SKYGRID EVE

Enabling Advanced Air Mobility

Automated Traffic Management Services for Low-Altitude Operations

White Paper

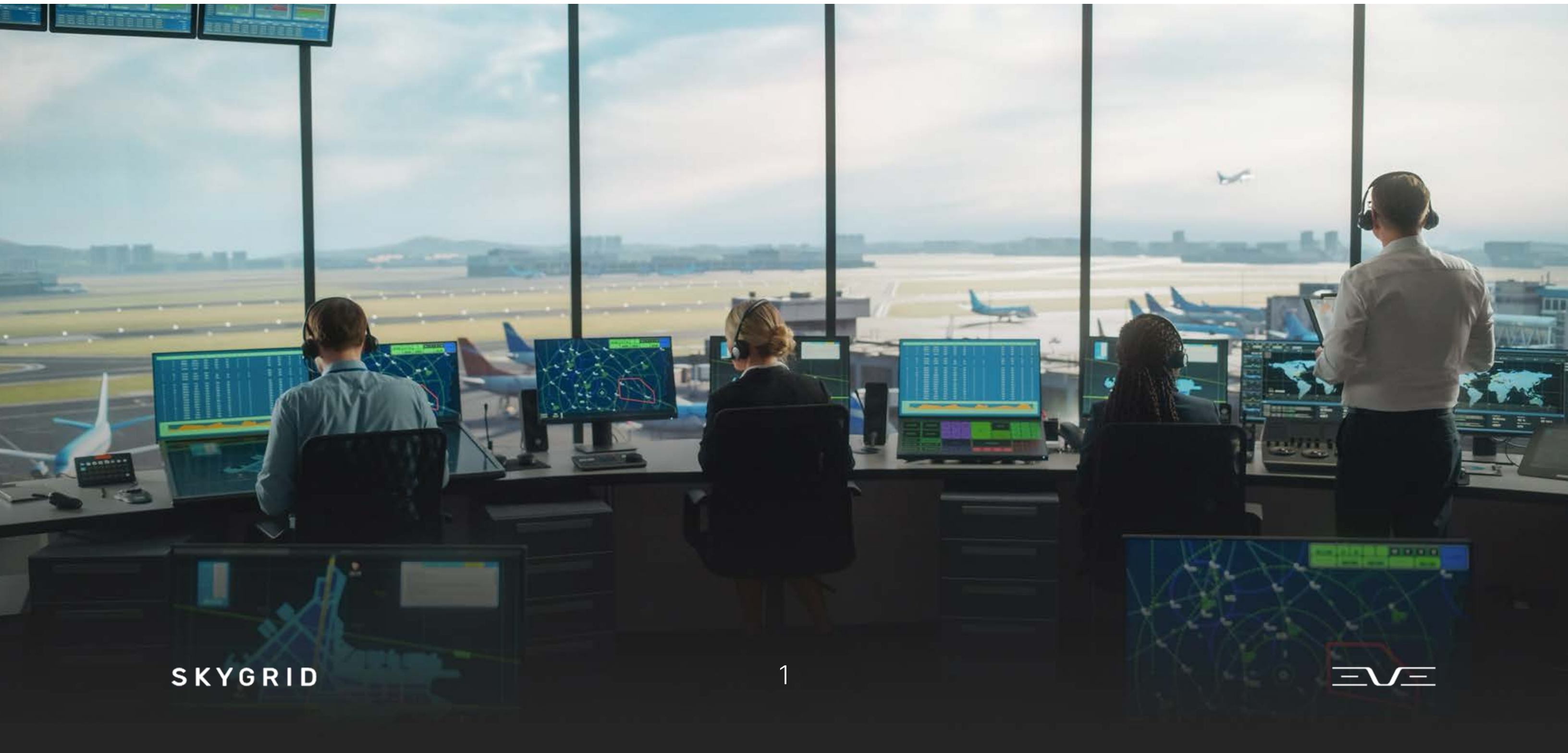
Foreword

SkyGrid and Eve Air Mobility recognize the pivotal moment the aviation industry faces. With our shared commitment to innovation and the foundational principle of safety, we hold a common vision: a future where the promise of Advanced Air Mobility (AAM) is fully realized.

This vision entails a transformed airspace system, one that seamlessly integrates a significantly higher volume of urban and regional missions in low-altitude airspace. Highly automated AAM operations will necessitate new traffic management paradigms and place new demands on Air Navigation Service Providers (ANSPs). Ensuring this evolution is conducted safely and efficiently, enabling the sustainable and widespread delivery of new aviation services to the global community, is an important industry priority.

In this paper we explore the need for new Automated Traffic Management Services to support high-density, low-altitude operations. In addition to this, we explore the potential for different service provision models, including the use of Third-Party Service Providers (under state oversight) as an alternative to traditional ANSP service provision.

We encourage industry collaboration to shape a more scalable Air Traffic Management (ATM) system that supports emerging aircraft operations and meets the needs of all users, both now and in the future.



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Introduction: Airspace Integration Challenges for Advanced Air Mobility

Advanced Air Mobility, or AAM, promises to introduce several novel operations into the global airspace system over the next decade, with example missions ranging from highly automated vertical take-off and landing (VTOL) operations in urban environments to remotely operated fixed-wing operations in regional settings. While the proposed use cases for AAM are diverse, they generally share the use of highly automated aircraft, deploying Simplified Vehicle Operations (SVO) with a pilot on board, or uncrewed operations with a remote supervisor.

With an industry objective of enabling a higher number of urban and regional missions at low altitudes (below 10,000 ft) using highly automated aircraft, AAM operations will place new demands on the use of airspace and management of operations by Air Navigation Service Providers (ANSPs). The key challenges of integrating AAM into airspace include:

- High-throughput, low-altitude AAM operations will have a greater necessity for traffic management services than existing low-altitude operations, such as helicopter operations under Visual Flight Rules (VFR). To deliver on the vision of AAM, improvements are needed in flight efficiency, capacity (ground infrastructure and airspace), predictability, and flexibility. Expanding air traffic services using existing concepts and technology is likely to be limited by constraints in surveillance coverage and air traffic controller workload.
- Early AAM operations using battery-powered aircraft will likely be energy-constrained, making in-flight air traffic delays undesirable. As current helicopter VFR operations in congested airspace are often impacted by such delays, greater predictability in trajectories, schedules, and airspace access will be needed to support high-tempo AAM operations. Additionally, air traffic delays reduce ground resource efficiency by increasing the need for on-ground charging and lowering the effective utilization of ground infrastructure.
- High-throughput AAM operations must be planned and managed to minimize their impact on current traffic, particularly when utilizing major airports. AAM aircraft need to be able to integrate with existing aircraft operations without incurring significant operational or cost impact.
- Uncrewed AAM operations will require increased data exchange with ground systems to remain clear of other traffic and to avoid environmental hazards and airspace constraints. Additionally, any data used by uncrewed aircraft for aeronautical decision-making must be protected using cybersecurity principles. For all AAM operations, developing a “digital picture” of the airspace that is shared among stakeholders can also provide significant advantages in collaborative decision-making.
- Highly automated and uncrewed aircraft may require novel interfaces for receiving air traffic services, as reliance on traditional pilot–Air Traffic Control (ATC) voice communication will likely limit the scalability of these operations.

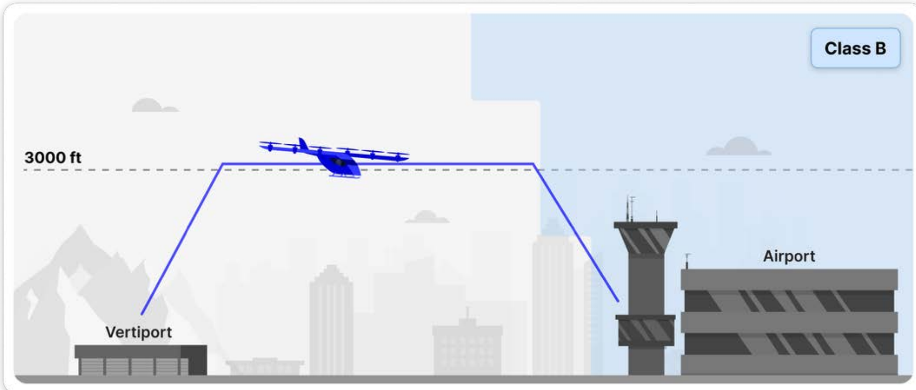


Figure 1. Industry is proposing AAM operations with eVTOLs as a new mode of passenger transport in urban environments.

Collectively, these challenges are driving industry efforts to develop new ground-based automation systems that will provide ANSPs with the data services and traffic management automation needed to support effective AAM integration. In the future, these services may be deployed in various ways within low-altitude airspace, as required to enable AAM operations.

- ANSP-provided model: Services could be provided by an ANSP under a traditional ATM service provider model and integrated directly into ANSP systems.
- Delegated model: Alternatively, these services could be provided by industry through third-party service providers (TSPs) under ANSP delegation and with state oversight.

Whichever model is adopted, these services are expected to be digital-first and modular, and to incorporate human–machine teaming. They will function within a cohesive, interoperable architecture with clearly defined accountability. Digitalization will serve as a foundational enabler for new automated traffic management capabilities, while interoperability, common data services, and safety assurance frameworks will be critical to their successful implementation.

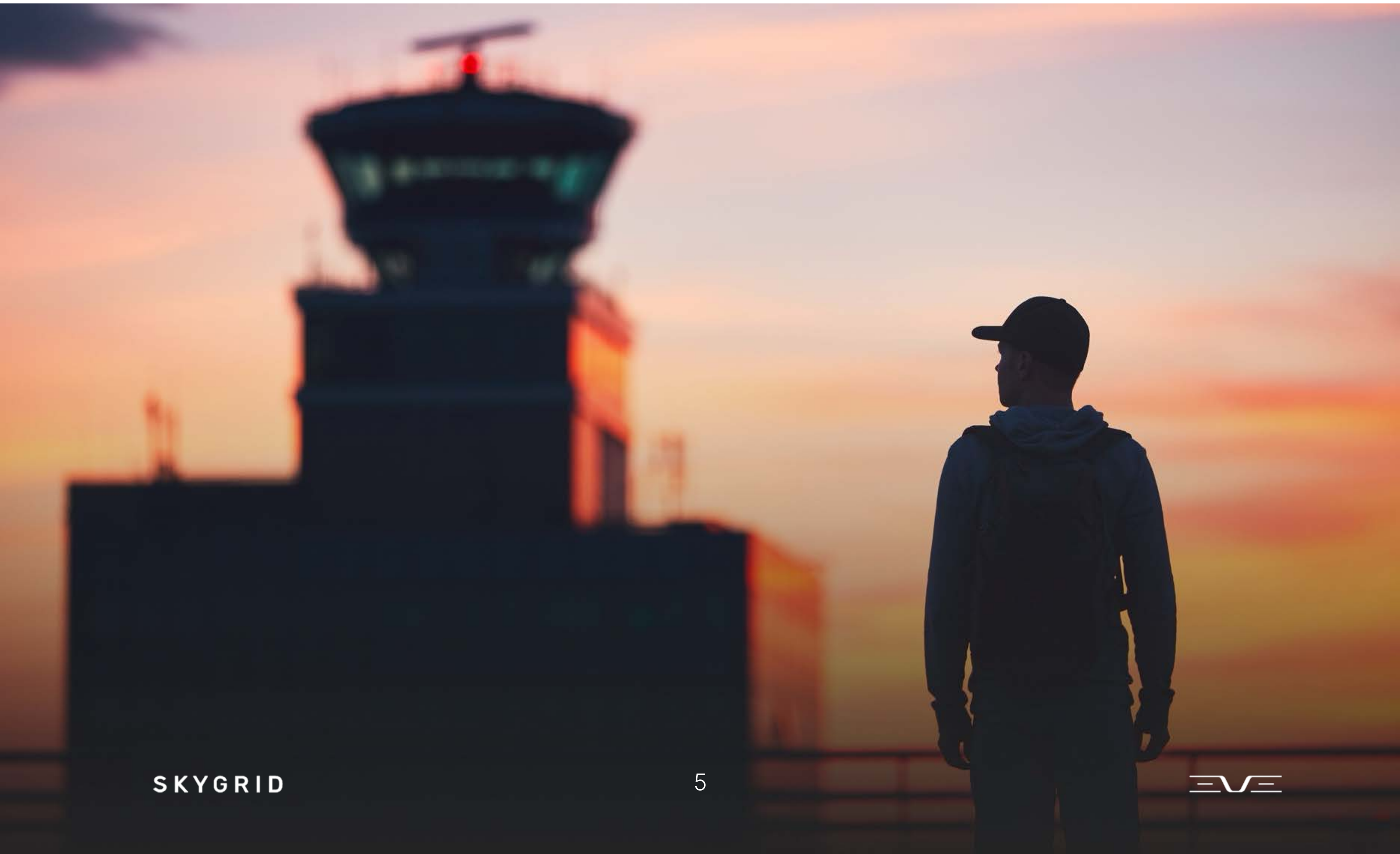
Low-altitude automated traffic management will depend on new, highly digital methods of coordination and communication. While some states may choose to continue with traditional ANSP-provided services, enabling third-party service providers that are unconstrained by legacy systems to deliver these services is likely to be both an effective and desirable approach.

The desirability of the delegated model, with state oversight and ATC integration, is further supported by the fact that most services will operate in areas that do not cross-national boundaries, limiting some challenges associated with privatized ATC services. While safety and security will still need to meet the regulatory standards applied to ANSPs, third-party service providers could operate in a manner similar to competitively tendered ATC tower services where a state-associated ANSP does not provide them. This model has been successfully implemented in several countries and offers a blueprint for regulated services delivered by third-party service providers. Depending on the regulatory framework, these services could be organized in either federated or centralized forms.

Allowing third-party service providers to deliver these services reduces the investment required of ANSPs to prepare for and provide dedicated services for AAM. This approach also aligns with CANSO's CATS CONOPS[1], which promotes the flexible provision of services by third-party service providers.

Whichever model, or service-by-service blend of models, is implemented, appropriate oversight by states, ATC interoperability, responsibility boundaries and contingency/disruption arrangements will need to be carefully managed.

[1] *Accessible at https://futureskyvision.com/cats-conops.*



Network-level outcomes

The benefits provided by novel low-altitude data services and traffic management automation can be quantified in terms of traditional International Civil Aviation Organization (ICAO) airspace performance metrics: Safety, Security, Environment, Cost Effectiveness, Capacity, Flight Efficiency, Flexibility, Predictability, Access & Equity, Participation & Collaboration and Global Interoperability.

Figure 2. ICAO Key Airspace Performance Areas.

- **Capacity:** New automated traffic management services will maximize the capacity of the airspace and vertiports through the application of strategic conflict management and digital communications.
- **Flight efficiency:** By prioritizing ground delays over airborne delays, automated traffic management services will support high operational efficiency for AAM operations.
- **Flexibility:** Automated traffic management services will support operators during contingency events, such as when a reroute or diversion is required.
- **Predictability:** Automated traffic management services will provide predictable sequencing in the airspace, with delays absorbed on the ground whenever possible.

Importantly these benefits are expected to be realized across all low-altitude airspace users and ensure that new AAM aircraft can be integrated with traditional airspace users and drones.

Additionally, these new services being developed to manage AAM traffic may also lead to the identification of new services, features and capabilities that could be applied to the modernization of traditional ATM systems used in other airspaces.

2

Addressing the Needs for AAM Airspace and Beyond

Conceptual studies by industry and government agencies have highlighted key needs for scaling AAM safely and effectively. The following paragraphs describe how automated traffic management services could address those needs.

Addressing the need for low-altitude traffic management services

As emerging AAM operators scale up, their operations could reach tempos comparable to those observed today at major high-capacity airports. This increase in traffic density will likely require greater use of airspace structures and expanded air traffic services in low-altitude airspace to ensure AAM flights remain safely organized.

While solutions exist for organizing and managing small Unmanned Aircraft Systems (UAS) operations through UAS Traffic Management (UTM), they are generally considered insufficient for larger, highly automated aircraft, especially those carrying passengers. Safely managing these vehicles in integrated airspace will require different capabilities and substantially higher levels of assurance. Nevertheless, the digital principles pioneered by UTM, such as shared responsibility for airspace management, digital-first approaches, high automation, and collaborative operations, remain highly relevant.

Automated traffic management services supporting AAM operations must accommodate different types of vehicles, including both piloted and unpiloted passenger-carrying aircraft. While UTM services may continue to manage airspace below 500 feet, the traffic management automation described here will be used to manage operations above that altitude.

UTM	AAM Automated Traffic Management Services
Support low-risk operations with simplified approval	Will be certified for safety-of-life operations
Enterprise software development paradigm	Aeronautical pedigree and system design assurance
Primarily support sUAS	Supports AAM and UAS with aviation-grade functions
Primarily volume-based operations	Primarily trajectory-based operations
Designed for segregated airspace	Designed for integrated airspace and corridors

Providing services in low-altitude airspace for AAM will require ANSPs to have sufficient surveillance coverage and the capability to manage additional traffic. To ensure the conspicuity of low-altitude airspace to air traffic controllers, third-party service providers will collaborate with ANSPs to deploy low-altitude surveillance hardware tailored to their airspace. This may include cooperative sensors (e.g., ADS-B receivers) and non-cooperative sensors (e.g., dedicated low-altitude radars).

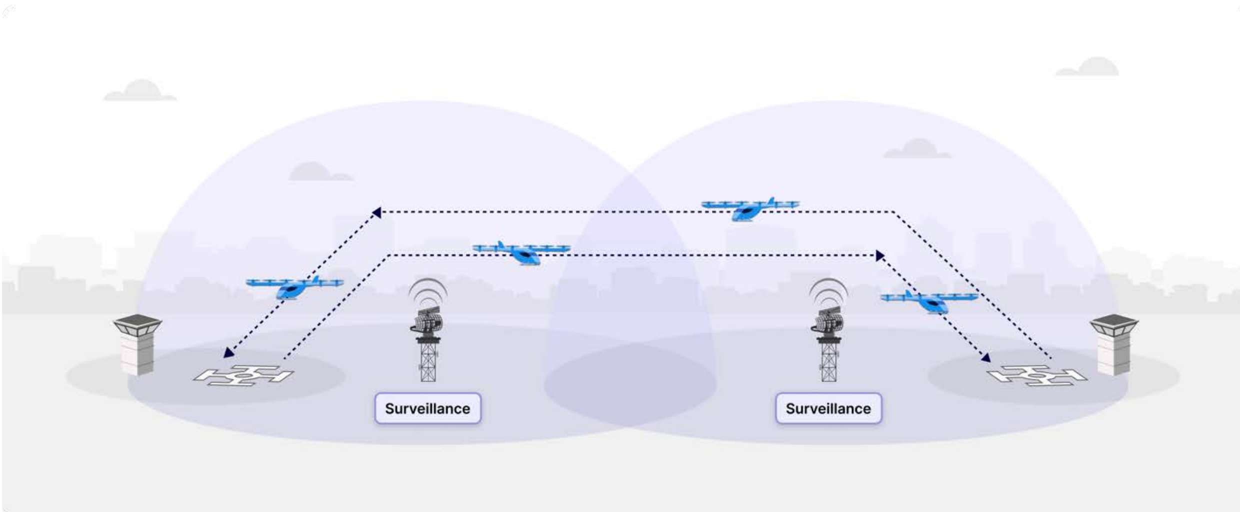


Figure 3. Notional illustration of a dedicated surveillance network deployed to manage low-altitude airspace.

To enable a high tempo of operations, point-to-point AAM flights will likely need to follow predictable route structures supported by traffic management automation. Early traffic management automation will include support for vertiport reservations and deconfliction of flight schedules through the application of demand-capacity balancing principles.

Other non-point-to-point operations, such as helicopter emergency services, may likewise utilize automated traffic management services while operating outside of a route structure. Combined, the new surveillance, low-altitude route structure and traffic management automation will enable airspace managers to accommodate more AAM aircraft in their airspace without increasing air traffic controller workload.

Addressing the need for greater trajectory and schedule flexibility

With many of the VTOL aircraft proposed for passenger-carrying AAM missions being electric, their endurance and ability to loiter will be significantly lower than that of conventional aircraft. This constraint makes operational predictability essential for AAM. In other words, in-flight trajectory changes that introduce delays will be undesirable from an operational perspective.

To mitigate this constraint, new traffic management automation will help ANSPs deliver more predictable services to AAM operations. This includes departure metering tools that will allow AAM departures to be timed based on real-time traffic conditions, ensuring any necessary delays are absorbed on the ground rather than in the air.

In addition to departure metering tools, increased observability of factors impacting AAM operations (weather, pop-up traffic, communications coverage) provided by third-party data services will allow automation to continuously develop and evaluate contingency plans, enhancing the overall network's resilience and preparedness for disruptions.

The tools and techniques that increase operational certainty can also be adapted to support traditional operations in the same airspace. By reducing uncertainty and enabling ATC to manage more traffic, these approaches benefit all airspace stakeholders.

Addressing the need for integration alongside established operations

In some cases, AAM operators may seek to fly into major airports, such as for city-to-airport missions. To ensure these operations do not disrupt established conventional traffic, careful AAM trajectory planning and traffic management will be required. While some airports may allow independent operations due to sufficient distance between runways and AAM landing sites, dependent[2] operations will likely be necessary at others. To support ANSPs in managing these scenarios, new services are desirable to manage AAM traffic flow into major airports and minimize impacts on conventional operations. For example, AAM departures can be sequenced from origin airfields so that arriving flights are properly spaced between consecutive jet operations (Figure 4).

[2] In this context, dependent operations mean that when two landing surfaces (e.g., a runway and a vertiport) are in close proximity, arriving traffic must be sequenced together, with specific separation rules applied.

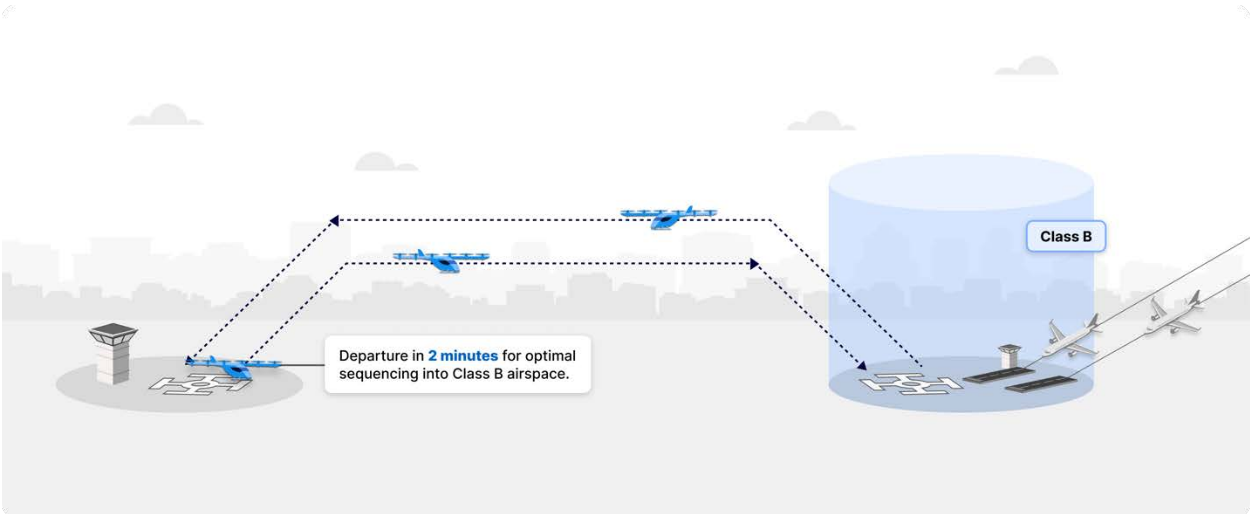


Figure 4. Notional illustration of departure metering automation offered by third-party automated traffic management services, which supports the sequencing of AAM aircraft in

Leveraging demand–capacity balancing and Collaborative Decision-Making (CDM) tools will be essential to enable effective coordination among key stakeholders, including ANSPs, AAM operators, vertiport managers, and airport operators. Shared situational awareness platforms will enhance timely, coordinated decision-making and help optimize the use of low-altitude airspace.

Addressing the need for novel data services to support highly automated aircraft

Some AAM aircraft are being designed to operate without an onboard pilot. For these aircraft, the absence of a pilot must be compensated with additional onboard sensors, ground-based data and automation to ensure that the aircraft system maintains situational awareness of its operating environment, including trajectory obligations, surrounding traffic, weather hazards, and airspace constraints.

In some regions, certain ANSPs currently provide traffic and weather services to aircraft operators. These services are typically informational and advisory only and are not approved for safety-critical purposes, such as avoiding other traffic in the airspace.

Given that uncrewed AAM aircraft may operate in airspaces without ATC-provided separation services, access to high-assurance traffic surveillance data is especially desirable and could support the future use of ground-based data and automation for traffic avoidance.

3

Roadmap for Automated Traffic Management Services for Low-Altitude Operations

The introduction of new entrants to the airspace, especially at scale, reveals limitations of current operating modes. The Complete Air Traffic Systems (CATS) Global Council introduces the following notion:

“The current standards outlined in ICAO Annex 2—Rules of the Air—primarily cater to traditional crewed aviation, leaving gaps in accommodating the specific needs of UAS and other emerging airspace users. This creates challenges in ensuring the safe and efficient integration of these new entrants into shared airspace. As aviation technologies advance, there is a pressing need to reassess these rules to ensure that they remain relevant and effective in a transformed operational environment.”[3]

Air traffic services remain a critical enabler for scaling operations safely and supporting higher traffic densities. However, it is posited that current systems will become strained and eventually unable to accommodate these new operations as densities rise. While scaling air traffic services would be necessary, simply deploying more of the current generation of equipment and increasing ATC staffing is likely impractical. This highlights the importance of airspace automation, including the automation of key air traffic services, as a crucial enabler. As part of this innovation, it will be essential to identify new approaches to human–machine teaming and collaborative decision-making, including the definition of responsibility boundaries during contingencies and disruption scenarios.

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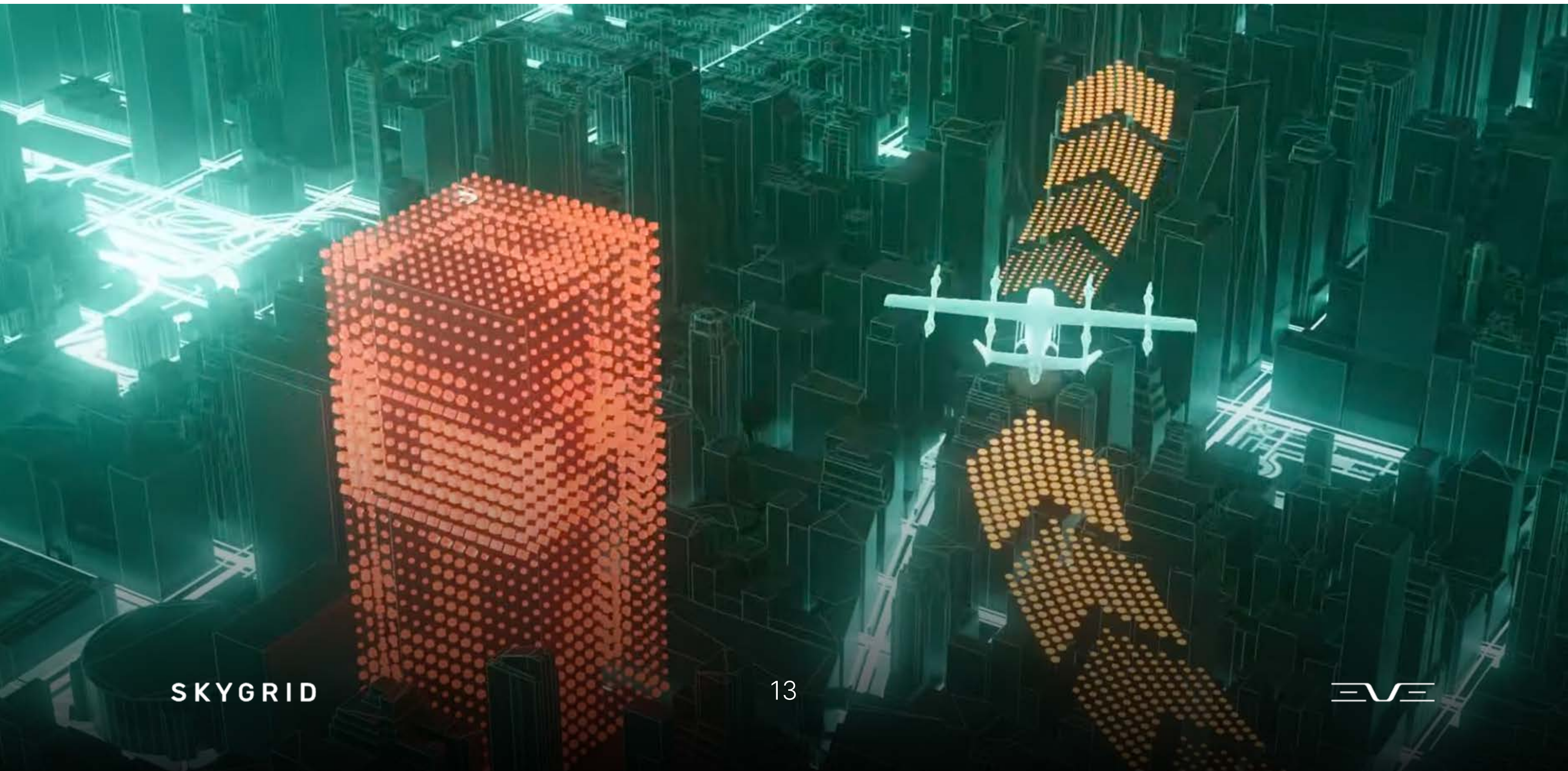
[3] *Complete Air Traffic System ConOps for Future Skies,” The Complete Air Traffic System (CATS) Global Council, April 2025.*



The adoption of automated traffic management services is expected to progress gradually, increasing in both complexity and scope over time. Initial implementations will likely focus on strategic conflict management, such as the deconfliction of flight schedules, and evolve to include more advanced capabilities such as tactical deconfliction. To maximize the long-term benefits of automated traffic management services, key ecosystem changes are highly desirable:

- Early adoption of services by ANSPs, working in collaboration with the initial operators of AAM aircraft and ground infrastructure.
- Harmonization and coordinated efforts among civil aviation regulatory authorities worldwide to ensure consistent standards for AAM data services and traffic management automation across the industry.
- New airspace structures will be required to define where AAM aircraft can operate using automated traffic management services. For instance, these may take the form of new airspace volumes (e.g., corridors) where traffic services are provided by automated systems. Local ANSPs will retain the ability to supervise this airspace, with an airspace manager at the ANSP facility having the ability to set the capacity (maximum number of aircraft allowed in the airspace) and the availability of the airspace.
- New flight rules are needed to define the equipage and operational requirements for this new airspace. While VFR relies on human perception for conflict management and Instrument Flight Rules (IFR) rely on pilot-ATC coordination, a new set of flight rules will be required that specifies how aircraft will conduct conflict management using automation and without human-to-human coordination.

Future developments in airspace structures and flight rules will be informed by ongoing and future CATS work on Seamless Airspace.

With new airspace structures and new flight rules implemented, the application of automated traffic management services will allow ANSPs, in the long run, to increase the capacity of their low-altitude airspace while reducing the effect of staffing and controller workload constraints.

The use of ground-based automation by AAM operators in safety-critical functions, such as in conflict management, will require new system and operational approval processes. Regulators and industry will need to collaborate to identify effective mechanisms for evaluating the safety of this new mode of operation, which emphasizes a greater degree of data exchange between air and ground systems.

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