# Design of UAM Network and Ecosystem Integration

Anjan Chakrabarty[1], Vaishali Hosagrahara[2] and Andrew Lei[3]
*Supernal 401 Kato Terrace Fremont, CA, 94350, USA*

**This paper investigates the routes and procedures to bring Supernal's Urban Air Mobility (UAM) vehicles to market in Los Angeles Metropolis. Integration of UAM traffic in the National Airspace System (NAS) is challenging, more so in a busy airspace surrounding Los Angeles International Airport (LAX), one of the busiest airports in the world. In this paper we analyze the current air traffic pattern in the LAX region and design possible vertiport locations and optimal routes connecting them. These selected routes are evaluated in our high-fidelity simulator for deployment in entry into service (EIS) and submitted to Provider of Services for UAM (PSU), an entity that supports UAM operators with meeting UAM operational requirements that enable safe, efficient, and secure use of the airspace. By integrating with a Vertiport Management System (VMS), we simulate the entire ecosystem that is needed to bring UAM to the market.**

## I. Nomenclature

*ADS-B* = Automatic Dependent Surveillance-Broadcast
*AGL* = Above Ground Level
*ATC* = Air Traffic Control
*COP* = Cooperative Operating Practice
*CP* = Charging Pad
*EIS* = Entry Into Service
*FAA* = Federal Aviation Administration
*GNSS* = Global Navigation Satellite System
*GPA* = Glide Path Angle
*GUFI* = Globally Unique Flight Identifier
*IFR* = Instrument Flight Rules
*LOA* = Letter of Agreement
*NAS* = National Airspace System
*PSU* = Provider of Services for UAM
*RNAV* = Area Navigation
*SA* = Staging Area
*SDSP* = Supplemental Data Service Provider
*SWIM* = System Wide Information Management
*TLOF* = Touch Down and Lift-off area
*UAM* = Urban Air Mobility
*VFR* = Visual Flight Rules
*VMS* = Vertiport Management System
*WAAS* = Wide Area Augmentation System

[1] Lead Aerospace Research Engineer, Intelligent Systems, Supernal.
[2] Senior UAM Airspace Integration Engineer, Intelligent Systems, Supernal.
[3] Microweather Data Engineer, Intelligent Systems, Supernal.

## II. Introduction

The increasing number of Urban Air Mobility (UAM) traffic [6] will challenge the current capabilities of Air Traffic Services (ATS). The Federal Aviation Administration's (FAA) Urban UAM Concept of Operations (ConOps) [1] and Vision ConOps [2] suggest new airspace structures that are scalable with increase in demand for UAM Operations. The proposed innovation that can help with the introduction of UAM traffic is establishing specific routes and corridors. The FAA's UAM ConOps suggests that new airspace structures like UAM corridors comply with the following criteria: 1) minimal impact on existing National Airspace System (NAS) operations, 2) minimal additional Air Traffic Control (ATC) services, 3) include public interest considerations such as noise, safety, and security, and 4) address customer demand. Inside UAM corridors, all aircraft operate under UAM specific rules, procedures, and performance requirements. The goal is to limit interaction with FAA air traffic controllers and minimize impact on conventional air traffic. The next section discusses the FAA concepts of operation with a distributed architecture.

### A. FAA Concepts of Operations

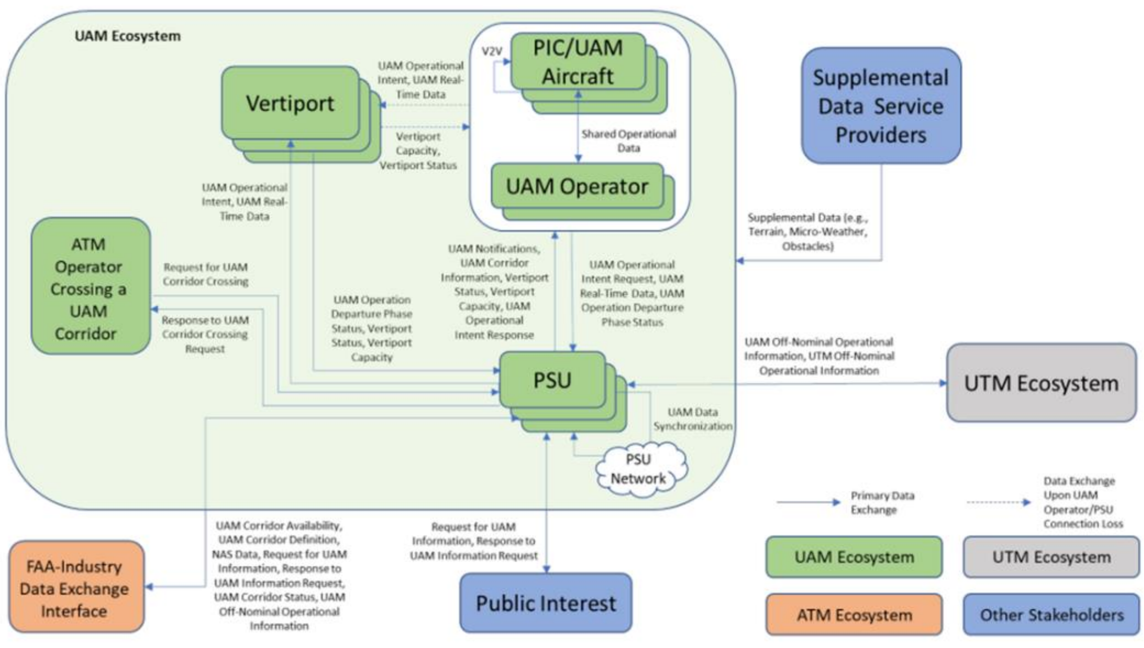


**Fig. 1 Notional UAM architecture**

The FAA published ConOps 2.0 in May 2023, updating the previous ConOps. Routes and corridors defined in FAA ConOps are like the area navigation procedures used today at busy airports. But instead of ATC managing the flow of traffic, FAA UAM concepts envision a third-party service provider performing this role as the Provider of Services for UAM (PSU) Network (Fig. 1). The PSU network comprised of individual PSU lies at the center of FAA UAM architecture. PSU exchanges data with UAM operators, Supplemental Data Service Providers (SDSPs) and ATC. Supernal is working with several PSUs to facilitate UAM operations in the Los Angeles area.

The airspace available in urban environments is limited by the height of buildings, the effect of weather (including wind gusts), privacy needs, noise impact on the community, and existing air traffic flows. New airspace structures would need to be located near large airports and heavily congested urban areas where the initial market demand is likely to exist. The primary function of corridors in controlled airspace is to facilitate separation of UAM aircraft from other conventional traffic [7,8]. This has the result of limiting controller workload since UAM aircraft will be self-managed inside corridors. Corridors will also simplify maintaining separation between UAM flights by constraining their direction, speed, and altitude within the corridor boundaries similar to the automobile freeway system.

### B. FAA Innovate 28

The primary focus of FAA Innovate 28 Implementation Plan, Version 1.0 [3], is to document the work required to enable initial Advanced Air Mobility (AAM) operations in a variety of operational settings or "key sites" in the near-term. Innovate28 (I28) is an FAA initiative that will culminate in integrated AAM operations with Original Equipment

Manufacturers (OEMs) and/or operators flying between multiple origins and destinations at one or more locations in the U.S. by 2028.

This paper outlines various corridors connecting different Origin-Destination (O-D) pairs within the Los Angeles area. It delves into the analysis of the impact of these corridors and the coexistence of conventional legacy traffic in the Los Angeles basin. Furthermore, it examines the seamless integration of the proposed routes with a PSU, with OneSky being the preferred choice for PSU in Los Angeles. Next, the paper explores integrations for takeoff and landing with ANRA's Vertiport Management System (VMS) and route compliance and optimization with OneSky's PSU. The subsequent section will delve into a detailed discussion covering UAM network design for Entry into Service (EIS), specifically, vertiport placement, route design in the Los Angeles area, and the integration with PSU and VMS. Finally, the paper concludes with an analysis of the network's performance in Los Angeles.

## III. UAM Network

### A. Vertiport Locations

Vertiport location plays a major role in determining the routes. Supernal has identified several possible regions in the Los Angeles area for EIS routes. These regions include several places like Los Angeles International Airport (LAX), Downtown Los Angeles Downtown (DTLA), Long Beach Airport, Raytheon, Warner Center, Universal Studios etc. (Fig. 2). These sites were chosen based on passenger demand and willingness to travel in a UAM aircraft and complement the existing forms of mobility in cities by connecting air modes to ground modes.

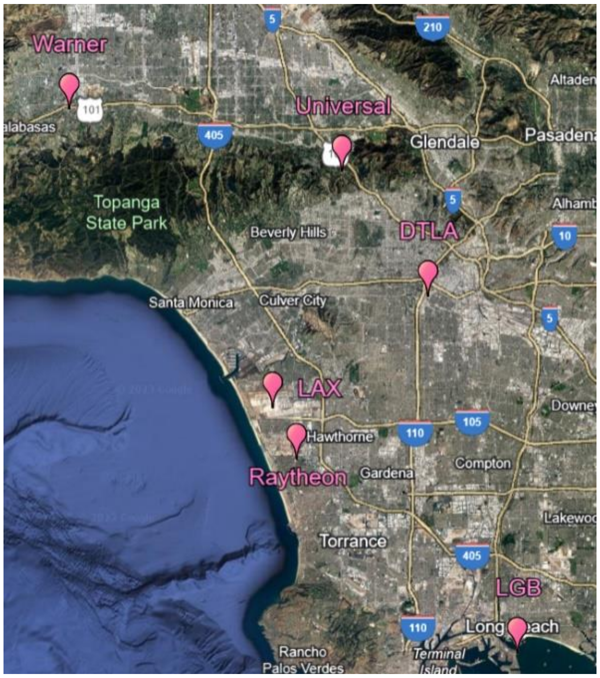


**Fig. 2 Possible vertiport locations around Los Angeles**

### B. Existing Routes Published by FAA

#### *1. VFR Flyway*

Visual Flight Rule (VFR) Flyways refer to general flight paths that are not specifically defined as a particular course. Pilots use these Flyways for planning flights into, out of, through or near complex terminal airspace to avoid Class B airspace. Importantly, pilots are not required to obtain an ATC clearance to fly these routes. VFR corridors, on the other hand, represent designated airspace within Class B airspace with specified vertical and lateral boundaries.

Aircraft operating within these corridors are not obligated to have an ATC clearance or maintain communication with ATC.

VFR transition routes are specific flight courses outlined on a terminal area chart for navigating through a particular Class B airspace. These routes come with ATC-assigned altitudes, and pilots are required to obtain an ATC clearance before entering Class B airspace along the designated route. Special flight rule areas are defined airspace regions, situated above land areas or territorial waters. Within these areas, aircraft operations are subject to the rules outlined in 14 CFR Part 93, unless otherwise authorized by ATC. The regulations within special flight rule areas may differ from standard VFR rules, necessitating adherence to specific guidelines unless otherwise directed by ATC.

*2. Low Altitude RNAV Routes*

T-routes, or Area Navigation (RNAV) routes, are designated airspace routes that are accessible for use by aircraft equipped with Global Positioning System (GPS) or Wide Area Augmentation System (WAAS) technology. These routes are available for use at altitudes starting from 1,200 feet above the surface.

Distinctively, TK-routes cater specifically to helicopters [12] that are equipped with Instrument Flight Rules (IFR) approved GPS or Global Navigation Satellite System (GNSS) equipment. Unlike standard T-routes, which are open to a broader range of GPS-equipped aircraft, TK-routes are tailored to meet the navigation needs of helicopters.

In the northeast corridor between the Washington, DC, and New York City metropolitan areas, there are two helicopter RNAV routes known as TK-routes. These routes are designed to facilitate the IFR navigation of helicopters equipped with GPS or GNSS technology, providing them with specific pathways for travel within this busy and geographically complex corridor. The existence of these TK-routes aims to enhance the efficiency and safety of helicopter operations in this particular airspace region, streamlining navigation procedures for helicopters equipped with the requisite technology.

***3.** Helicopter Routes*

The FAA has released helicopter routes in five major cities across the United States. In Los Angeles, numerous routes have received authorization and are regularly utilized by helicopter pilots. Figure 3 illustrates the published helicopter routes near LAX, specifically in areas with high concentrations of helicopter activity. These approved helicopter routes, often aligned with highways or rivers, will serve as fixed corridors for UAM operations. Initially, Letter of Agreements (LOA) must be established between LAX and these routes until FAA approval is obtained for the designated corridors. Primarily VFR routes, many of these helicopter routes require significant adjustments to achieve IFR compliance. IFR are essential for accommodating all-weather and nighttime operations for our vehicles. Evaluation of these routes is crucial to assess their effectiveness and potential impact on ATC workload, including communication considerations.


**Fig. 3 Published Helicopter Charts in Los Angeles.**

### C. Routes Connecting the Vertiports

Taking into account the various established routes by the FAA, we have established connections between all the vertiports using a combination of helicopter routes and low-altitude T-routes. The initial routes connecting the different vertiports are illustrated in Fig. 4. The altitude of these routes is determined by the specific sector of airspace we are operating within, as well as the performance capabilities of our vehicles. Once these routes are established, the subsequent step involves defining the approach and departure procedures for entering and exiting the vertiports. This comprehensive planning ensures the integration of our UAM operations with existing airspace infrastructure while considering factors such as airspace classification and the capabilities of our UAM vehicles. The trajectory design consists of finding routes joining different O-D pairs which can be approved by FAA. Each trajectory consists of approach and departure procedures in and out of vertiport and fixed approved corridors. We examine different existing routes published by FAA that can be used to build the initial route network and corridor

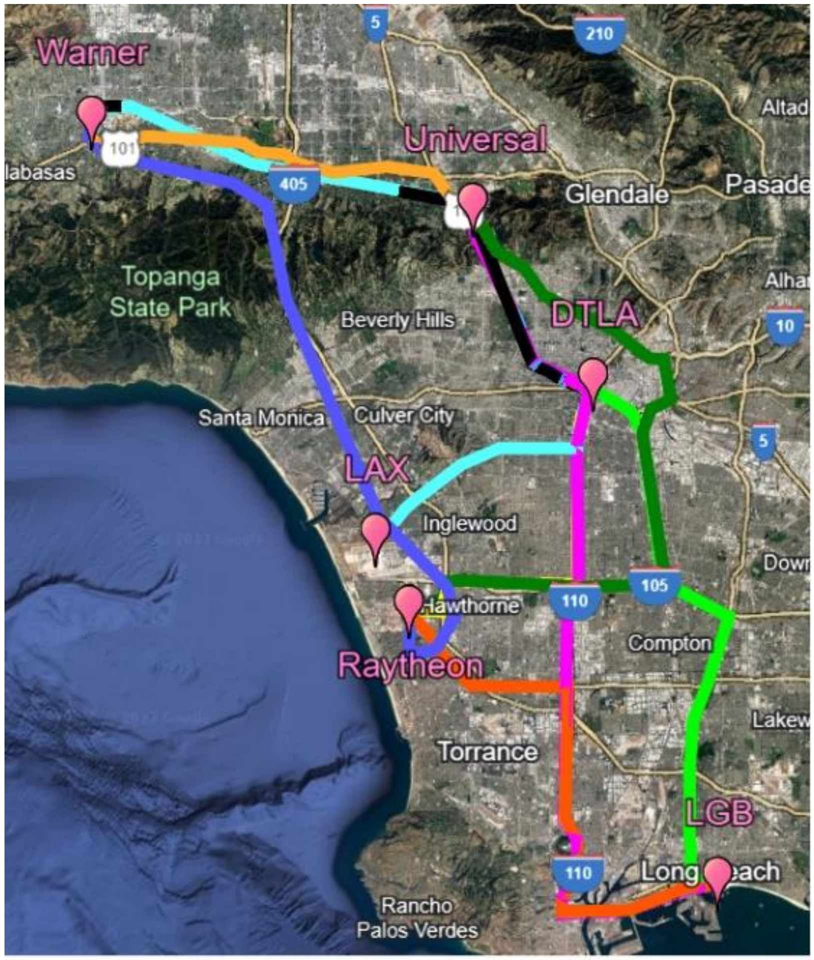


**Fig. 4 Routes connecting Vertiports**

### D. Approach Departure Procedures

Designing approach and departure procedures for UAM vehicles presents a unique challenge due to the hybrid mode of operation characteristic of these vehicles. UAM vehicles have the capability to take off and land vertically, allowing them to approach any vertiport from various directions and then transition to vertical ascent or descent.

Addressing this challenge prompted the introduction of the "wheel" concept, proposed by Zahn from NASA, to establish standardized procedures for the approach and departure of UAM vehicles [10, 11]. Figure 5 (left side) illustrates the wheel concept specifically for arrival procedures.

With the wheel concept, a vertiport can be approached from any direction, and the vehicle then seamlessly transitions to the landing phase. NASA conducted a series of flight tests to determine the optimal size of the wheel, with the glide path angle (GPA) playing a crucial role in its definition. The size of the wheel is determined by the GPA, where, for example, a 9-degree approach corresponds to a wheel diameter of approximately 2 nautical miles (NM), and for a 6-degree GPA, it is about 3 NM. Considering our current vehicle performance, the wheel diameter is defined as the Vertiport Operational Area (VOA) and is approximately 3 NM. This concept establishes a standardized and scalable framework for approach and departure procedures, accommodating the versatile operational capabilities of UAM vehicles.

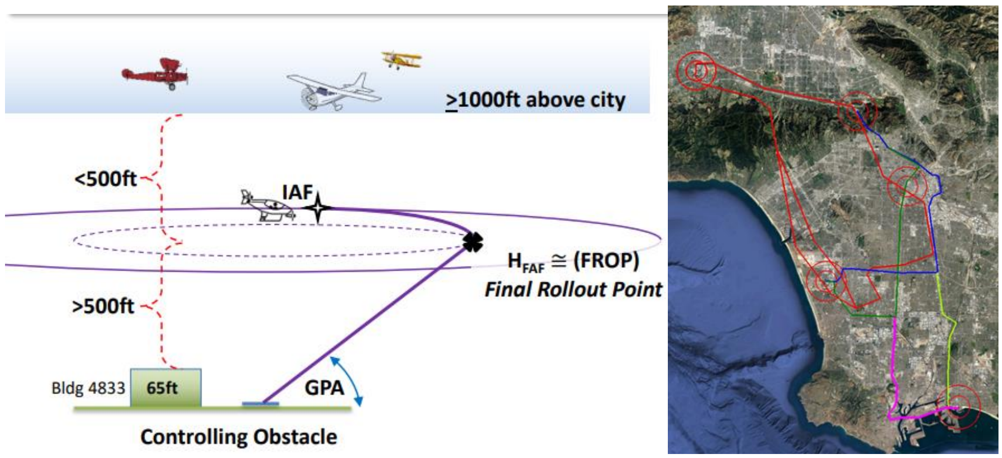


**Fig. 5 NASA Wheel concept for arrival procedures (left side). LA network with Wheel surrounding each vertiport for "deproach" [15] (right side)**

## E. Flight profile

The flight profile of a Supernal vehicle will have a significant influence on the design of the trajectory. The given route or waypoints that must be flown by our vehicle. Figure 6 shows the flight profile of a Joby S4 vehicle. Supernal's vehicle, which is being tested now will have similar characteristics as the Joby vehicle. The vehicle has vertical takeoff up to 50 feet and then transitions into forward flight with a 4.5% gradient. Similarly, during landing the vehicle is capable of a glide slope of 6 degrees. The glide slope of 6 degrees was also chosen for passenger comfort.

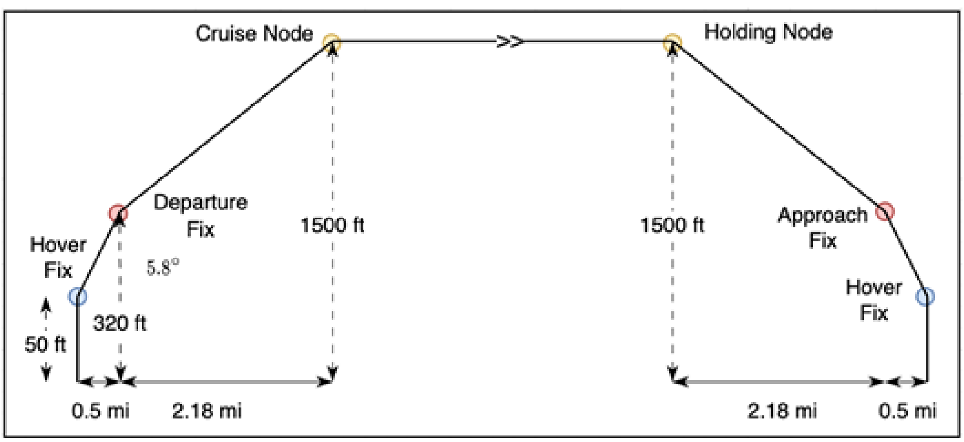


**Fig. 6 Flight profile of example vehicle (Joby S4)**

Based on Joby's S4 vehicle flight profile, Fig. 7 shows the flight profile of our vehicle along the designed trajectory from LAX to DTLA. As shown in Fig. 7, the vehicle was able to follow the designed waypoints within the given constraints. With a glide slope of 5.9 degrees the desired glide slope was as close to the designed glide slope for the approach.

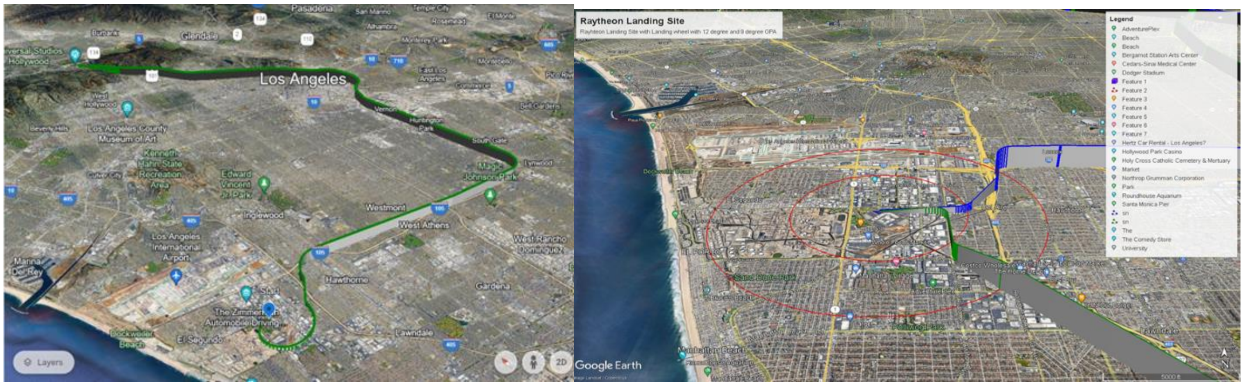


**Fig. 7 Flight trajectory for the entire route (left side). Approach and departure trajectory based on NASA's wheel concept (right side).**

The routes were designed to minimize energy consumption by maintaining takeoff and landing hover between 50-200 feet above ground level (AGL) and shallow climb rate. They also take into consideration public stakeholder needs, like, local environmental and noise by flying over roads and waterways instead of residences and workplaces.

Trajectories were meticulously crafted for each designated route, aligning with our vehicle profile and incorporating specific approach and departure procedures tailored to each vertiport. On the right, Fig. 5 illustrates all trajectories, including their respective VOAs, while Fig. 7 provides an in-depth view of the trajectory between Raytheon and Universal.

Following the design of these trajectories connecting each vertiport, comprehensive testing was conducted using our high-fidelity simulator, Microsoft Airsim [13]. This simulation involved interfacing with the components of the ecosystem, including the VMS and PSU. The ensuing section provides a detailed exploration of the intricate connections within the ecosystem.

## IV.Ecosystem Integration

### A. Vertiport Management System

The VMS developed by ANRA[4] manages operations in and around a vertiport supporting both takeoff and landing operations of UAM vehicles as well as ground operations of the vehicles before and after each flight. VMS plays a pivotal role by intelligently exchanging real-time data with all the necessary services to facilitate the safe arrival and departure of UAM aircraft and ensures movement of the vehicles across the vertiport surface, charging schedules and passenger handling [5]. It provides overall status of vertiport resources and requests for reservations, rolling notifications window of operational status, system checks to verify system checks of various outbound flights from a vertiport and live surveillance of the aircraft traffic around the vertiport area (Fig. 8).

The vertiport manager uses vertiport surface procedures for the inbound and outbound traffic. An inbound aircraft submits a request for landing at the vertiport's Touch Down and Lift Off (TLOF) area. The vertiport manager assigns an available TLOF and Staging Area (SA) for passenger unloading after assessing the available resources. After receiving the clearance, the aircraft lands at the assigned TLOF and taxis to the assigned SA to unload the passengers in the vertiport. It then taxis to the assigned Charging Pad (CP) if the distance traveled by the aircraft was greater than 30 miles to charge its batteries. An outbound aircraft loads the passengers from vertiport manager assigned SA and taxis to the assigned TLOF and takes off as soon it receives departure clearance from the vertiport manager.

[4] https://www.anratechnologies.com/home/

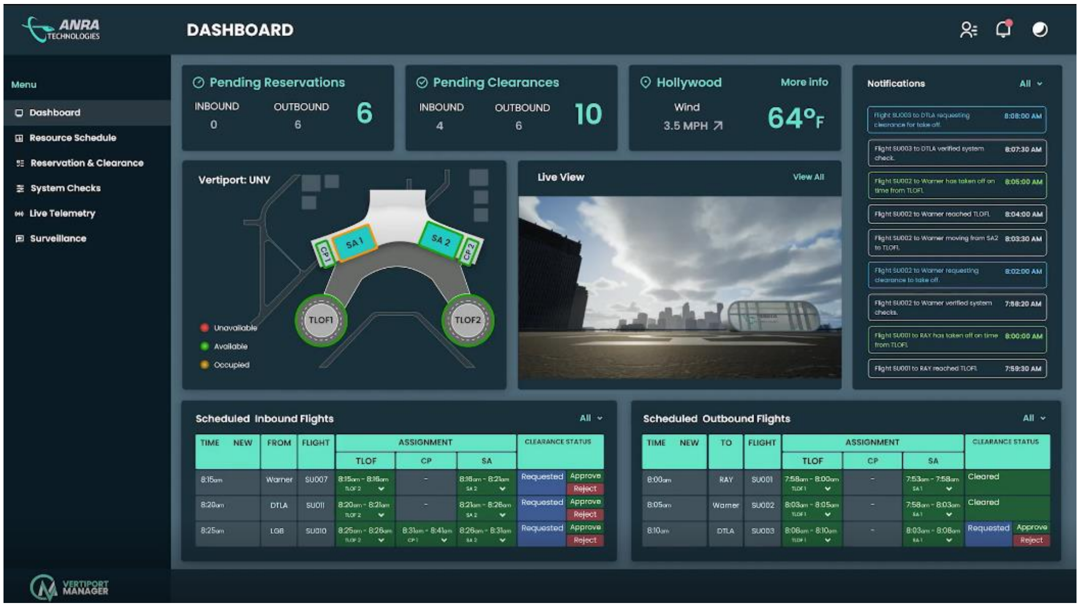


**Fig. 8 Vertiport Management System Dashboard**

## B. OneSky 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. PSU takes on the central role of being the primary service and data provider for UAM stakeholders [5]. It acts as the interface between the UAM ecosystem and the FAA. The PSU serves as a communication bridge between federated UAM actors, allowing seamless communication from one PSU to another via the network. This aids in supporting subscribing UAM operators to meet regulatory and operational requirements for UAM operations. Next generation traffic management systems produced by OneSky[5] provide the ability to show air space restrictions and changes in real time.

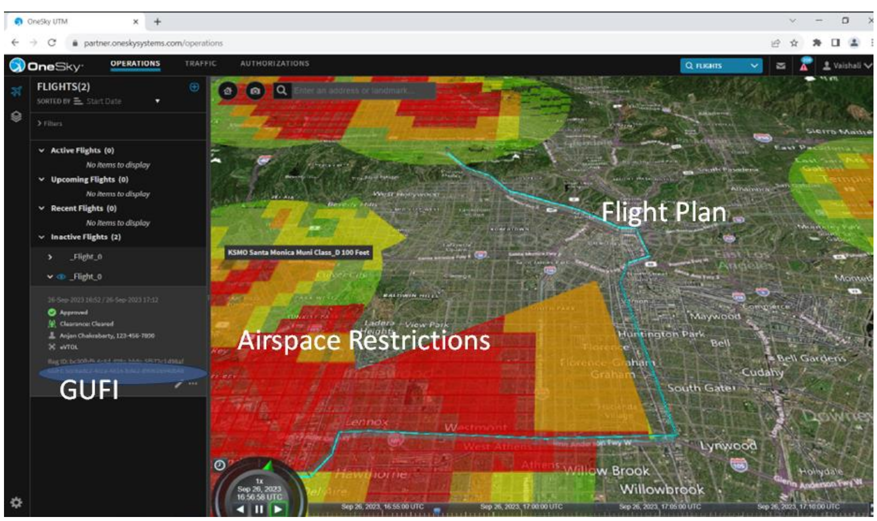


**Fig. 9 OneSky PSU displaying submitted flight plan along with airspace restrictions.**

[5] https://www.onesky.xyz/

The proposed flight route is submitted to OneSky as a flight plan (Fig. 9). These changes are communicated with all the network participants simultaneously keeping the system running at its most optimal state. OneSky analyzes and confirms that a submitted UAM Operational Intent is complete, consistent with current advisories and restrictions, and strategically deconflicted. It takes into consideration previously confirmed UAM Operational Intents, Cooperative Operating Practices (COPs), UAM Corridor capacity, airspace restrictions, vertiport resource availability, and adverse environmental conditions. Once approved, it assigns a Globally Unique Flight Identifier (GUFI) to the flight plan which can be executed in a simulation platform which continuously publishes telemetry information to OneSky, as depicted in the process flow diagram in Fig. 10. This allows tighter spacing, predictive capabilities, system adaptations to change, and streamlining operations that will avoid overburdening the existing FAA ATC system as UAM scales.

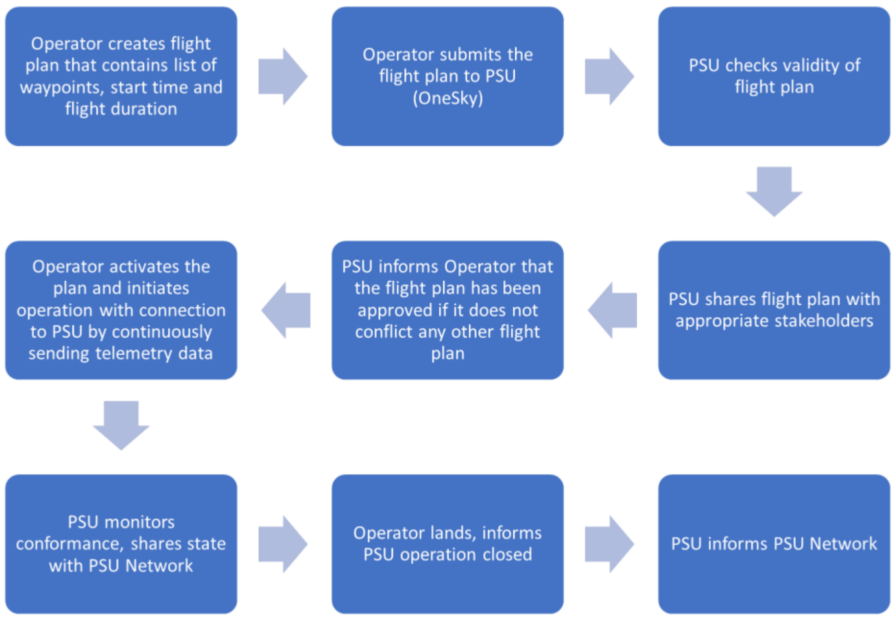


**Fig. 10 PSU process workflow**

Flight plans associated with 10 routes (Fig. 4) that connect the 6 vertiports (Fig. 2) and use the arrival and departure schedules as shown in Tables 1 and 2 are submitted to OneSky using their software programming framework. UNV, RAY, LGB and DTLA represent Universal Studios, Raytheon, Long Beach and downtown LA vertiport locations, respectively. The submitted flight plans, corridors associated with the routes and the approval status with respect to the current traffic can be visualized in the OneSky portal (Fig. 11).

**Table 1: Outbound traffic schedule from Universal Studios (UNV) vertiport**

| **Flight Reference Name** | **Aircraft Name** | **Destination** | **Departure Time** | **TLOF Time (minutes)** | **CP Time (minutes)** | **SA Time (minutes)** |
|---|---|---|---|---|---|---|
| UNV_RAY_01 | SU001 | Raytheon | 08:00:00 | 2 | 0 | 5 |
| UNV_Warner_01 | SU002 | Warner | 08:05:00 | 2 | 0 | 5 |
| UNV_DTLA_01 | SU003 | Down-Town Los Angeles | 08:10:00 | 2 | 0 | 5 |
| UNV_LGB_01 | SU004 | Long Beach | 08:15:00 | 2 | 0 | 5 |
| UNV_RAY_02 | SU005 | Raytheon | 08:20:00 | 2 | 0 | 5 |
| UNV_Warner_02 | SU006 | Warner | 08:25:00 | 2 | 0 | 5 |
| UNV_DTLA_02 | SU007 | Down-Town Los Angeles | 08:30:00 | 2 | 0 | 5 |
| UNV_LGB_02 | SU008 | Long Beach | 08:35:00 | 2 | 0 | 5 |

**Table 2: Inbound traffic schedule for Universal Studios (UNV) vertiport**

| Flight Reference Name | Aircraft Name | Origin | Arrival Time | TLOF Time (minutes) | CP Time (minutes) | SA Time (minutes) |
|---|---|---|---|---|---|---|
| Warner_UNV_01 | SU007 | Warner | 08:15:00 | 1 | 0 | 6 |
| DTLA_UNV_01 | SU011 | Down-Town Los Angeles | 08:20:05 | 1 | 0 | 5 |
| LGB_UNV_01 | SU010 | Long Beach | 08:25:00 | 1 | 10 | 5 |
| RAY_UNV_01 | SU014 | Raytheon | 08:27:00 | 1 | 10 | 5 |

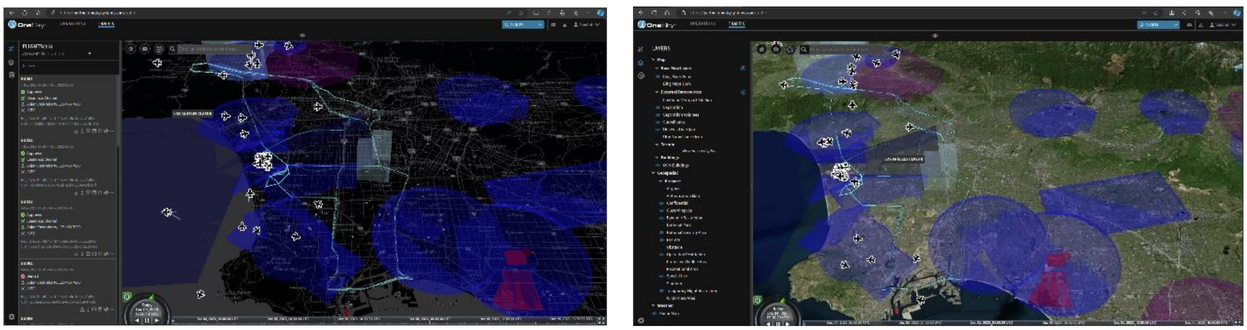

**Fig. 11 OneSky PSU displaying 10 routes connecting 6 vertiports.**

Once approved, they are activated for execution and simulated in Microsoft Airsim [13], concurrently publishing the telemetry data, that is, position information to OneSky (Fig. 12). This allows continuous conformance monitoring of the aircraft in the airspace. Along with it the conventional air traffic data in ADS-B format has been collected for 2 hours.

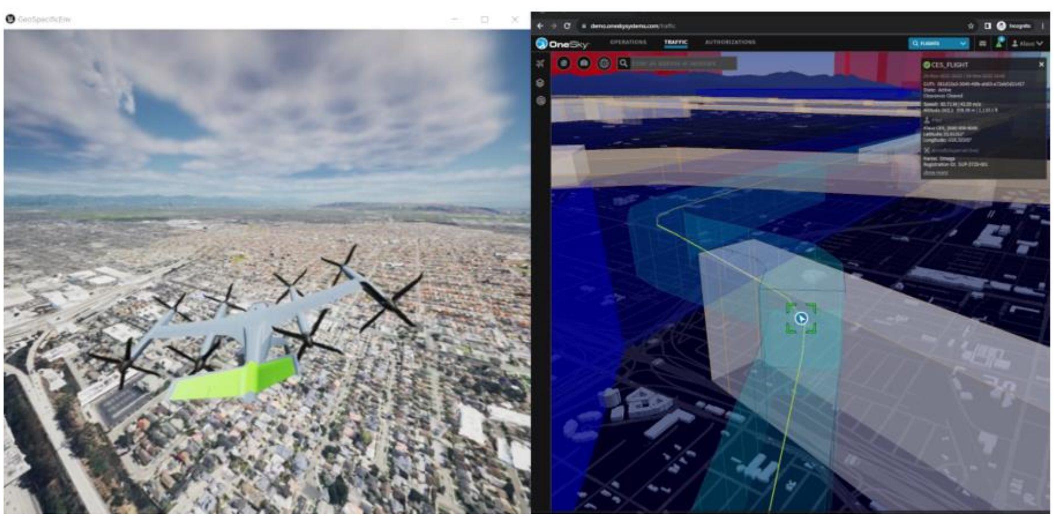

**Fig. 12 Airsim simulating the trajectory approved by OneSky (left side) and telemetry data streamed to OneSky displaying aircraft position within the reserved corridor (right side)**

## V. Analyzing the Impact of Conventional Air Traffic and PSU integration on UAM Network

FAA requires that the ATC must provide wake turbulence advisories to aircraft with less than 2,500 feet lateral or 1,000 feet vertical separation [4]. With the objective to have the least amount of conflict between UAM operations and conventional air traffic, and to minimize UAM aircraft interactions with ATC, these criteria were used to compare the proposed flight routes with ADS-B data to see how many of the 458 flights in the sampled time would conflict with the proposed routes.

While the proposed routes are defined using coarse waypoints, the ADS-B data is trajectory-based which is a refined set of flyable points once every 3 seconds. To save on time complexity, the data was sampled once every minute. The path connecting time-adjacent points is a line segment in 3-D space. To find out if the conventional air traffic was too close to the proposed routes, each ADS-B segment of the conventional flight was compared with each route segment of the proposed flight route. In most cases, the equation for the shortest distance between two-line segments in 3-D space would be sufficient. However, the shortest path between lines fails for a few edge cases since the vertical and lateral violation distances differ from each other. These outliers were handled by generating sample points along the compared flight segments and individually checking for violations between points on opposing segments.

**Table 3: Proximity of proposed flight routes with conventional air traffic (ADS-B data)**

| Name | Number of Warnings | Percentage Warnings |
|---|---|---|
| RAY_Warner | 107 | 23.362% |
| LAX_DTLA | 69 | 15.066% |
| DTLA_LGB | 16 | 3.493% |
| UNV_LGB | 12 | 2.620% |
| RAY_LGB | 9 | 1.965% |
| Warner_UNV | 8 | 1.747% |
| RAY_UNV | 5 | 1.092% |
| RAY_DTLA | 5 | 1.092% |
| Warner_DTLA | 5 | 1.092% |
| UNV_Warner | 3 | 0.655% |
| UNV_DTLA | 3 | 0.655% |

Table 3 contains the proposed flight routes that violate the separation clearance with respect to the conventional air traffic ADS-B data and generate warnings. However, it is noteworthy that while the ADS-B flight data are timestamped, the flight route is not. This analysis provides insight into planning the departure and arrival schedule of the proposed routes to strategically deconflict with the conventional air traffic according to regulations. Figure 13 showcases the route with maximum number of violations/warnings (white) due to proximity to ADS-B flights (red) as displayed by Google Earth [14].


**Fig. 13 Proposed "RAY_Warner" route interaction with conventional air traffic ADS-B data**

FAA provides System Wide Information Management (SWIM) data for all traffic over United States [9]. SWIM data was collected from 27th Feb 2022 and 5th March 2022 and the proposed flight routes were analyzed against the traffic pattern in the Los Angeles area. Figure 14 shows all the aircraft trajectories at 1500 feet mean sea level (MSL) (left side) and 5000 feet MSL (right side) for IFR traffic over Los Angeles. The vertical bars in the figure correspond to the airports in the Los Angeles area. Table 4 contains the proposed flight routes that violate the separation clearance with respect to the SWIM data that contained 15283 flights. The route, Raytheon to Waner (blue) with the maximum number of violations with the SWIM data (yellow and green) has been displayed in Fig. 15.

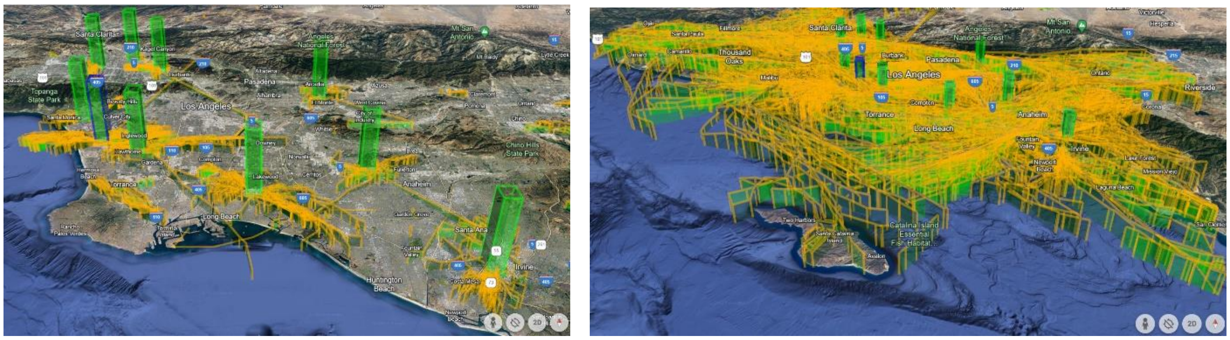

**Fig. 14 IFR Traffic Over Los Angeles at 1500 feet MSL. The Vertical Bars are the location of different Airports in Los Angeles.**

**Table 4: Proximity of proposed flight routes with conventional air traffic (SWIM data)**

| **Name** | **Number of Warnings** | **Percentage Warnings** |
|---|---|---|
| RAY_Warner | 3653 | 23.902% |
| RAY_DTLA | 1945 | 12.727% |
| RAY_UNV | 1935 | 12.661% |
| LAX_DTLA | 1205 | 7.885% |
| Warner_UNV | 383 | 2.506% |
| UNV_Warner | 170 | 1.112% |
| Warner_DTLA | 164 | 1.073% |
| UNV_LGB | 117 | 0.765% |
| DTLA_LGB | 94 | 0.615% |
| RAY_LGB | 46 | 0.301% |
| UNV_DTLA | 1 | 0.007% |

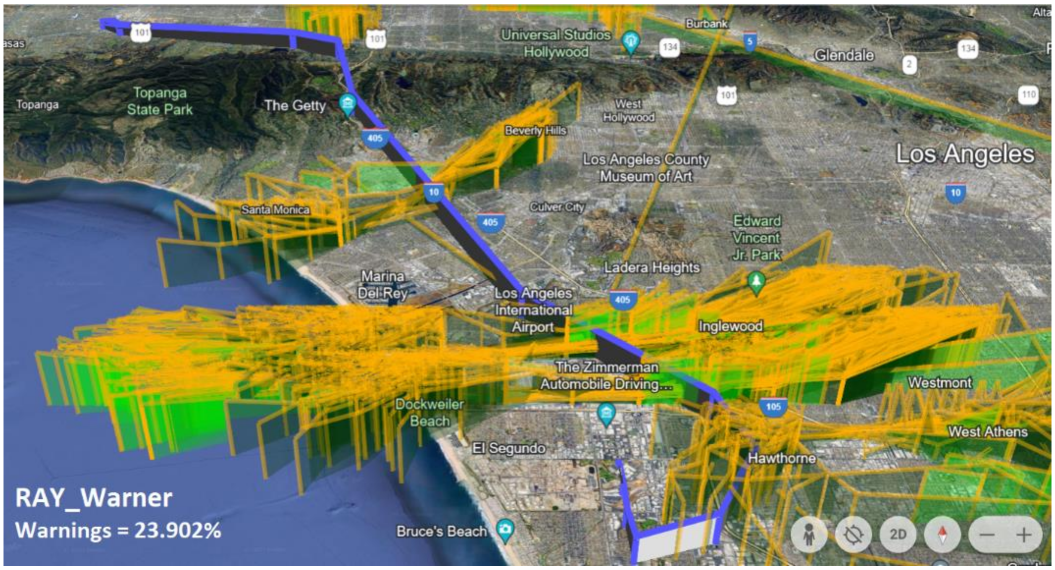


**Fig. 15 Proposed "RAY_Warner" route interaction with conventional air traffic SWIM data**

Integration with the PSU reports the flight plans that are denied approval due non-conformance with other flight plans. The routes connecting the 6 vertiports were submitted to OneSky PSU as per the time schedule listed in Tables 1 and 2. Five of them were denied approval due to conflict with the existing air traffic. The trajectory associated with the route connecting Raytheon and Universal Studios (SU014) was simulated in Airsim transmitting telemetry data to OneSky which reported non-conformance whenever it deviated from the submitted flight plan (Fig. 16). The non-conformance was mostly around sharp turns where the trajectory and the submitted flight route were different. This can be avoided by submitting a more refined flight plan that captures the flyable trajectory around the turns.

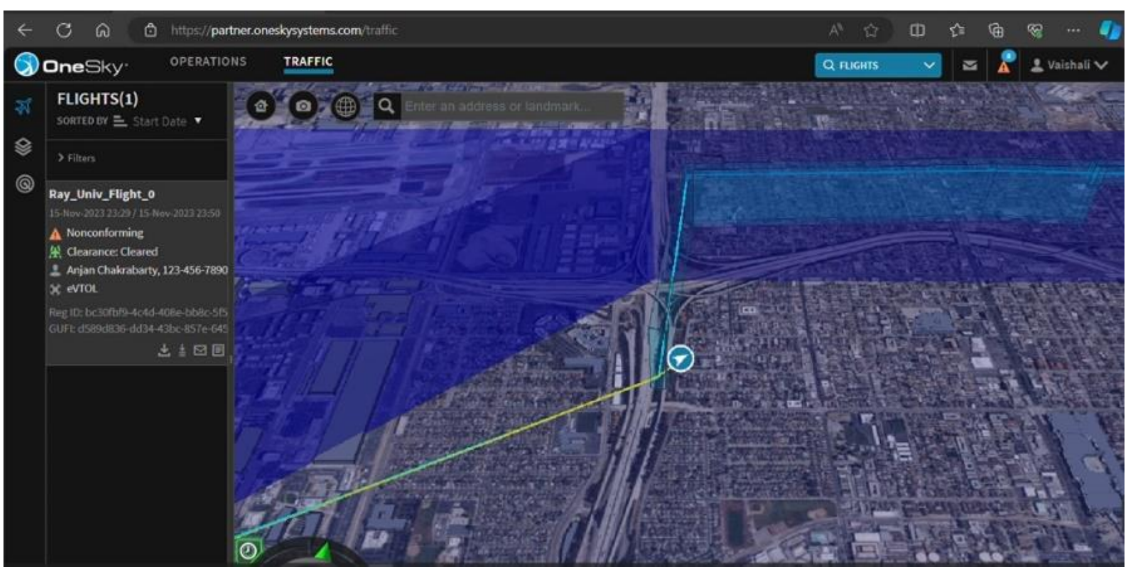


**Fig. 16 OneSky PSU reporting non-conformance**

## VI. Conclusion

This paper analyses the complexities in designing corridors in Los Angeles. The paper utilizes established helicopter routes to design UAM corridors in LA which can be approved by FAA. Routes are constrained by vehicle performance and conventional air traffic. The paper utilizes several concepts introduced by NASA to design approach and departure procedures in and out of the vertiports. The routes were tested in our high-fidelity simulator and connected with our Ecosystem partners Onesky (PSU provider) and ANRA (Vertiport Management System.) The paper shows a working ecosystem network that needs to be developed for introducing UAM vehicles. The developed routes were tested against conventional legacy traffic and each route was evaluated with proximity to legacy operations in LA.

The proposed routes need to be tested in FAA simulators before being approved by FAA. Several flight tests should be conducted using LOA with all the airports in LA before these routes can be used in practice. Supernal is also working with different micro weather and communication providers which will be critical for UAM missions.

## VII.Acknowledgments

The work presented in this paper has been contributed by City Activation Group and Integrated Simulation Systems team at Supernal, OneSky and ANRA. The author acknowledges the contribution of each and every person who has contributed through several discussions and engagements.

## References

[1] FAA Concept of Operations V2.0 Urban Air Mobility (UAM), Federal Aviation Administration, Washington, D.C., 2023.
[2] Hill, Brian P., et al. "UAM Vision Concept of Operations (ConOps) UAM Maturity Level (UML) 4.", 2020.
[3] Advanced Air Mobility (AAM) Implementation Plan, Near-term (Innovate28) Focus with an Eye on the Future of AAM, V1.0, Federal Aviation Administration, Washington, D.C., 2023.
[4] Federal Aviation Administration (2014b), FAA Order JO 7110.65V, Air Traffic Control. Washington, DC: Federal Aviation Administration: Department of Transportation.
[5] High-density Automated Vertiport Concept of Operations, Northeast UAS Airspace Integration Research Alliance (NUAIR).
[6] Mueller, E., Kopardekar, P., and Goodrich, K., "Enabling Airspace Integration for High-Density On-Demand Mobility Operations," 17th AIAA Aviation Technology, Integration, and Operations Conference, Paper 2017-3086, June 2017.
[7] Keeler, J., Verma, S., and Edwards, E., "Investigation of Communications Involved in Near-term UAM Operations," 38th IEEE/AIAA Digital Aviation Systems Conference, September 2019, pp. 2018-3676.
[8] Dulchinos, V., Verma, S., Wood, R.B., Farrahi, A., Mogford, R., Shyr, M., and Ghatas, R., "Design and analysis of corridors for UAM operations." 2022 IEEE/AIAA 41st Digital Avionics Systems Conference (DASC). IEEE, 2022.
[9] Meserole, J. S., and Moore, J.W. "What is system wide information management (SWIM)?." 2006 IEEE/AIAA 25TH Digital Avionics Systems Conference. IEEE, 2006.
[10] Snelling, B., and Baccheschi, N. (2023). Airspace Automation Flight Tabletop Exercise (No. AAM-NC-113-001).
[11] Homola, J., et al. "Missed Approach Procedures in Advanced Air Mobility: Conceptual Exploration." AIAA AVIATION 2023 Forum, 2023.
[12] Gonzaga-Lopez, C. "Design of Rotorcraft Performance-Based Navigation Routes and Procedures: Current Challenges and Prospects," Journal of Aviation Technology and Engineering 10:1 (2021) 2–11, 2021.
[13] Airsim ver 2023.6.16, Microsoft and Community, Mountain View, CA.
[14] Google Earth ver 10.42.0.1. Google, Mountain View, CA.
[15] Zahn, David, Ryan Naru, Andrew Guion, and Sarah Eggum. UAM Instrument Flight Procedure Design and Evaluation in the Joby Flight Simulator. No. AAM-NC-115-001. 2023.