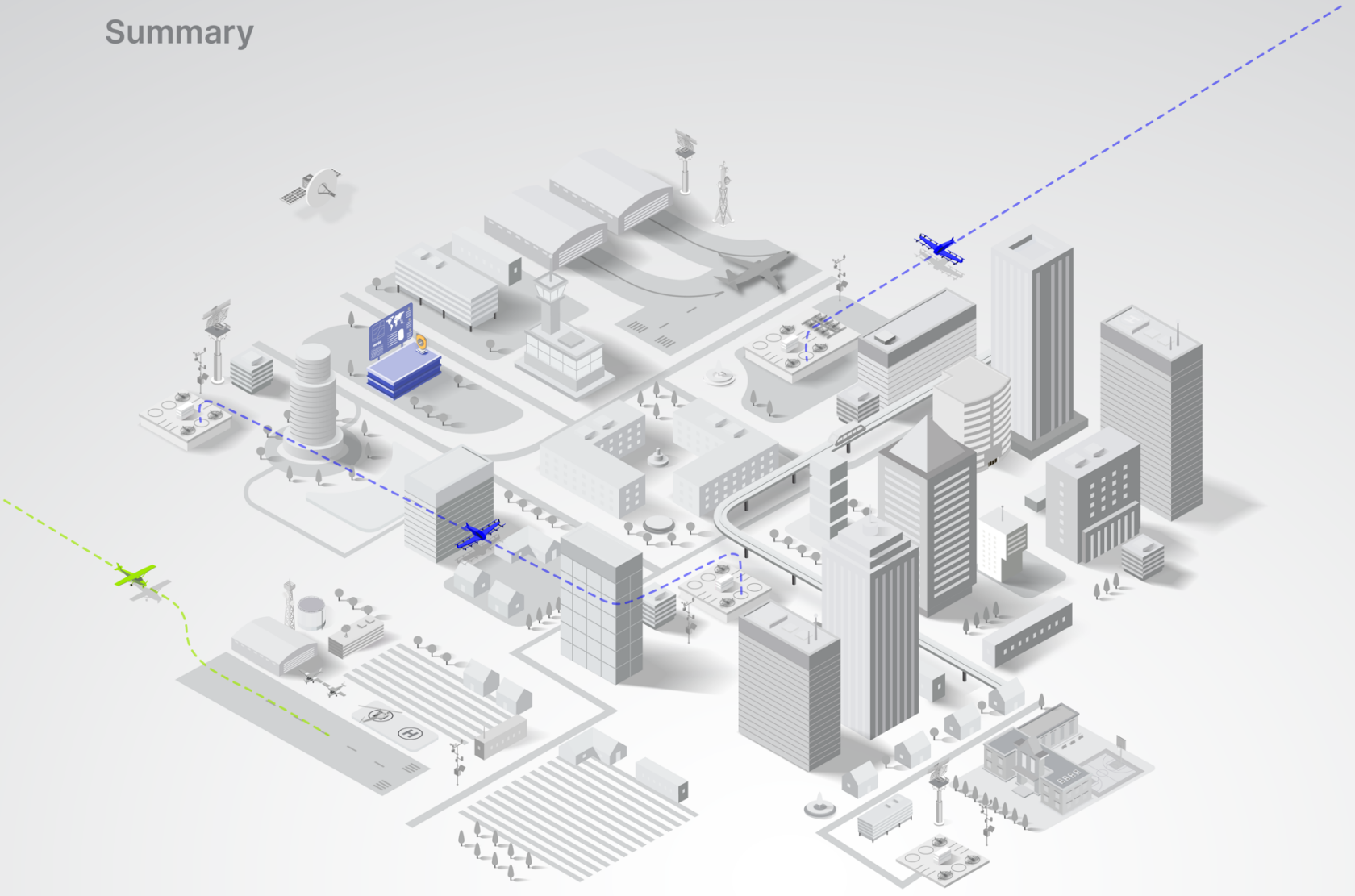
SKYGRID

Concept of Operations for Third-Party Services

Supporting the Airspace Integration of Advanced Air Mobility

Summary



Foreword

“The desire to fly is an idea handed down to us by our ancestors who, in their grueling travels across trackless lands in prehistoric times, looked enviously on the birds soaring freely through space, at full speed, above all obstacles, on the infinite highway of the air.” - Orville Wright

Contemporary humans gridlocked on terrestrial highways must also look enviously on the birds soaring freely through space. There must be a better way.

More than a century ago, the persevering genius of Orville and Wilbur Wright ushered forth the history of practical flight. Today, the convergence of autonomy, digitization, and electrification promises to fully open the third dimension of mobility – to render into life, with even greater vividness and fluidity, Orville's infinite highway of the air.

Delivery drones, autonomous cargo aircraft, and air taxis are among the new "advanced aerial mobility" vehicles that will soon soar above and connect our communities. These aircraft upend aviation’s once immutable scaling and economic laws – no longer are vehicles necessarily sized by the pilot.

They challenge the steep performance tradeoffs in vertical and transitional flight with electrification and new configurations. And they usher forth, we hope and engineer, an era of pervasive and accessible aerial mobility.

SkyGrid answers this call. We exist to open the sky for autonomous aviation and advanced air mobility. We achieve this by delivering assured data, decision support, and infrastructure integration to support AAM operations, autonomous aircraft integration, and airspace automation. And we know with conviction that we must do this at a demonstrably high level of assurance.

This concept of operations sets forth our vision for integrating AAM and autonomous aviation into today's airspace. The capabilities outlined in this ConOps will operate even more efficiently and support more aviation segments as the global airspace digitizes. We write this ConOps to help elevate and enrich the vital conversation around AAM operations and airspace integration. Your feedback and engagement will help us make this vision real with OEMs, operators, regulators, and our partners at Boeing and Wisk. On a mission that takes a literal global village, we must not – and will not journey alone.

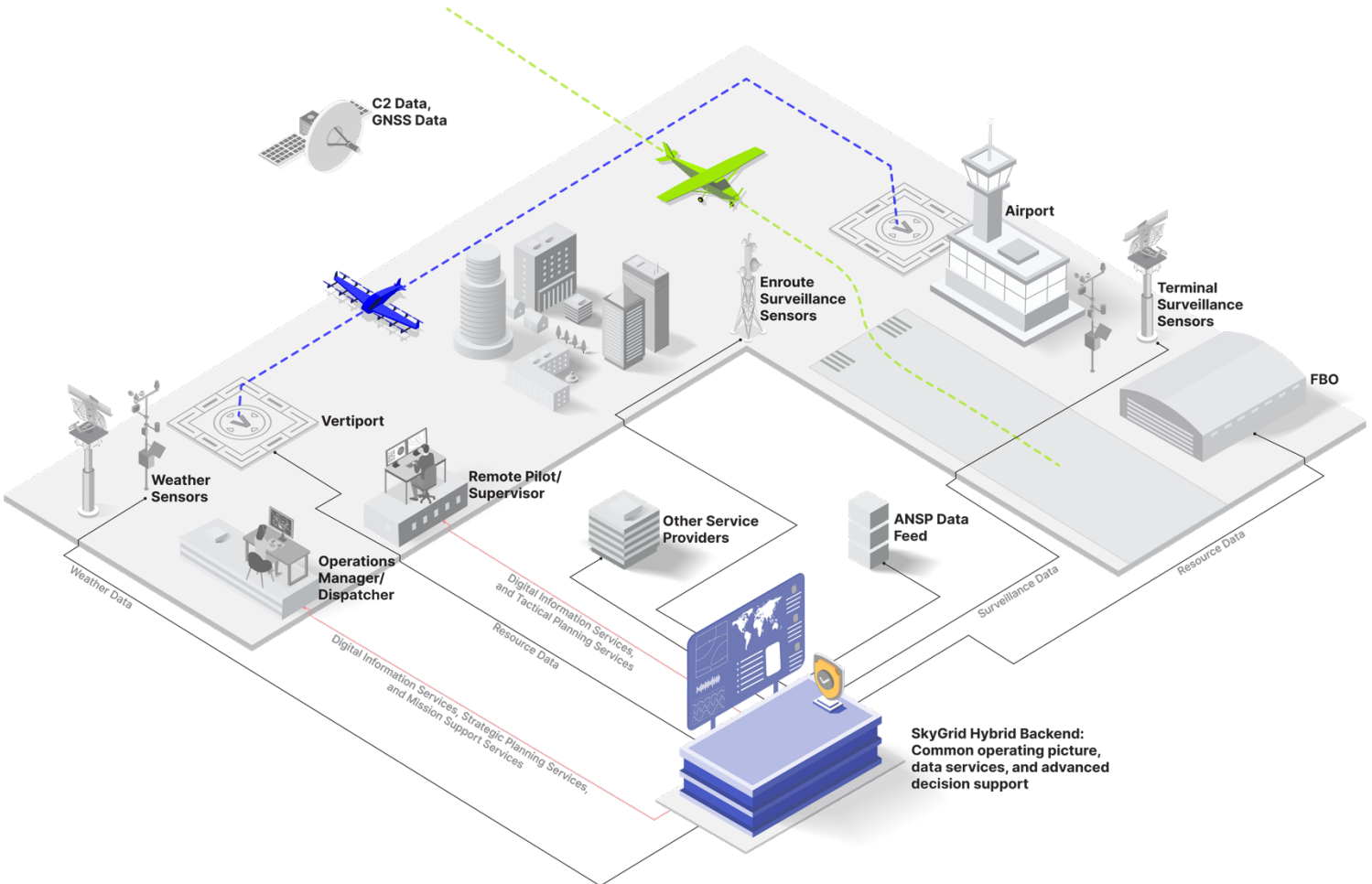
Jia Xu
CEO, SkyGrid

Introduction

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

Given an industry focus on urban and regional markets, AAM operations will often take place in highly complex, structured, and constrained environments. These environments may impose several restrictions on AAM operations, including the need to be deconflicted from existing aircraft operations and to not exceed the workload capacity of current Air Traffic Control (ATC). In addition, when operating uncrewed, AAM operations will require new capabilities to enable a Remote Pilot or Supervisor to develop the necessary situational awareness of their operating environment.

To operate effectively in this context, AAM operations will require a detailed understanding of their operating environments. In addition, uncrewed AAM operations will require new ground-based technology and services to retain their situational awareness and ability to avoid hazards without a pilot onboard. As an aviation Third-Party Service Provider (TSP), SkyGrid is developing a ground-based system to address these emerging needs.

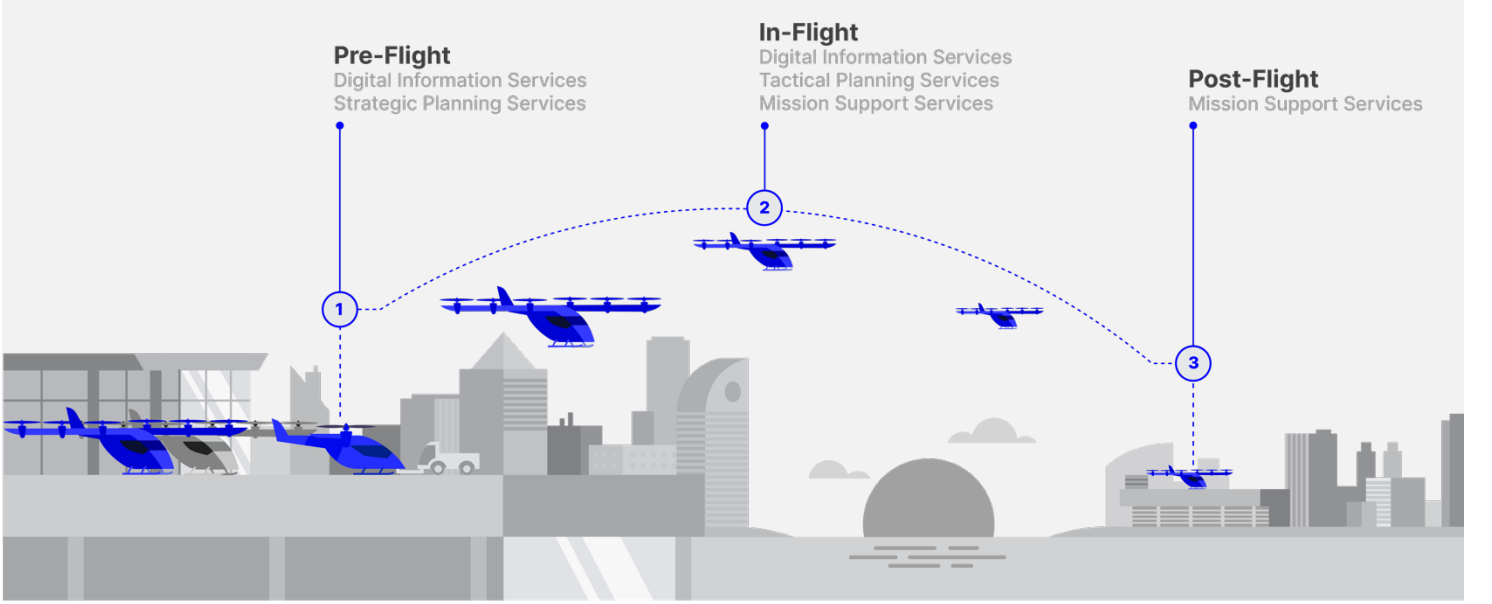


The foundation of SkyGrid's system will be a high-fidelity and high-assurance digital representation of the airspace. This model will provide operators with accurate real-time and forecast information from their operating environment, including information on traffic, weather, airspace structure, and ground infrastructure. Additional strategic and tactical decision support services will be offered by SkyGrid that leverage this digital representation. Before a flight, strategic decision support capabilities will support the airspace integration of AAM by helping operators plan flights that are safe, efficient, and airspace compatible. During a flight, tactical decision support tools will help operators manage new conditions, hazards and constraints – a key capability for enabling uncrewed operations.

This Concept of Operations (ConOps) document provides an overview of the SkyGrid system, its envisioned use, and planned capabilities during early to midterm AAM operations. During this period, SkyGrid expects that AAM operations will take place using Visual and Instrument Flight Rules (VFR and IFR) without changes to airspace structure, and with ATC retaining responsibility for providing air traffic services. The objective of this ConOps is to describe, from an operator perspective, how the SkyGrid system will be used in this context to facilitate the airspace integration of AAM. In addition, this ConOps describes SkyGrid's vision for how the role of TSPs may evolve over time as ground-based capabilities, AAM operations, and operational rules mature. The ConOps is intended for all stakeholders who will use, support, regulate, or otherwise interact with the SkyGrid system in the context of AAM operations.

Operational Vignette

AAM operators will interact with the SkyGrid system during their mission and will use SkyGrid's services to plan and execute their operation. Before a flight, the operator will use SkyGrid's system to assess the operating area, schedule a flight, plan the flight route, verify flight plan feasibility, and prepare for departure. During a flight, the operator will use SkyGrid's system to monitor the operating environment, respond to new hazards and constraints, respond to traffic flow conditions, and respond to traffic encounters.



Roadmap for SkyGrid's Third-Party Services

SkyGrid has identified an evolutionary approach to the development of its TSP system, with the intent of eventually offering high-assurance third-party services to support mature AAM operations. In this future state of operations, the SkyGrid system will support the cooperative management of AAM operations without direct ATC involvement, contributing directly to the scaling of operations. In the United States, the FAA has referred to this type of mature TSP system as a Provider of Services for Urban Air Mobility (PSU).

Based on this long-term target, SkyGrid identifies three phases of operation for its system, with earlier phases supporting the integration of AAM operations within the current air traffic system and under existing regulations. As the SkyGrid system matures, specific services provided by SkyGrid will evolve from being informational-only, to providing alerts and advisories, to providing automated decision-making and being delegated responsibility for safety-critical tasks. The three proposed phases of operation, along with their anticipated timelines, are:

Phase I
(Entry-into-service, 2026-2028)

The SkyGrid system, which is expected to enter service in 2026, will initially provide flight-relevant information to operators. This information will be provided by SkyGrid's Digital Information Services and will offer operators a detailed understanding of their operating environment. During this phase of operations, the SkyGrid system will be used by operators for pre-flight situational awareness, and by operators of uncrewed aircraft as their primary source of information for in-flight situational awareness and decision-making.

Phase II
(2028-2032)

During this phase, the SkyGrid system will provide AAM operators with additional decision support services to assist them during the planning and execution of flights within the current air traffic system. These services are represented by SkyGrid's Strategic and Tactical Planning Services and will offer alerting and advisory capabilities. The addition of decision support services during this phase of operations will contribute to more efficient AAM flights and reduce the need for ATC intervention in AAM operations, leading to more scalable operations. SkyGrid anticipates that this phase will offer opportunities for gaining experience with PSU functions in a decision support capacity and producing evidence for their future operational approval.

Phase III
(2032+)

In this phase, the SkyGrid system will support mature AAM operations within corridors, which will be conducted without direct ATC involvement. In the transition to this phase, SkyGrid expects that its system will transition from providing decision support to providing automated decision-making in a responsible capacity, helping to maintain a safe and orderly flow of traffic within AAM corridors as a PSU. Services offered by SkyGrid in this phase will consist of evolved forms of the decision support services offered in Phase II.

Given this incremental development approach, **this ConOps focuses on describing the operation of the SkyGrid system during Phase II described above**, during which the system will provide decision support capabilities to help early AAM operators navigate the current air traffic system. A more detailed discussion of Phase III will be the target of future SkyGrid publications.

Principles and Assumptions

This ConOps provides an overview of the SkyGrid system, its envisioned use, and planned capabilities during Phase II (2028-2032) of the SkyGrid system roadmap. The table below summarizes the key assumptions made by SkyGrid with regard to the AAM operating environment during this phase of operations.

Feature of Operating Environment	Assumption
Flight Rules	Crewed AAM operations will take place using existing VFR and IFR rules. Uncrewed AAM operations will take place under IFR only.
Airspace Structure	Existing airspace and sector structure will be retained. Airspace “keyholes” or “carve outs” may be used to omit the airspace above vertiport locations from controlled airspaces.
Air Traffic Services	Aircraft separation and traffic flow management will be provided by Air Traffic Control (ATC) in controlled airspaces. Third-Party Service Providers (TSP) may generate tactical advisories to operators, including flow management advisories.
Separation Standards	Existing separation standards will be retained (e.g., FAA Order 7110.65). Uncrewed aircraft will satisfy Remain Well Clear and See and Avoid requirements using new airborne and ground-based systems.
Routes	Existing VFR corridors and ATC-preferred IFR routes will be leveraged where applicable. New IFR routes may be created to serve AAM operations, such as TK/ZK routes based on the RNP 0.3 Navigation Specification (NavSpec). Routes will provide higher predictability of AAM operations to air traffic controllers.

Feature of Operating Environment	Assumption
Instrument Flight Procedures (IFP)	Existing IFPs will be leveraged where applicable. New NavSpecs and IFPs may be created to serve uncrewed AAM aircraft, including approach procedures that support automated landings (similar to ILS CAT III).
Communication Infrastructure	Existing two-way VHF communication between AAM operators and ATC will be retained. Ground-to-ground communication may be established between a Remote Pilot or Remote Supervisor and ATC. Datalink will be leveraged where applicable, such as for Pre-Departure Clearances (PDC).
Surveillance Infrastructure	Existing surveillance infrastructure will be leveraged (ADS-B, ASR-9, ASDE-X, WAM, etc.). New low-altitude surveillance sensors may be installed in the local areas of airports and vertiports to augment surveillance coverage.
Takeoff and Landing Sites	VTOL aircraft will operate from existing airports and vertiports. New vertiports may be built. CTOL aircraft will operate from existing airports. Third-Party Service Providers (TSP) will interface with vertiports and FBOs to reserve departure, arrival, and parking slots on behalf of operators.
Role of Third-Party Service Providers (TSP)	Third-Party Service Providers (TSP) will provide AAM operators with data services and decision support to improve their situational awareness, operational efficiency, airspace access, and throughput. Decision support services offered by TSPs, particularly during flight, will not compete with ATC instructions and will be provided outside of the typical time horizon of ATC actions.

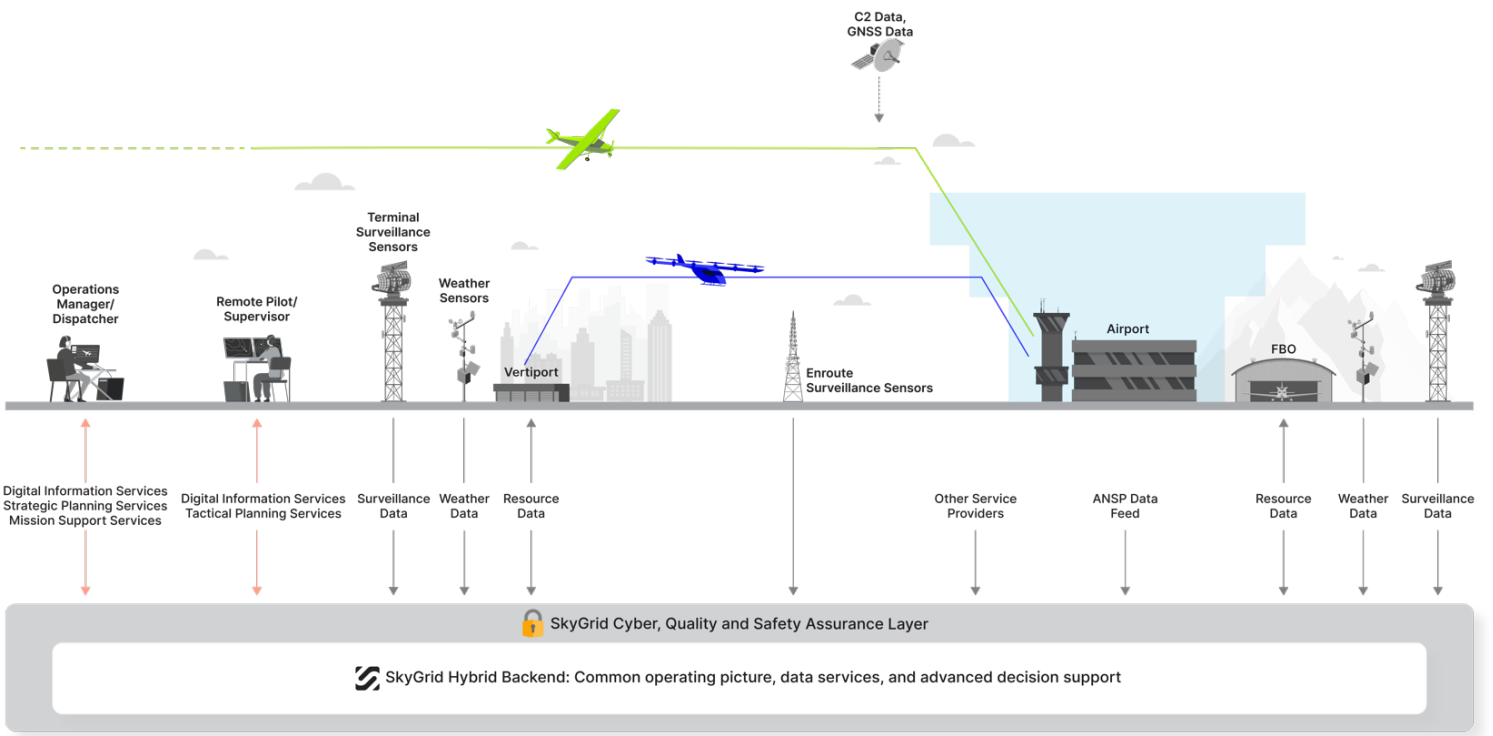
Overview of SkyGrid System

The SkyGrid system will be a ground-based system with a dedicated user interface and output API. The system is being designed based on aviation standards to serve as a high-assurance source of flight information. The system will deliver a variety of digital services to operators to support the airspace integration of novel AAM operations. These will include data services to support an operator's understanding of their operating environment, and decision support services to assist operators in planning and executing AAM flights safely and efficiently.

Development of the SkyGrid system is guided by four high-level system goals:

- **System Goal 1:** Provide a high-fidelity digital representation of the operating environment for operator situational awareness and decision-making.
- **System Goal 2:** Enable uncrewed operations by providing high-assurance traffic awareness needed to satisfy remain-well-clear and collision avoidance requirements.
- **System Goal 3:** Increase efficiency of operations by providing flight planning solutions based on detailed knowledge of the airspace, its structure, hazards, and constraints.
- **System Goal 4:** Streamline airspace access and help scale AAM operations by helping operators execute flights in ways that minimize the need for ATC intervention.

A high-level operational concept graphic (OV-1) for the SkyGrid system is shown in the figure below, highlighting the external interfaces of the system.



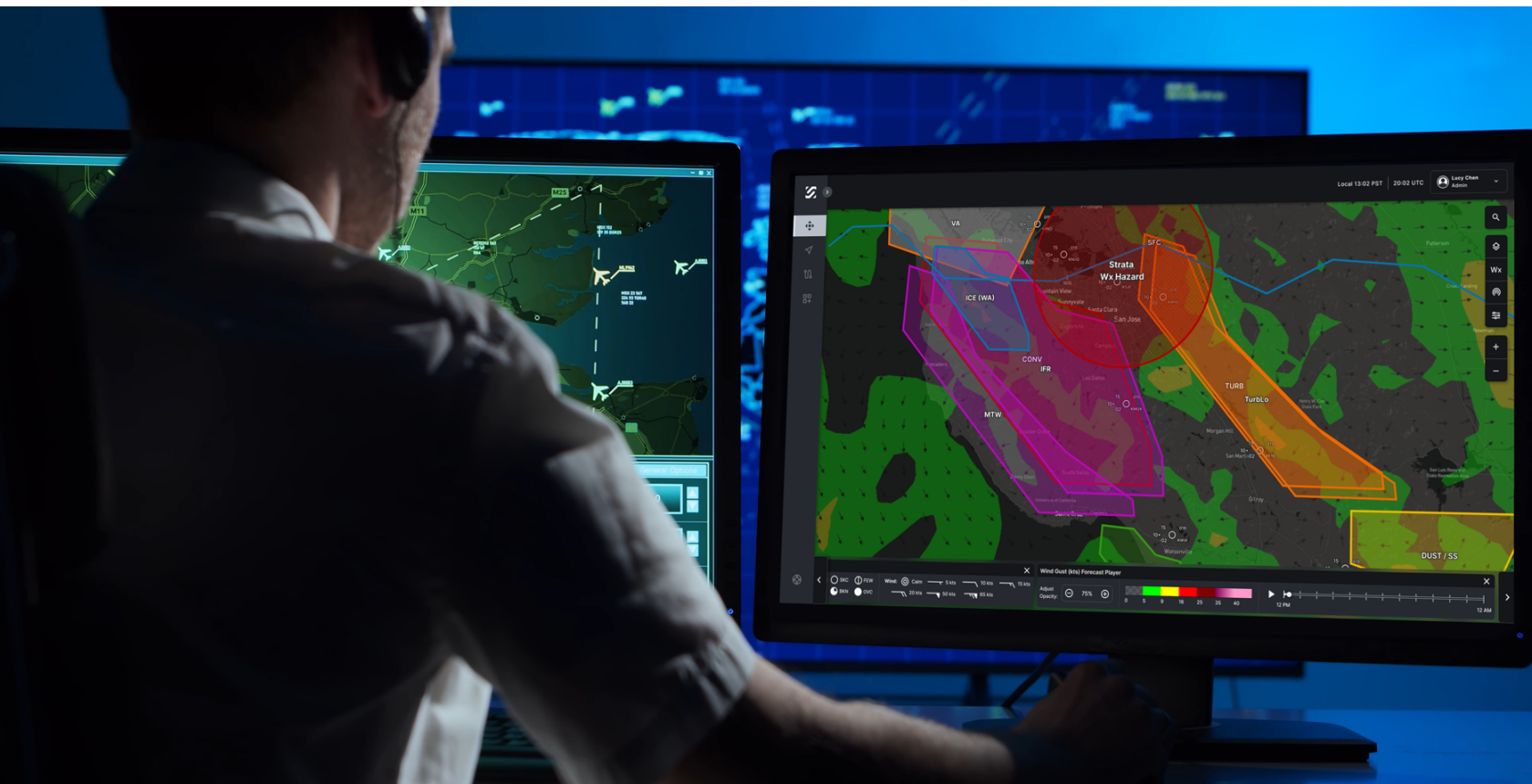
The SkyGrid system will support both crewed and uncrewed AAM operations within the current air traffic system. For crewed operations, services will be provided to an Operations Manager in charge of planning, monitoring, and analyzing flights. These services include SkyGrid's Digital Information Services, Strategic Planning Services, and Mission Support Services. Onboard pilots will not interface with the SkyGrid system during flight.

For uncrewed operations, the Operations Manager will be provided the same services as in crewed operations, and additional Tactical Planning Services will be provided to a Remote Pilot or Supervisor responsible for the flight. During flight, the Remote Pilot or Supervisor will interface with the SkyGrid system directly, using it as a primary source of information for their situational awareness and decision-making.

The SkyGrid system will receive and aggregate data from a variety of sources, including Surveillance Data Providers, Weather Data Providers, Aeronautical Data Providers, and C2 Data Providers. Data will be received, processed and distributed using secure processes. High-criticality data will have additional requirements for security, latency, and assurance.

Traffic surveillance will be supported by new commercial surveillance sensors deployed by Surveillance Data Providers, as well as dependent surveillance broadcasts from aircraft (i.e., ADS-B). In terminal environments (i.e., in the vicinity of vertiports and airports), Surveillance Data Providers will provide additional low-altitude coverage. Similarly, Weather Data Providers will deploy and operate new sensor infrastructure for assessing weather conditions at new takeoff and landing sites.

Data on the status and capacity of vertiports and FBOs will be shared with SkyGrid by those facilities, for the purpose of AAM flight scheduling and slot allocation. Additional information on the status and capacity of airspace and airport resources will be received from the local ANSP or ATM system.



Examples of Planned Services

Services delivered by the SkyGrid system are classified under four types:

Digital Information Services, Strategic Planning Services, Tactical Planning Services, and Mission Support Services. A list of services proposed under each category is shown below, with additional service descriptions available in the full version of this ConOps.

Digital Information Services

- Terrain and Obstacle Data
- Weather Data
- Ground-Based Traffic Surveillance
- NOTAMs
- ATM/TSP Integration
- Aerodrome and Airspace Data
- C2 and GNSS Performance Data
- Resource Status and Capacity Data

Strategic Planning Services

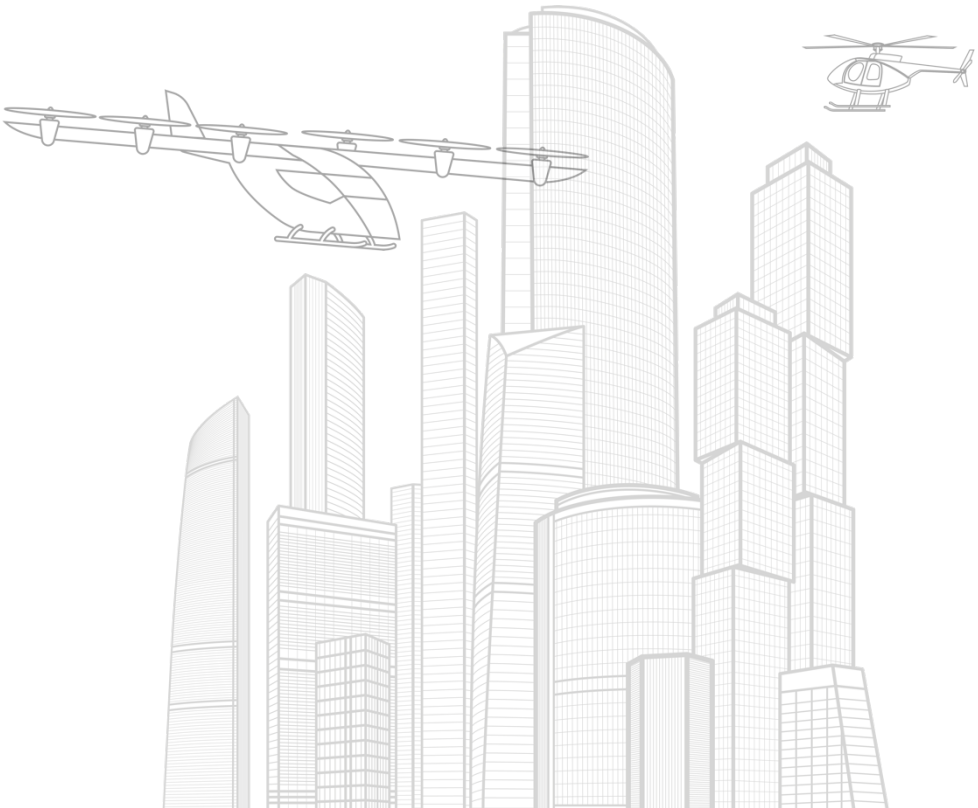
- Advanced Flight Planning
- Flight Plan Validation
- Demand-Capacity Balancing
- Traffic Synchronization
- Operational Area Forecasting

Tactical Planning Services

- Dynamic Rerouting
- Hazard and Constraint Monitoring
- Flow Management
- Conformance Monitoring
- Ground-Based Detect-and-Avoid

Mission Support Services

- Flight Tracking
- Mission Recording
- Operations Data Management



Digital Information Services

Digital Information Services will provide operators with high-fidelity information about their operating environment, supporting their situational awareness. Example services in this category include *Ground-Based Traffic Surveillance (GBTS)* and *Resource Status and Capacity Data*.

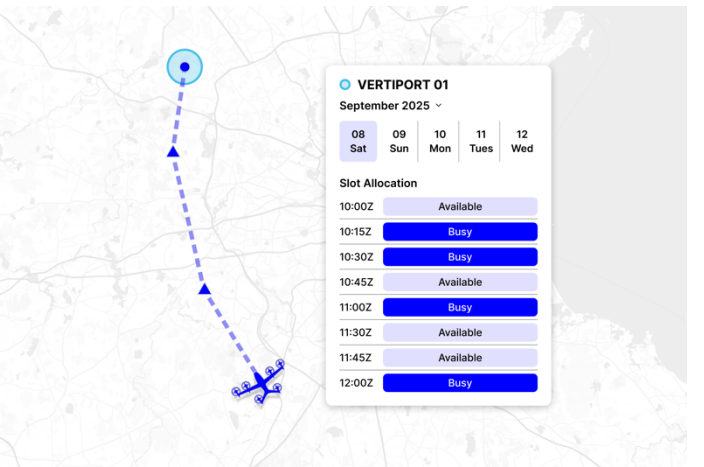
Ground-Based Traffic Surveillance

GBTS will integrate traffic information from several surveillance sources to provide operators with a complete traffic picture of their operating environment. Operators will receive high-integrity and low-latency traffic surveillance data, including tracks for cooperative and non-cooperative aircraft. In addition to aircraft track data, the SkyGrid system will provide real-time data on the performance of surveillance systems and expected coverage volumes. This data may be visualized in real-time by operators via the SkyGrid user interface.

Notional operator view of SkyGrid's Ground-Based Traffic Surveillance service, showing aircraft traffic.

Resource Status and Capacity Data

Resource Status and Capacity Data will provide operators with information on capacity-constrained resources, including vertiports, airport runways, FBO parking stands, and AAM routes. Resource status refers to whether a resource is operating normally, or closed. Resource capacity refers to the total number of available slots at vertiports and FBO parking stands, and to the maximum acceptable throughput of routes and runways. SkyGrid envisions receiving and integrating data from Vertiport/FBO Manager systems and ANSP/ATM systems as part of this service.



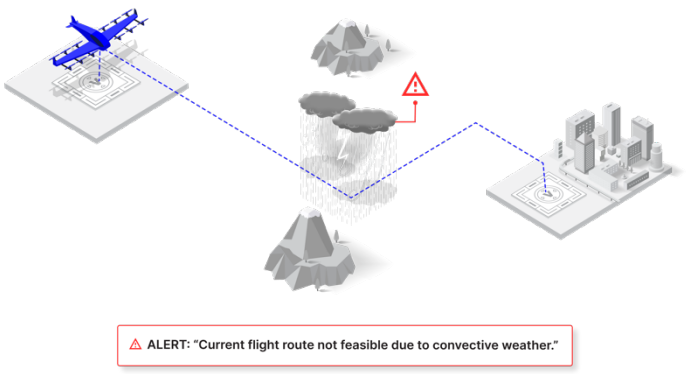
Notional operator view of SkyGrid's Resource Status and Capacity Data service, showing available slots for arrival and handling at a vertiport.

Strategic Planning Services

Strategic Planning Services will provide decision-support services that will help operators plan AAM flights that are safe, efficient, and compatible with their operating airspace. Example services in this category include *Flight Plan Validation* and *Traffic Synchronization*, which will leverage the highly detailed digital representation of the operating environment that make up SkyGrid's Digital Information Services.

Flight Plan Validation

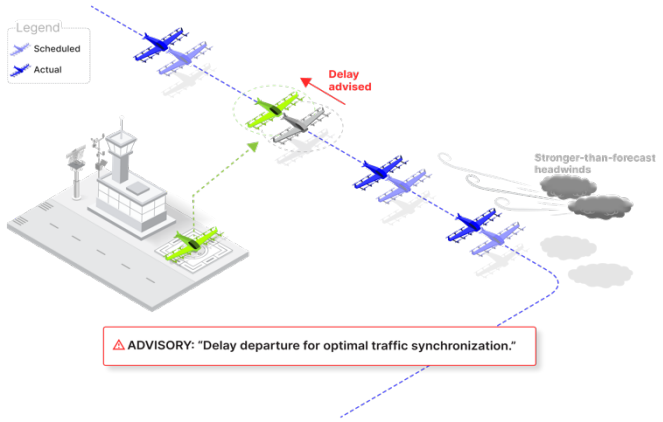
After an operator has prepared a flight plan, the Flight Plan Validation service will begin to perform periodic validations to ensure its feasibility up until departure. The Flight Plan Validation service will monitor hazards and constraints that are considered dynamic (i.e., time-varying) – if a new hazard or constraint is detected that makes the original flight plan infeasible, the operator will be alerted. Hazards and constraints monitored as part of this service will include airspace closures, availability of surveillance services, hazardous weather, resource capacity, and changes in airspace configuration.



SkyGrid's Flight Plan Validation service will periodically re-evaluate a submitted flight plan and alert the operator if the plan becomes infeasible.

Traffic Synchronization

Simultaneously, and before the scheduled departure time, the Traffic Synchronization service will monitor real-time traffic conditions and the near-term availability of capacity-constrained resources (e.g., vertiports, airports, and waypoints) along the route of flight. This service may suggest fine adjustments to the operation's scheduled time of departure based on the following factors: 1) requirement to be separated from departing and arriving aircraft at the origin vertiport/airport; 2) requirement to be separated from other enroute aircraft at common route waypoints, and; 3) requirement to be separated from other arriving aircraft at the destination airport.



SkyGrid's Traffic Synchronization service will provide departure time adjustments based on current conditions to improve traffic flow.

Tactical Planning Services

Tactical Planning Services, which include services such as *Flow Management* and *Ground-Based Detect-and-Avoid (GBDAA)*, will help operators manage in-flight conditions, hazards and constraints safely and efficiently. These decision-support services will also enable uncrewed aircraft to avoid hazards without a pilot onboard.

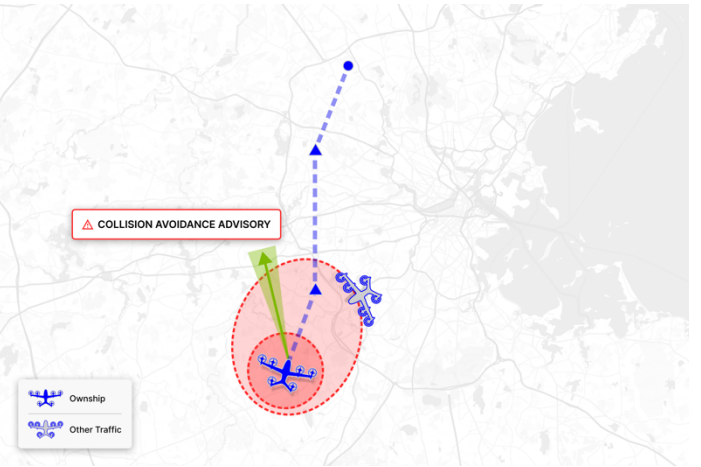
Flow Management

During flight, SkyGrid's Flow Management service will assist operators in maintaining an orderly flow of traffic on AAM routes and at vertiports/airports. To achieve this, the Flow Management service will monitor traffic flow on AAM routes and issue flow management advisories to operators when applicable. Traffic flow parameters monitored by the SkyGrid system will include: 1) in-trail spacing between aircraft on AAM routes, 2) expected times of arrival of AAM aircraft at waypoints, and 3) expected times of arrival of AAM aircraft at vertiports/airports.

Notional operator view of SkyGrid's Flow Management service, showing a speed change advisory to maintain in-trail separation between aircraft.

Ground-Based Detect-and-Avoid

GBDAA will provide operators with in-flight alerts and advisory guidance to remain well clear of other traffic in both visual and instrument meteorological conditions. In the event of a loss of well-clear separation between the ownship and another aircraft, the GBDAA service will provide collision avoidance advisory to the operator following applicable standards. This service will be a key enabler of uncrewed operations by allowing operators of uncrewed aircraft to satisfy the operational requirement to remain well clear of other traffic without a pilot onboard and without additional onboard systems.



Notional operator view of SkyGrid's Ground-Based Detect-and-Avoid service, showing a collision avoidance advisory.

Feedback

We invite your input and feedback to this concept of operations for third-party services supporting the airspace integration of advanced air mobility.

Please send an email with feedback to conops@skygrid.com.

Disclaimer:
Please do not include any confidential information in your feedback. Feedback becomes the property of SkyGrid, LLC.

SKYGRID

For more information, read our Concept of Operations at
www.skygrid.com/conops

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