industry responsibilities for the infrastructure, services, and entities that interact as part of UAM. The FAA-Industry Data Exchange Protocol provides an interface for the FAA to request UAM operational data on demand and send FAA information to the federated service network for distribution to UAM operators, PICs, UAM aircraft, and public interest stakeholders through the Service Security Gateway.

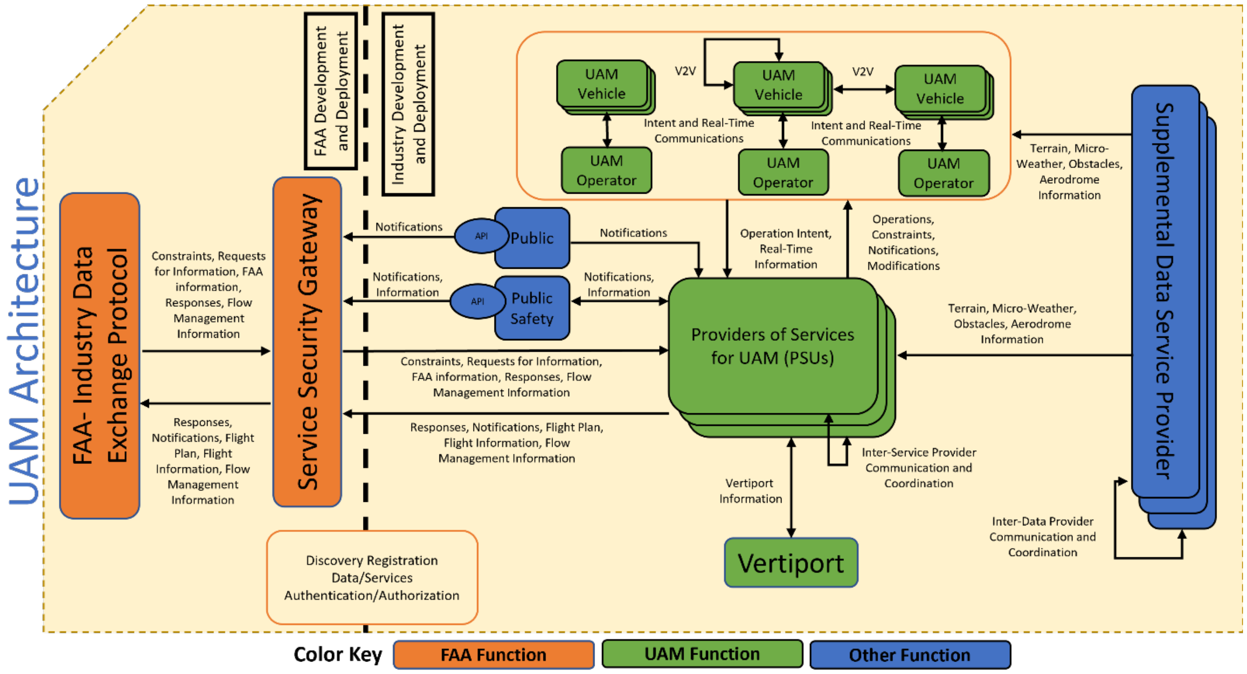

Figure 8: Notional UAM Architecture

5.1 Supporting Services

UAM services that may be provided by PSUs and SDSPs are intended to be modular and discrete, allowing for increased flexibility in the design and implementation of new services. This modular approach would allow the FAA to provide tailored oversight of UAM operations and allows PSUs and SDSPs to provide focused services consistent with a business model and subscriber needs. Similar to UTM, UAM services may be characterized in one of the following ways.

1. Services that are required to be used by UAM operators due to FAA regulation or for a direct connection to FAA systems. These services must be qualified and approved by the FAA.
2. Services that may be used by a UAM operator to meet all or part of an FAA regulation. These services must meet an acceptable means of compliance and may be individually qualified and approved by the FAA.
3. Services that provide value-added assistance to a UAM operator but are not used for FAA regulatory compliance. These services may meet an industry standard but may not be qualified or approved by the FAA.

6 UAM Scenarios

This section provides high-level scenarios reflecting two operations. The first is conducted from departure to arrival within a UAM Corridor. The second operation departs a vertiport in the current Class B service environment (ATS), enters a UAM Corridor for a portion of the flight, exits back into Class B (ATS) and arrives at the vertiport. These scenarios further explore the UAM concept and each steps through phases of the flight's operation, illustrating the operational and architectural information from Sections 4 and 5.

The scenarios demonstrate a subset of UAM operations and interactions during specific nominal operations. A nominal UAM operation is a single UAM operation that executes in accordance with the established performances, rules, policies, and procedures.

6.1 Nominal UAM Operation Completed Within a UAM Corridor

6.1.1 Planning Phase

Planning of this operation starts with the UAM operator receiving a request from an individual flight between Vertiport 1 and Vertiport 2.

The UAM operator obtains current conditions from the information provided by the subscribed PSU and relevant SDSP service. After determining that the current conditions are acceptable for the operation, the UAM operator submits desired UAM Operational Intent information (e.g., identifying information, vertiport locations, route of flight via UAM Corridor(s), desired time of operation) to the subscribed PSU.

The PSU, through the federated service network:

1. Evaluates the desired UAM Operational Intent against other operations that may cause a strategic conflict.
2. Evaluates UAM Operational Intent against known airspace constraints (e.g., FAA originating constraints, local restrictions).
3. Identifies availability of UAM Corridors and UAM vertiport resources.

Because there are no conflicting operations, airspace restrictions (e.g., Temporary Flight Restrictions [TFRs]), or vertiport resource limitations, the UAM operator's desired UAM Operational Intent is considered strategically deconflicted and confirmed. The PSU notifies the UAM operator and provides the UAM Operational Intent to the federated service network.

The UAM operator considers possible modifications to the Operational Intent in the event of an off-nominal situation. The airspace classes and ATC facilities with jurisdiction for the airspaces that border the UAM Corridor(s) for the operation are identified. These prepare the PIC in case a contingency operation is required.

Most of the planning actions and information exchanges between the UAM operator and PSU are automated and expected to take very little time from the initial customer request to the confirmed UAM Operational Intent.

6.1.2 In-Flight Phases

Throughout all phases of flight, the UAM aircraft identification and location information are available to the UAM operator and subscribed PSU. The PIC and UAM operator monitor aircraft performance to ensure nominal operation status is maintained. The PSU monitors Operational Intent conformance.

6.1.2.1 Departure Phase

The PIC departs from Vertiport 1 within the departure compliance window and enters the UAM Corridor.

6.1.2.2 En Route Phase

The PIC navigates along the UAM Corridor per the UAM Operational Intent. The UAM aircraft completes the en route portion of the flight per the UAM Operational Intent and approaches the arrival vertiport within the compliance window of the arrival time.

6.1.2.3 Arrival Phase

As the UAM aircraft approaches Vertiport 2, the PIC, UAM operator, PSU, and UAM vertiport confirm the landing pad is still available per the UAM Operational Intent. The PIC navigates to the allocated vertiport pad and lands the aircraft.

6.1.3 Post-Operations Phase

The UAM operator and PIC provide mission complete indication to the PSU. The PSU archives required UAM operational data per regulation.

6.2 Nominal UAM Operation Across Service Environments

This scenario describes a situation where a UAM operator plans a flight that departs from Vertiport 3, located in Class B airspace, and arrives at Vertiport 4, within Class B airspace, after using a UAM Corridor for transit. The operator enters and exits the UAM service environment through CEPs. Confirmed UAM Operational Intent is required for participation within the UAM environment. The UAM operators utilize a PSU who provides flight plan filing services.

6.2.1 Planning Phase

Planning of this operation starts with the UAM operator receiving a request from an individual customer for a flight between Vertiport 3 and Vertiport 4. The UAM operator obtains current conditions and vertiport availability from their subscribed PSU as well as relevant SDSP services (e.g., environment, situational awareness, strategic operational demand, supplemental data).

After determining the current conditions are acceptable for the operation, the UAM operator provides the necessary information to the PSU. In this case, the operation will use a UAM Corridor that traverses Class B airspace and operate within the Class B airspace to/from the UAM Corridor. In recognition of the cross-service environment operation, the operator's information for the portion of the flight planned for the UAM Corridor includes the desired UAM Operational Intent information (e.g., identifying information, vertiport locations, route of flight via UAM Corridor(s), CEP locations, desired time of operation). As the operation, upon departure, will operate in Class B airspace, the operator also provides the PSU the required flight plan information for the ATS environment (e.g., flight ID, type of aircraft, route to CEP from departure vertiport, route from CEP to arrival vertiport). The PSU uses the flight plan information to coordinate with TFM and CFM services to secure clearance times and slot reservations for CEPs within the CA.

The subscribed PSU transmits the applicable information (e.g., flight information, flight plan) to the relevant ATS/xTM data exchange network as required by relevant regulations and COPs. The PSU receives information (e.g., ATC/TFM responses, notices, constraints) from the ATS data exchange portal for the UAM operator to use for situational awareness or to modify the planned intent/flight plan.

The PSU, through the federated service network:

1. Evaluates the desired UAM Operational Intent for other operations that may cause a strategic conflict.
2. Evaluates the UAM Operational Intent against known airspace constraints (e.g., FAA originating constraints, local restrictions).
3. Identifies availability of the UAM Corridor and UAM vertiport resources.
4. Receives any applicable flow management initiatives or constraints.
5. Files the flight plan from Vertiport 3 to Vertiport 4 through the UAM Corridor.

If there are no conflicting operations, airspace restrictions (e.g., TFRs), applicable flow management constraints (i.e., CFM and TFM), or vertiport resource limitations, the UAM operator's desired UAM Operational Intent is considered strategically deconflicted and confirmed. The PSU notifies the UAM operator and provides the final UAM Operational Intent to the federated service network and flight plan information to the ATS exchange (e.g., Expect Departure Clearance Time [EDCT]).

Most of the planning actions and information exchanges (e.g., intent, flight plan filing) across the federated service network, ATS (i.e., ATC and TFM), operator, and PSU are automated and expected to take very little time from the initial customer request to the confirmed UAM Operational Intent and flight plan filing.

6.2.2 In-Flight Phases

Throughout all phases of flight (e.g., departure, en route, arrival) for a UAM operation, the UAM aircraft identification and location information are available to the UAM operator, ATC facility, and subscribed PSU. The PIC and UAM operator monitor aircraft performance to identify an off-nominal state. The PSU monitors operational conformance to the confirmed UAM Operational Intents. Data exchange between CFM and TFM are monitored for accuracy and relayed to ATC and the PSU.

6.2.2.1 Departure Phase

Prior to departure, the PIC establishes two-way communication with the appropriate ATC facility to open the submitted flight plan that was submitted by the PSU. The PIC departs from Vertiport 3 within the departure compliance window, notifies the PSU (via automated departure acquisition), and enters Class B airspace. The UAM PIC monitors applicable ATC frequencies and complies with instructions while in Class B airspace. The UAM aircraft transitions into the UAM Corridor through the CEP submitted through the Operational Intent.

6.2.2.2 En Route Phase

The PIC navigates along the UAM Corridor per the confirmed UAM Operational Intent. The PIC deconflicts from other aircraft within the UAM Corridor with possible support from the UAM aircraft equipage or PSU services (e.g., flight data from active operations in the UAM Corridor). Flight status is monitored by CFM to TFM and updated as necessary within the system. The UAM aircraft completes the en route portion of the flight per the UAM Operational Intent and approaches the CEP within the compliance window of the arrival time.

6.2.2.3 Arrival Phase

Prior to arriving at the submitted CEP to exit the UAM Corridor into Class B airspace, the data exchange (e.g., handoff) is activated to ATC and frequency change is conducted. The UAM PIC establishes two-way communication and positive clearance with the appropriate ATC facility. The UAM aircraft enters Class B airspace through the CEP per ATC instruction.

As the UAM aircraft approaches Vertiport 4, the PIC, UAM operator, PSU, and UAM vertiport confirm the landing pad is still available per the UAM Operational Intent. The PIC navigates to the allocated vertiport pad and lands the aircraft.

6.2.3 Post-Operations Phase

The UAM operator/PIC provides mission completion indication to the PSU and the ATC facility. The PSU archives required UAM operational data.

7 UAM Evolution

The UAM ConOps 2.0 reflects FAA efforts, in collaboration with NASA, industry, and other stakeholders, to advance UAM. It begins with the introduction of low-complexity, low-operational tempo operations leveraging the current regulatory framework (e.g., VFR, IFR) and building toward higher operational tempo with the institution of UAM airspace structures (i.e., UAM Corridors) where and when operationally advantageous, using a performance-based construct.

As operations occur and experience is gained, the concept may mature and evolve as the FAA continues to engage stakeholders for their perspectives on new technologies, techniques, and automation, both ground-based and airborne, to identify those most capable of addressing the evolving challenges and opportunities. This evolutionary approach to UAM could provide advantages. By initially supporting lower complexity operations, implementation can be streamlined to the environment using current capabilities that meet performance requirements and do not require full-scale regulatory and operational infrastructure changes. Incremental changes to the regulatory framework, “hard” infrastructure (e.g., systems and vertiports), and “soft” infrastructure (e.g., processes and procedures) could help support the UAM operational demand and complexity as they increase in concert with other cooperative environments, such as UTM and AAM. These incremental changes may also support the progression of the existing ATS system, maintaining fair and equitable access to airspace across the full airspace user community.

Appendix A References

[1] International Civil Aviation Organization (ICAO), Document 9854, Global Air Traffic Management Operational Concept (GATMOC), First Edition, 2005.

[2] FAA, Unmanned Aircraft System (UAS) Traffic Management (UTM) Concept of Operations (ConOps) Version 2.0. 2020.

[3] FAA, Upper Class E Traffic Management (ETM) Concept of Operations (ConOps) Version 1.0. 2020.

Appendix B Acronyms

All acronyms used throughout the document are provided in Table 1.

Table 1: Acronyms

Acronym	Definition
AAM	Advanced Air Mobility
AFR	Automated Flight Rule
ATC	Air Traffic Control
ATS	Air Traffic Services
CA	Cooperative Area
CBR	Community Business Rule
CEP	Corridor Entry/Exit Point
CFM	Cooperative Flow Management
CNS	Communication, Navigation, and Surveillance
COP	Cooperative Operating Practice
ConOps	Concept of Operations
DCB	Demand-Capacity Balancing
DEP	Distributed Electric Propulsion
DOT	Department of Transportation
EDCT	Expect Departure Clearance Time
ETM	Upper Class E Traffic Management
eVTOL	Electric Vertical Takeoff and Landing
FAA	Federal Aviation Administration
G/G	Ground-to-Ground
HOTL	Human-on-the-Loop
HOVTL	Human-Over-the-Loop
HWTL	Human-Within-the-Loop
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
LOA	Letter of Agreement
MRO	Maintenance, Repair, and Overhaul

Acronym	Definition
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NOTAM	Notice to Air Missions
PIC	Pilot in Command
PSU	Provider of Services for UAM
RPIC	Remote Pilot in Command
SAA	Special Activity Airspace
SDSP	Supplemental Data Service Provider
TFM	Traffic Flow Management
TFR	Temporary Flight Restriction
UAM	Urban Air Mobility
UAS	Unmanned Aircraft Systems
USS	UAS Service Supplier
UTM	UAS Traffic Management
V2V	Vehicle-to-Vehicle
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VTOL	Vertical Takeoff and Landing
xTM	Extensible Traffic Management

Appendix C Glossary

Table 2 provides a glossary of UAM terms used throughout this ConOps. These terms are in addition to those defined in Section 1.4, which provides terms key to establishing the context of the UAM concept.

Table 2: Glossary

Acronym	Definition
Advanced Air Mobility (AAM)	The terms “advanced air mobility” and “AAM” mean a transportation system that transports people and property by air between two points in the United States using aircraft with advanced technologies, including electric aircraft or electric vertical take-off and landing aircraft, in both controlled and uncontrolled airspace.
Conflict	Any situation involving aircraft and hazards in which the applicable separation minima may be compromised [1].
Constraint	An impact to the capacity or use of a resource preferred by an operator, defined with time and geographically specified airspace information. A constraint may restrict access to airspace for operations or may be advisory in nature.
Cooperative Separation	Separation based on shared flight intent and data exchanges between operators, stakeholders, and service providers. Cooperative separation is supported by defined COPs as well as applicable rules, regulations, and policies.
Demand-Capacity Balancing (DCB)	Strategic evaluation of system-wide traffic flows and aerodrome capacities to allow airspace users to determine when, where, and how they operate, while mitigating conflicting needs for airspace and aerodrome capacity. This collaborative process allows for the efficient management of air traffic flow through the use of information on system-wide air traffic flows, weather, and assets [1].
Human-on-the-Loop (HOTL)	Human supervisory control of the automation (i.e., systems) where the human actively monitors the systems and can take full control when required or desired.
Human-Over-the-Loop (HOVTL)	Human informed, or engaged, by the automation (i.e., systems) to take actions. Human passively monitors the systems and is informed by automation if, and what, action is required. Human is engaged by the automation either for exceptions that are not reconcilable or as part of rule set escalation.
Human-Within-the-Loop (HWTL)	Human is always in direct control of the automation (systems).

Acronym	Definition
Operational Intent	Also referred to as operation intent, the future operational position information, consisting of spatial and temporal elements, that is exchanged between xTM operators to support cooperative traffic management.
Operational Tempo	The density, frequency, and complexity of operations.
Provider of Services for UAM (PSU)	An entity that assists UAM operators with meeting UAM operational requirements to enable safe and efficient use of UAM Corridors and vertiports. This service provider shares operational data with stakeholders and confirms flight intent.
Strategic Deconfliction	The process of arranging, negotiating, and prioritizing Operational Intent (e.g., volumes, routes, trajectories, time assignments) of aircraft to minimize the likelihood of airborne conflicts between operations.
Tactical Deconfliction	The process of executing one or more actions to avoid an airborne conflict in a timely manner when strategic deconfliction has failed or was not executed.
UAS Traffic Management (UTM)	The manner in which the FAA will support operations for UAS operating in low-altitude airspace.