August 16, 2023

Carlos Monje
Under Secretary for Policy
U.S. Department of Transportation
1200 New Jersey Ave., S.E.
Washington, D.C. 20590

RE: U.S. Department of Transportation; Notice and Request for Information
Request for Information on Advanced Air Mobility
Docket No. DOT-OST-2023-0079 (May 17, 2023)

Dear Under Secretary Monje:

The American Association of Airport Executives (AAAE), the world's largest professional organization for airport executives, appreciates the opportunity to provide its feedback and perspectives in response to the U.S. Department of Transportation's (DOT) notice, "Request for Information (RFI) on Advanced Air Mobility."[1]

As a representative of over 9,000 members from nearly 875 public-use commercial service and general aviation (GA) airports, we have been significantly engaged in advanced air mobility (AAM), a relatively new concept of air transportation using electric vertical takeoff and landing (eVTOL) aircraft to transport cargo and passengers between rural, suburban, and urban markets. From the outset, AAAE has supported the safe integration of AAM operations into the National Airspace System (NAS) because of the potential for these operations to open new markets, stimulate economic activity, and advance key environmental sustainability goals by reducing emissions and noise. We also specifically supported the AAM Coordination and Leadership Act, which Congress passed in 2022 and requires the newly formed AAM Interagency Working Group (IWG) to develop a national strategy for AAM.[2]

The objective of our comments is to communicate our airport members' perspectives for the purpose of helping the AAM IWG develop its national strategy and ensure the federal government is taking effective steps to promote the growth of the new AAM industry. There are some key takeaways that are worth emphasizing at the outset.

While many airports have begun conducting preliminary planning exercises and analyses on how they could accommodate or support AAM operations, there are major obstacles

[1] 88 Fed. Reg. 31,593 (May 17, 2023). DOT extended the deadline to respond to August 16, 2023. Request for Information on Advanced Air Mobility; Extension of Comment Period, 88 Fed. Reg. 41,715 (June 27, 2023).
[2] Pub. L. No. 117-203, §2(f), 136 Stat. 2227, 2229.

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preventing airports from making investments and taking more meaningful steps. These include a limited supply of electrical power to meet future demand from AAM operations; questions surrounding the viability and reliability of future AAM commercial operations; and a lack of guidance from the Federal Aviation Administration (FAA) on how to safely integrate these AAM operations into their facilities. Airports have numerous capital development projects planned for the next 5 to 10 years. To ensure AAM-specific infrastructure is prioritized, our members need clear guidance and reliable operators to ensure that any investment made in such operation will be returned to the airport and benefit its community and users.

AAAE's Response to DOT's RFI on AAM

In its May 17 RFI, DOT solicited comments to twenty (20) separate topics that the AAM IWG's subgroups deemed important. We limited our response to the topics where our organization can provide expertise. As a result, AAAE is pleased to provide the following response to DOT's request, organized in accordance with the topics outlined in the RFI.

1. **Most Likely Use Cases: What are the most likely use cases for AAM in the short, medium, and long term, along with high-level estimations of when these use cases may come to market? Also, what government actions could enhance or inhibit those market timelines? Are there use cases that are a national priority?**

As an organization representing the airport industry, we cannot provide any opinions or feedback on the most likely use cases for eVTOL operators and when they might come to market. We respectfully defer to the operators and companies trying to launch such operations for their plans and timelines. However, we did survey our airport members to determine what types of use cases and applications airports expect to support or accommodate in the future. Unsurprisingly, our members' responses largely depended on the size of the airport and the local community or region they serve. However, the use cases cited fall into three general categories:

- Short distance cargo deliveries where efficiencies could be gained through eVTOL operations rather than driving or ferrying cargo (for airports serving an island);
- Regional and local passenger-carrying services (e.g., intracity travel, connecting passengers to or from an airport, passenger resort shuttle network, transporting workers to and from offshore oil platforms); and
- Other operations that currently utilize traditional helicopters (e.g., agriculture operations, crop dusting, pipeline inspections, medical emergency flights).

2. **Safety Enhancements: Understanding that safety must be the key component of any future AAM operations, provide information on how new concepts in aviation, such as automation and new forms of navigation-enabling infrastructure, provide for, or even enhance, the level of safety of operations.**

In the AAM Coordination and Leadership Act, Congress defined AAM as a transportation system that moves people and property by air using "aircraft with advanced technologies, including electric aircraft or [eVTOLs] . . . ."[3] DOT observes that one of the defining characteristics of AAM-specific aircraft is the electric propulsion component and vertical or short takeoff and landing capabilities. In the long run, some of these eVTOLs may incorporate more automation into flight controls and other parts of the aircraft. From an airport perspective, we cannot identify any specific feedback regarding how new aviation concepts associated with AAM operations may provide for or even enhance the existing level of safety. We recognize that FAA has exclusive authority over all aviation safety aspects of AAM integration, including operating rules, aircraft certification, and pilot certification. Thus, our members expect that FAA has established, or will establish, sufficient certification standards that ensure an equivalent level of safety as existing operations.

Notwithstanding, AAAE expects that AAM will introduce at least one additional risk in the airport environment. Specifically, electric propulsion presents new and unique hazards for emergency response and aircraft rescue and firefighting (ARFF) personnel at airports. Firefighters and emergency managers are already trying to better understand how to respond to lithium-ion battery fires, both onboard and off-board aircraft. In FAA's engineering brief on vertiport design, the agency noted that the firefighting techniques for VTOL aircraft are still unknown and may differ from one eVTOL to another.[4] ARFF and emergency response protocols for electrical propulsion will certainly be a risk that will require additional training for personnel. We strongly urge FAA to address this gap in guidance.

3. **Expected Customer Experience: Information about AAM regarding scheduling and ticketing a flight, arrival at a vertiport, passenger and baggage screening, flights boarding, and flight and postflight experience.**

AAAE recognizes that DOT's inquiry focuses on the entire range of potential phases of the customers' AAM experience. This would include scheduling and ticketing a flight, arrival at a vertiport, passenger and baggage screening, boarding of flights, assistance available for passengers on board the aircraft or on the ground, expected level of comfort in the cabin, heat ventilation and air quality, cabin noise, and any post-flight procedures. As an organization representing airports, we cannot opine on the customer's experience with any specific future AAM operator or a vertiport that is not managed by an airport sponsor.

For vertiports that are located on airport property, most of our members expect that AAM operations to and from the vertiport would occur either at (a) dedicated facilities similar to a fixed-based operator (FBO) or an operation under 14 C.F.R. Part 135, or (b) a location on the unsecured landside portion of the airport. It is unlikely that these operations would occur on or near a commercial airport terminal in the short to medium term. We anticipate that AAM passengers would be screened by the operator, similar to how existing charter operations vet

[3] §2(i)(1), 136 Stat. at 2229.
[4] Federal Aviation Administration, Engineering Brief No. 105, Vertiport Design, at 46 (2022).

their passengers. If the AAM operation is destined for an airport, the aircraft would land at a location away from the terminal. The passenger would then transition from their eVTOL flight to a secured terminal for a traditional airplane flight and their destination. The downside is that passengers would have to take a shuttle or other means of transportation to reach the airport terminal, which may lower the value proposition of taking the initial eVTOL flight.

We understand that there may be a perception that AAM passengers can arrive on the roof of an airport terminal and easily access the airport terminal. However, there are a few major obstacles associated with implementing that model:

- *First*, allowing an eVTOL to land on an airport terminal or immediately adjacent to an existing terminal could introduce a wake turbulence safety risk depending on the airport environment and its configuration. Airspace integration and airfield design at each airport would need to be carefully evaluated and executed to avoid these risks. Mitigation measures, however, may not be possible without significant costs.

- *Second*, airports would need to make substantial capital improvements to upgrade their terminals to support a seamless customer experience from a local AAM operation to a traditional passenger-carrying flight from a terminal. The significant investment required makes such a concept more of a long-term possibility after the AAM proof of concept and value proposition have been demonstrated.

5. **Statutory and Regulatory Scheme: Information about specific statutes, federal regulations, or other legal authorities that could be created or updated to support AAM in the United States and maintain the regulatory agility necessary to safely enable this new form of transportation.**

AAAE believes there are two recommendations that the AAM IWG should consider including in its report and national strategy. *First*, we have urged Congress to ensure that AAM operators, along with other new entrants, are paying their fair share for the costs of air traffic control (ATC) services and the infrastructure needed to accommodate their operations. This could include, for example, a fee based on the amount of electric charge, akin to a fuel tax, and/or a ticket fee for passenger-carrying operations. *Second*, many of our members have expressed support for a federal grant program that would support the development of vertiport infrastructure across the country. We believe the program, if recommended, should be funded by a source separate and independent from the Airport Improvement Program (AIP). Demands on AIP already vastly exceed the amount of funding made available on an annual basis, and the program is critical for supporting and maintaining existing airport infrastructure.

6. **Role of State, Local, Tribal, and Territorial Governments: Information about the role that state, local, tribal, and territorial governments should play in enabling AAM in the United States.**

AAAE does not anticipate any major changes to the existing roles and responsibilities associated with managing the current aviation system. The federal government, including FAA, needs to maintain and exercise its exclusive authority over aviation safety, including operating rules, aircraft certification, and pilot certification, and ensure the efficient use of airspace and safe integration of AAM operations. FAA should also have the primary responsibility for developing performance-based design standards for vertiports and ensuring there are clear processes and guidelines for airports that want to pursue the development of an on-airport vertiport. AAAE has also promoted federal funding opportunities for vertiports and other regional AAM planning initiatives, similar to the Advanced Air Mobility Infrastructure Pilot Program, which authorized $25 million over two years for planning grants to assist in the development of vertiport infrastructure.[5] We believe the funding source, however, should be independent of AIP, which is already very oversubscribed on an annual basis.

States should focus on enacting laws authorizing appropriate zoning and land use at the local level and help with the planning and development of a regional, multi-modal infrastructure system. Local governments should focus on implementing zoning and land use laws and determining suitable sites and locations for vertiports and associated AAM facilities. Similar to airports now, local governments may become operators of vertiports, either in a standalone form or co-located with an existing airport. Both state and local governments will have to work together on determining how to meet power demands from AAM operators. While local governments and airports have taken a significant role in community engagement, we believe that this should be a shared responsibility and FAA needs to take a more active role in such engagement to ensure public acceptance, especially with air traffic and airspace integration and noise related concerns.

7. **Anticipated Power Requirements: Information about the anticipated demand on power grids by AAM, the ability of municipal power grids to accommodate this anticipated demand, and improvements or investments in power infrastructure needed to enable such operations.**

The anticipated power requirements needed for AAM operators is an issue that is being extensively discussed within the airport community and as part of the broader national conversation about electrification. In response to a survey, the overwhelming majority of airports reported that they do not have the electrical capacity to support these new aircraft because of all the other competing demands for such power, including electric ground support equipment (GSEs), rental car companies moving to electric vehicles (EVs), and charging stations in parking facilities for the general public's EVs, among other things. Airports reported that they are already struggling to meet the demand for EV charging stations, and AAM would strain limited capacity. The lack of electrical capacity was the most consistent challenge cited by airports on what types of barriers exist for AAM implementation.

[5] Consolidated Appropriations Act, 2023, Pub. L. No. 117-328, § 101, 136 Stat. 4459, 5246.

We would also underscore that most airports do not control their local power grids, which are managed by separate and independent utility companies. Many airports have begun engagement with these companies to determine how to supply more power to meet the needs of their users. These members, however, report that this is a lengthy and costly process. Some airports noted that they are exploring micro-grids and solar farms to potentially augment power generation until more permanent solutions or investments can be made. Investments in expanding or upgrading the power grid can be very high—in the millions of dollars depending on the region and amount of capacity needed. Concerns have been expressed by airports over the ability to meet current and future demands and who would be expected to fund these substantial investments, especially for AAM and operations that are unproven at this stage.

It is important to note that each airport is unique and the ability for airports to meet growing electrical demands in the future depends on a variety of factors. Last year, AAAE's ACT Program formed an AAM Working Group that consisted of airports from across the country, Joby Aviation, and airport planning experts.[6] The group developed an AAM white paper that examined in detail how eVTOL operations could be integrated into four different airports of all sizes, including the ability to provide electrical capacity for these operations.[7] For the SJC and PHX case studies, the analysis showed that meeting the power demands for AAM operators would be challenging. For example, SJC noted that the airport did not have sufficient infrastructure to support large-scale charging of airline GSE, so setting up charging facilities for eVTOL aircraft would require a large capital investment.

We highly encourage the AAM IWG to review the white paper, which we have attached as Exhibit "A." The document addresses the many considerations and issues associated with integrating AAM operations into airports, including unique local factors and more specifics on power demands through the four case studies.

12. **<u>National Security and Aviation Security Implications</u>: Information about the national security implications of accelerating AAM, specifically how physical security of passengers and cargo should be addressed and who should bear responsibility for security assurances, security and system resilience, and what threats exist.**

For any AAM operations that occur at a vertiport located at or on airport property, we believe that physical security of passengers and cargo will depend on how the vertiport's operations are integrated into the airport environment. As described above, most airports envision that AAM operations would occur either at (a) dedicated facilities similar to an FBO or Part 135 operation, or (b) a location on the unsecured landside portion of the airport. If

[6] The program provides a collaborative forum for airports, industry partners, and others to address innovative and future-focused topics, such as AAM.

[7] American Association of Airport Executives, ACT Program, Advanced Air Mobility (2022). The four airports included Eagle County Regional Airport in Gypsum, Colorado (EGE); Eugene Mahlon Sweet Field in Eugene, Oregon (EUG); San José Mineta International Airport (SJC); and Phoenix Sky Harbor International Airport (PHX).

managed similar to a Part 135 operation, we believe that the AAM operator would be responsible for ensuring the security and safety of passengers and cargo. If passengers are arriving at the airport from the landside or need to be transferred to the terminal, they would be screened by the Transportation Security Administration (TSA) in the same manner as traditional airport passengers.

There may be different scenarios depending on the airport and how AAM operations are integrated into that environment. For example, if an airport does allow an AAM operation to drop passengers off in the secure area of the terminal, those passengers would have be pre-screened at their departure point in order for that to occur. While that may simply be another airport terminal with a TSA screening process, the operation may also originate from an off-airport vertiport. If no pre-screening occurs prior to departure, those passengers should arrive in the unsecured portion of the airport and proceed to TSA screening. To be clear though, our members believe that most AAM operations will occur on the landside or at a portion of the airport where airline and traditional passenger activity does not occur, which would require a transfer of any AAM passengers to the airport's terminal where the normal TSA screening process applies.

13. <u>Vertiport Development and Operations</u>: Information about the expected role of governments and private industries at all levels as to the development, funding, and operation of vertiports. The AAM IWG seeks information on whether system planning similar to the National Plan of Integrated Airport Systems (NPIAS) should exist for vertiports, and what level of coordination is required for effective vertiport planning and use.

FAA should be responsible for establishing performance-based vertiport design standards, guidance for airports and local governments to determine appropriate locations for vertiport siting, and airspace and air traffic planning around vertiports. These responsibilities would help ensure consistency and the safety of AAM operations throughout the NAS. We expect that state and local governments and private entities will all be interested in developing, funding, and operating vertiports in some form. Our members do believe that FAA or the federal government should have some involvement in helping fund and develop vertiport infrastructure. However, the source of this funding should be separate and independent from AIP funding, which is already very oversubscribed and being used to support and maintain existing airport infrastructure.

Whether FAA should be responsible for nationwide planning—similar to the NPIAS—depends on a few factors. We think a similar planning process for vertiports would be prudent if such an effort was necessary to ensure the safe and efficient use of the NAS and if there was a separate funding program available for vertiport development (again, independent of AIP). Most of the identified AAM-use cases are expected to be regional or local in nature. FAA's involvement in regional and local planning of vertiport infrastructure—in coordination with regional transportation planning organizations—may help address potential conflicts with traditional airport operations and ensure the safe and efficient use of the airspace, especially if the agency developed guidelines to help with vertiport siting determinations.

Moreover, FAA's NPIAS process identifies airports that are necessary for the national airport system, making that airport eligible for federal funding. It also helps Congress and FAA understand and estimate airport development needs. FAA's NPIAS and systemic planning process also requires close coordination between the agency and the airport, including sharing of capital development and planning documents. Vertiports may be operated privately and/or may not want to share such planning information with FAA, especially if no funding opportunities or regulatory requirement to do so exists. In short, without federal funding, the value of a NPIAS-like process for vertiports is less clear. And in that case, we would urge FAA to create a new systemic planning program that focuses on ensuring off-airport vertiport siting and development does not disrupt existing aircraft operations.

20. <u>Other Areas of Interest</u>: Respondents are encouraged to identify areas that are not directly identified or not adequately expressed for which inter-governmental coordination is critical to the success of AAM ecosystem.

We understand that the AAM IWG will be producing a comprehensive national strategy with a focus on interagency, multi-modal, global leadership, and intergovernmental cooperation issues. The stated objective is to, among other things, identify <u>challenges</u> that must be overcome by federal agencies for a successful AAM system to develop in the United States. DOT and the group also encouraged feedback on any existing barriers to success for AAM implementation. While many airports have begun conducting preliminary planning exercises and analyses on how they could accommodate or support AAM operations, there are major obstacles preventing airports from making investments and taking more meaningful steps. These include:

- *Questions surrounding the reliability and/or viability of AAM commercial operations*. The eVTOLs being evaluated under FAA's aircraft certification process are not expected to be operated in instrument meteorological conditions (IMC), which could limit their commercial value. There is an uncertain timeframe for FAA to certify and allow AAM operations on a wide scale, especially from an air traffic and airspace integration perspective. These factors, along with an unproven business model, create some uncertainty as to how much demand there will be for AAM operations.

- *Lack of specificity from FAA and AAM operators regarding what type of support and infrastructure investment is needed from airports*. Airports often have numerous capital development projects that are planned over the next 5 to 10 years. These projects take years to complete, especially for organizations that run extremely complex operations centered on safety. Airports need clear FAA guidance and a reliable and long-term operator to ensure proper planning and that any investment made in such operation will be returned to the airport and benefit its community and users.

- *Lack of electrical capacity at airports to scale and meet AAM operator demand*. The significantly increased demand from airport users for electrical capacity has well exceeded existing supply and is becoming one of the biggest challenges for the industry. The nationwide consumer movement toward EVs is leading rental car companies and other users to request charging stations and other electrical infrastructure. Absent a substantial investment in the power grid, AAM operators are competing with other users for a limited supply of power.

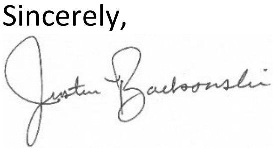
- *Questions surrounding community and public acceptance*. Some AAAE members noted that their communities are unlikely to embrace AAM as a mode of transportation if, for example, flight paths are not designed through community engagement, noise concerns arise, or eVTOLs are primarily used for wealthy individuals. Community engagement and public acceptance of AAM operations should not be understated and should be a shared responsibility between federal, state, and local governments and operators.

Again, we are supportive of AAM and the safe integration of these operations into the NAS and our airport environments across the country. We want to make sure the AAM IWG has a firm understanding of the challenges and barriers, as seen from the airport community, to inform their deliberations and recommendations for the national strategy.

* * *

AAAE appreciates the opportunity to provide comments in response to DOT's request for information. Please do not hesitate to reach out if you have any questions or require any additional information. I can be reached at justin.barkowski@aaae.org or at (703) 824-0504.

Sincerely,



Justin T. Barkowski
Vice President, Regulatory Affairs

EXHIBIT “A”

ADVANCED AIR MOBILITY

AIRPORT CONSORTIUM ON CUSTOMER TRUST

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Introduction

eVTOL Background

The Airport Consortium on Customer Trust (ACT) program provides a collaborative forum for airports, industry partners, and other interest partners to address innovative and future-focused topics with research for airports in preparation for the future. One such topic is Advanced Air Mobility (AAM), and a working group was assembled to prepare for this new technology. The AAM working group was divided into three subgroups – Small/Non-Hub, Medium Hub, and Large Hub – to study how each size airport could accommodate AAM and potential offsite locations. Significant investments have been made to advance the design and manufacturing of electrical Vertical Take Off and Landing vehicles (eVTOLs). Companies with eVTOLs in production include Joby Aviation, Beta, Archer, Volocopter, Lilium, Wisk, Supernal, and Jaunt Air Mobility. The range and capacity of the various models vary significantly. Some are piloted, others are not. Some are designed for cargo. Most likely, initial operations will use piloted aircraft. Future operations may utilize remote piloted aircraft and, ultimately, autonomous aircraft.

- Because eVTOLs are less expensive to operate than helicopters and do not have the severe noise footprint of helicopters, the demand for this service is expected to be high.
- As urban traffic delays build, the demand for reduced trip time grows.
- For regional trips, total trip time using eVTOL can be significantly less than the total time spent in commercial airport processing plus travel.
- Cities are eager for more sustainable transportation modes. Zero emission operations of eVTOLs and adaptive reuse of existing parking lots and helipads both support this goal.
- United Airlines, American Airlines, UPS, and Exxon have placed advance orders for eVTOLs, confirming the value of this type of aircraft and its associated service.

State or local reviews of AAM models will entail a broad range of issues, including safety, noise, multimodal connectivity, equity, sustainability, workforce development, and economic growth. The two main issues from an infrastructure standpoint are power requirements (long lead equipment) and fire safety (lithium batteries).

Once the vehicles and operations are certified by the FAA, the introduction of these vehicles into the National Airspace System (NAS) ranges from relatively simple (Class E and G airspace) using existing helicopter routes, to complex (entering, operating, and exiting Class B, C, or D airspace) while maintaining separation and wake turbulence protection. Further, the scalability ultimately will require new air traffic systems and procedures.

A recent GAO report (GAO-22—10520 Transforming Aviation, May 2022) states that a "highly automated air traffic control system, micro-scale weather sensing and forecasting, resilient communications…." will be required (GAO page 18). NASA, with cooperation from Dallas Fort Worth International Airport, NASA's Ames Research Center, Langley Research Center, and Joby, evaluated five use cases for flights operating both in uncontrolled air space and controlled air space (NASA-TM-20220009944, June 2022).

There is significant federal interest in AAM. Both the U.S. House and Senate have passed bills that would help communities prepare for and develop the necessary infrastructure to facilitate AAM technologies. The bills passed with strong bipartisan support for the future of AAM and its safe integration into the national airspace system. Senate Bill 516 became public law No. 117-203 on October 17, 2022 and can be found at http://www.congress.gov/bill/117th-congress/senate-bill/516/actions. At the August 3, 2022, White House AAM summit, Acting FAA Administrator Billy Nolen stated that, "We're looking at every aspect of this enterprise – the vehicle itself, the framework for operations, access to the airspace, operator training, infrastructure development, and community engagement." He mentioned that two operators are expected to receive certification in 2024 and are believed to be Joby and BETA. Last, U.S. DOT, states, and cities have stated goals of increasing global competitiveness, and AAM is the obvious path to achieve these goals.

An additional recent development is the Boeing-Wisk Concept of Operations document, and it can be found at www.boeing.com/innovation/con-ops.

Overview of AAAE ACT Working Group on Advanced Air Mobility

AAAE members utilized the ACT working group model to address current planning efforts for AAM. The AAM working group co-chairs are Judy Ross, A.A.E. of SJC, and Greg Dyer of Woolpert. Woolpert was the lead consultant, and Joby Aviation participated as an Original Equipment Manufacturer (OEM). Within the AAM working group there were three airport subgroups based on size: Small/Non-Hub, Medium Hub, and Large Hub.

Assumptions

Use Cases

There is currently much speculation on eVTOL use cases, but details are insufficient for the requirements of the planned development beyond first-level efforts, which are characterized as operating much like helicopters today. These operations depend on visual weather conditions in which pilots determine the flight paths in conjunction with air traffic control instructions.

A foundational statement about use cases is that eVTOLs will prioritize markets that have high-density modes of transportation that can be utilized throughout the day, not just during rush hours. The primary goal is to connect areas where people gather to business centers and airports, and to develop Touchdown and Liftoff Area (TLOF) locations where aircraft can arrive with passengers and depart with new passengers. Deeper discussion on the expected use cases ranged from airport-specific markets to technology-based constraints.

Each airport in the case studies was able to identify opportunities for eVTOL operations.

The subgroups discussed many options for vertiport locations at an existing airport. The ideal location for a vertiport varies significantly based on the use case. Whether the footprint of the vertiport is designed to be like a helipad, or in accordance with the FAA's draft Advisory Circular EB105, the dimensions of a TLOF can be accommodated at several locations at each of the studied airports (the final Vertiport Design Engineering Brief 105 was issued on September 21, 2022, after the conclusion of the work of the case study teams). The FAA Engineering Brief can be found at www.faa.gov/airports/engineering/engineering_briefs/engineering_brief_105_vertiport_design.

Therefore, the workgroup discussions hinged on the definition of the use cases.

Low Operational Pace

Some in the industry are suggesting the initial plans for eVTOL operations should be thought of as simple helicopter operations. Typically, existing airports accommodate helicopter activity via arrival and departure flight paths that are perpendicular to fixed wing traffic patterns, and they operate outside of the runway footprint. If we assume a flight path along these lines for the first several miles, with a TLOF at an existing FBO, all the airports in the subgroup case studies could accommodate a small range of visual weather conditions, like helicopter operations.

Medium Operational Pace

Several recent industry studies have noted an ideal ratio of parking spots to TLOFs is in the range of 4-10 to 1. This is based on predicted operational timing, which is based on turnaround time for an eVTOL to land, unload, take on new passengers/payload, and depart. With this ratio, eVTOL #1 could land and taxi to parking, allowing other vehicles to taxi to use the TLOF with several more arriving in between departures, eVTOL #1 then could charge for approximately an hour and be ready to depart again.

As use cases emerge that optimally keep eVTOL vehicles moving, this TLOF-to-parking ratio will help to define the capacity of the eventual vertiport.

At this medium operational pace (adding 4-10 parking spots per TLOF), all the subgroup case studies could accommodate at least one single TLOF plus parking. However, it was noted that as a TLOF reaches full operational throughput, the need for scheduling and coordination via air traffic control or an automation system to ensure evenly spaced arrival demand becomes important, as battery-powered vehicles will not have a high tolerance for operational queuing while waiting for an available TLOF.

High Operational Pace

Very high operational pace eVTOL operations were not evaluated deeply by the subgroups. The anticipated pace for large-scale manufacturing to begin, along with the support infrastructure of people and facilities, means there will be time to learn from the small and medium operationally paced data and experience to inform larger throughput designs. It was noted that in addition to the physically larger footprints of multiple TLOFs with the proportional needs for parking, once a high operational pace is possible there will be higher expectations for connecting vertiports to the traditional airport terminal space. Planning for such a facility and cross-airfield access or terminal-adjacent access is a more complex design challenge than the subgroups can address with current information.

Participants

Each subgroup provided detailed analyses of vertiport functions on the represented airport(s).

The airports included:

- **Small and Non-Hub:** Eagle County Regional Airport in Gypsum, Colorado, and Eugene Mahlon Sweet Field in Eugene, Oregon
- **Medium Hub**: Norman Y. Mineta San José International Airport
- **Large Hub**: Phoenix Sky Harbor International Airport
- **Off-Airport Site**: General Site

Data Collection

Methodology

In addition to a defined outline that was provided to each subgroup to address, the subgroups were asked to consider the most likely locations for vertiports at their focus airport(s). The subgroups reviewed considerations such as airspace, airport land availability, electrical capacity and accessibility, lease considerations, and use cases.

The subgroups assessed available information regarding use cases and the emerging details of vehicle performance characteristics. As the platforms by Joby and Lilium are the most publicly discussed at this point, the profiles of vehicle performance, while not exclusive to those manufacturers, mostly focused on those two vehicles. These subgroups focused on eVTOL vehicles and did not study Short Take Off and Landing (STOL) vehicles in depth.

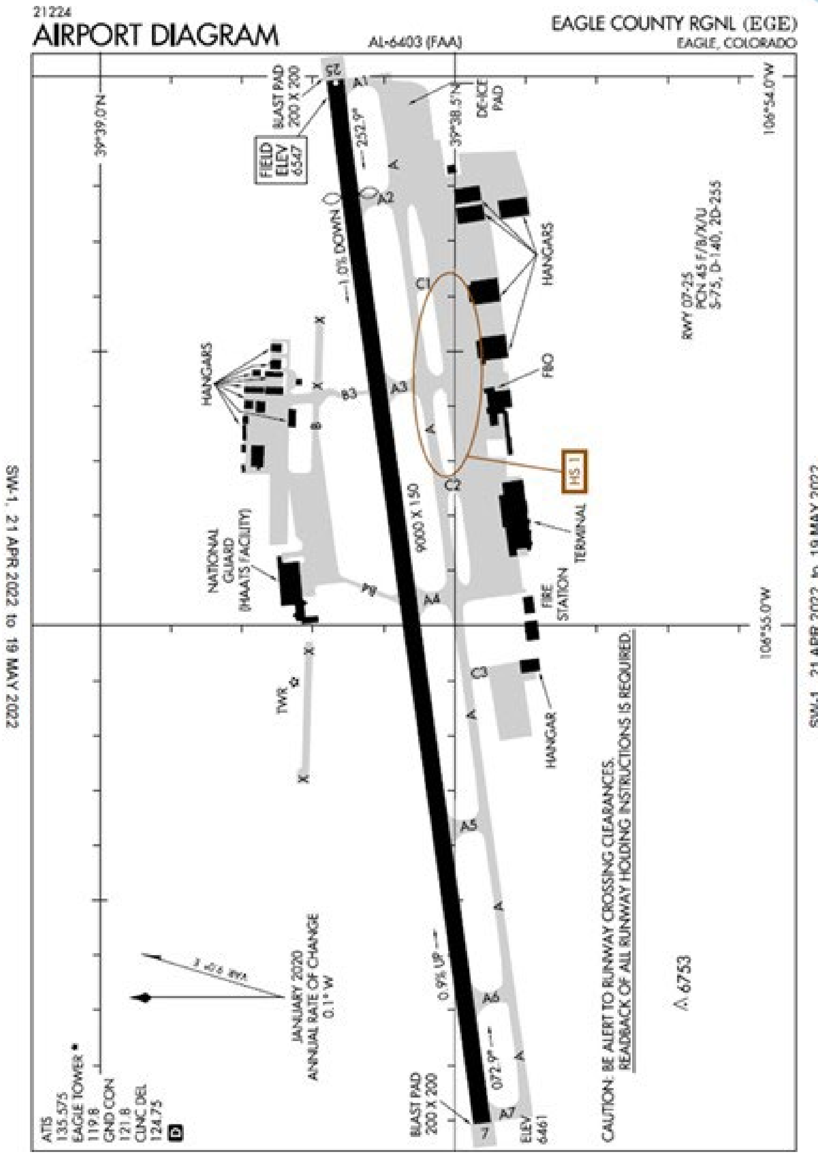
Case Studies

Small Hub

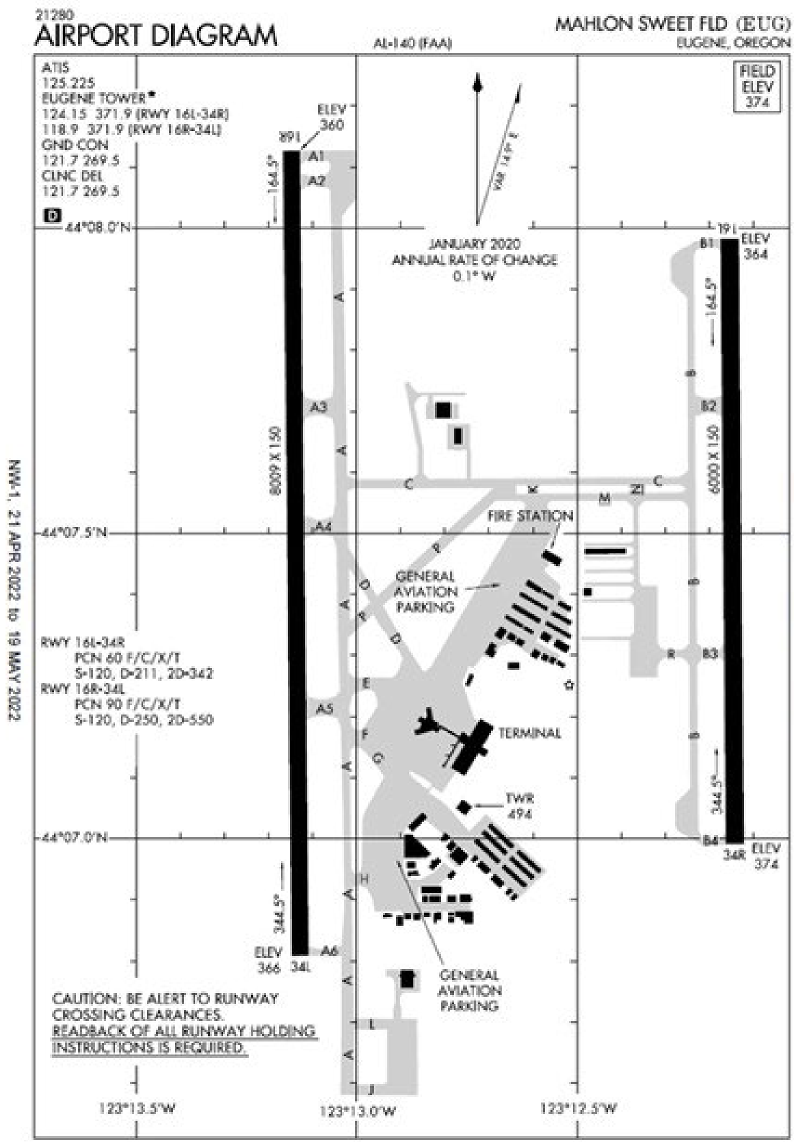
Eagle County, Colorado, enjoys a strong tourism market with a high volume of private aircraft customers. These customers can be expected to be first in a market that values time-savings and access. Passengers arriving at Eagle County Regional Airport are likely to find that using a renewable energy-sourced eVTOL to cover the final leg of their journey as an attractive option, so there is opportunity to offer this option at a premium rate. It also could expand access to a variety of destinations that would be further than an hour's drive from the airport, but nearly immediate using an eVTOL. Any eVTOL service likely would be limited to late spring/summer to early fall, to avoid icy conditions.

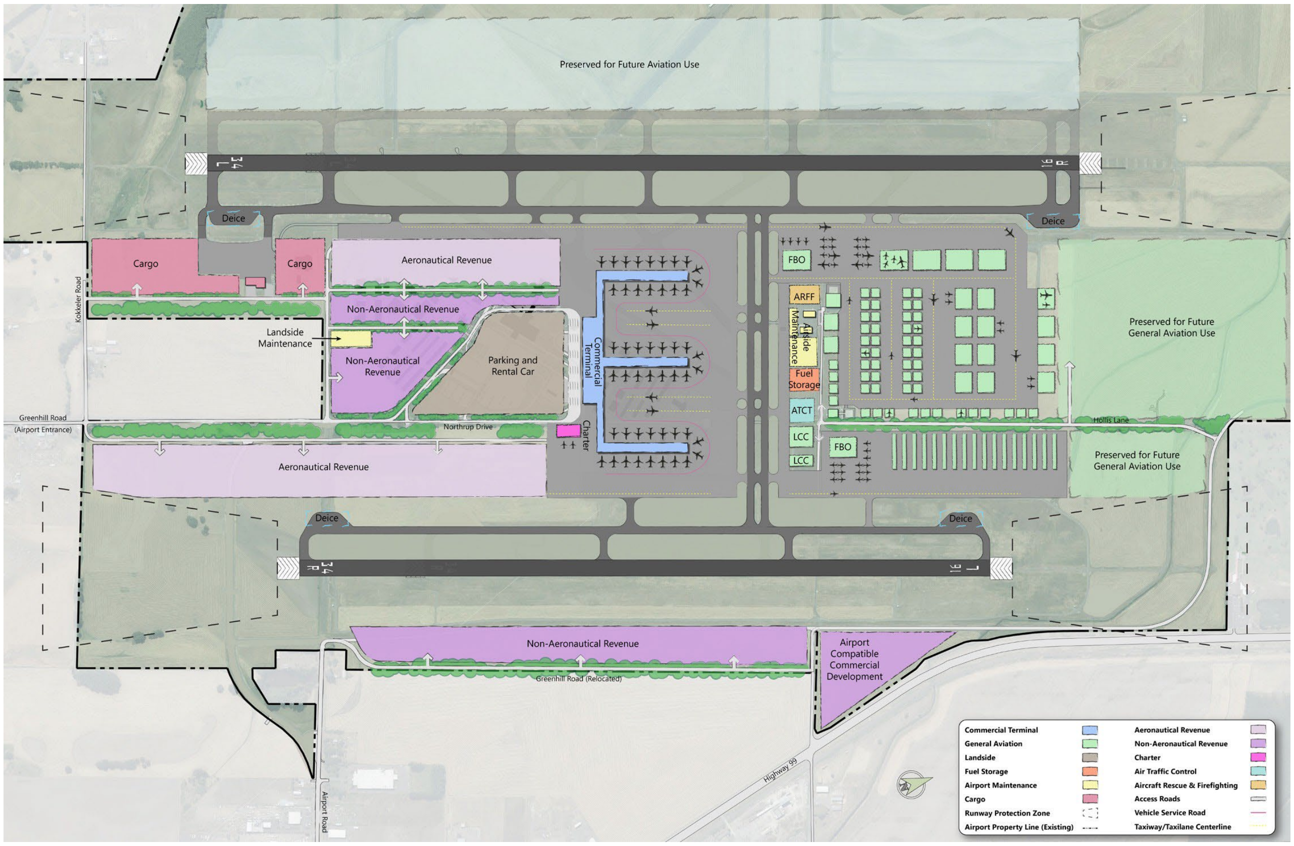
Eugene is a college community located in central Oregon, along the main interstate. In addition to connecting to local events, Eugene offers an opportunity for eVTOLs to connect many communities within their 730,000-person catchment area to the airport. An eVTOL network may be a new way for small communities to connect to the legacy commercial airline network and save significant time. The general aviation airports in the vicinity provide opportunities for such a network, but the strongest demand will probably be the high-tech locations.

EAGLE COUNTY REGIONAL AIRPORT (EGE)



MAHLON SWEET FIELD (EUG)





Eugene-Mahlon Sweet Field Airport: Ultimate Airport Layout (excerpt from Airport Master Plan).

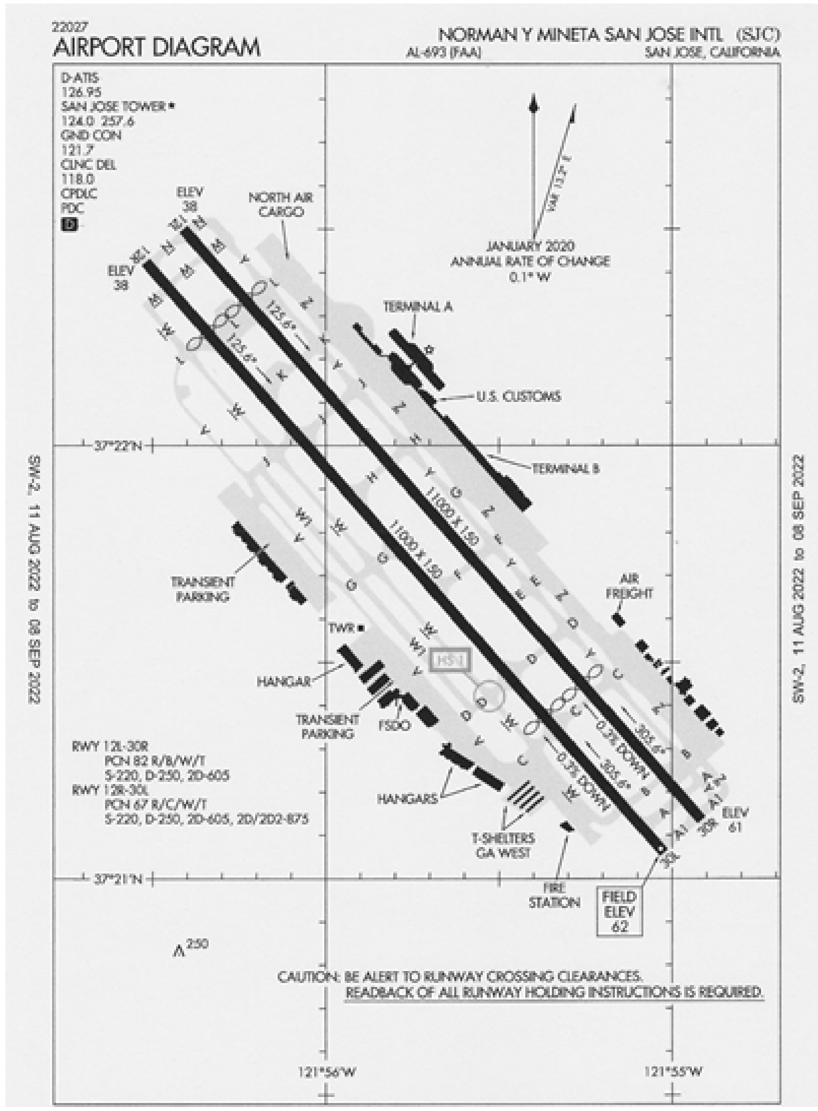
Medium Hub

California's Norman Y. Mineta San Jose International Airport (SJC) has a lot of potential for eVTOL use. Its unique geographic location offers direct access to Silicon Valley's large population base. The catchment area includes established Silicon Valley companies, which include technology companies, start-ups, venture capital, and other investment firms.

Stanford University, Santa Clara University, and San Jose State University are near SJC. This well-educated population with disposable income could become an early adaptor of eVTOL services.

The region is a highly developed urban area, with additional major developments on the way, including Google, Apple, and Nvidia. Significant traffic congestion has impacted the ability to move from point-to-point within this region, as well as access to the airport with its extensive airline network, creating multiple opportunities for eVTOLs to minimize travel time and expand the reach for single-day travel.

SAN JOSE INTERNATIONAL AIRPORT (SJC)



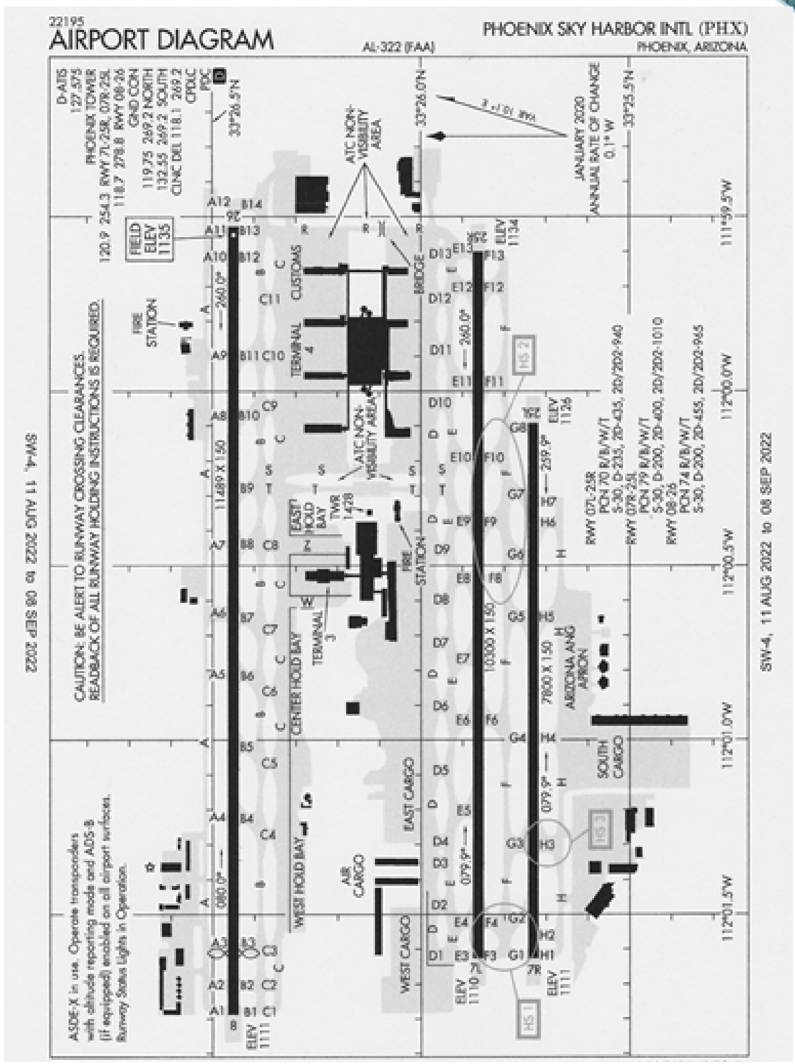
Large Hub

Phoenix, Arizona, has 1.6 million residents and a far-reaching geographic spread, so the ability to move to and from the airport from outlying destinations within 100 miles of Phoenix would be attractive to many passengers. With several GA airports in the vicinity, the subgroup suggested that a network approach for connecting GA airports with Phoenix Sky Harbor should be the first next step in the eVTOL planning effort.

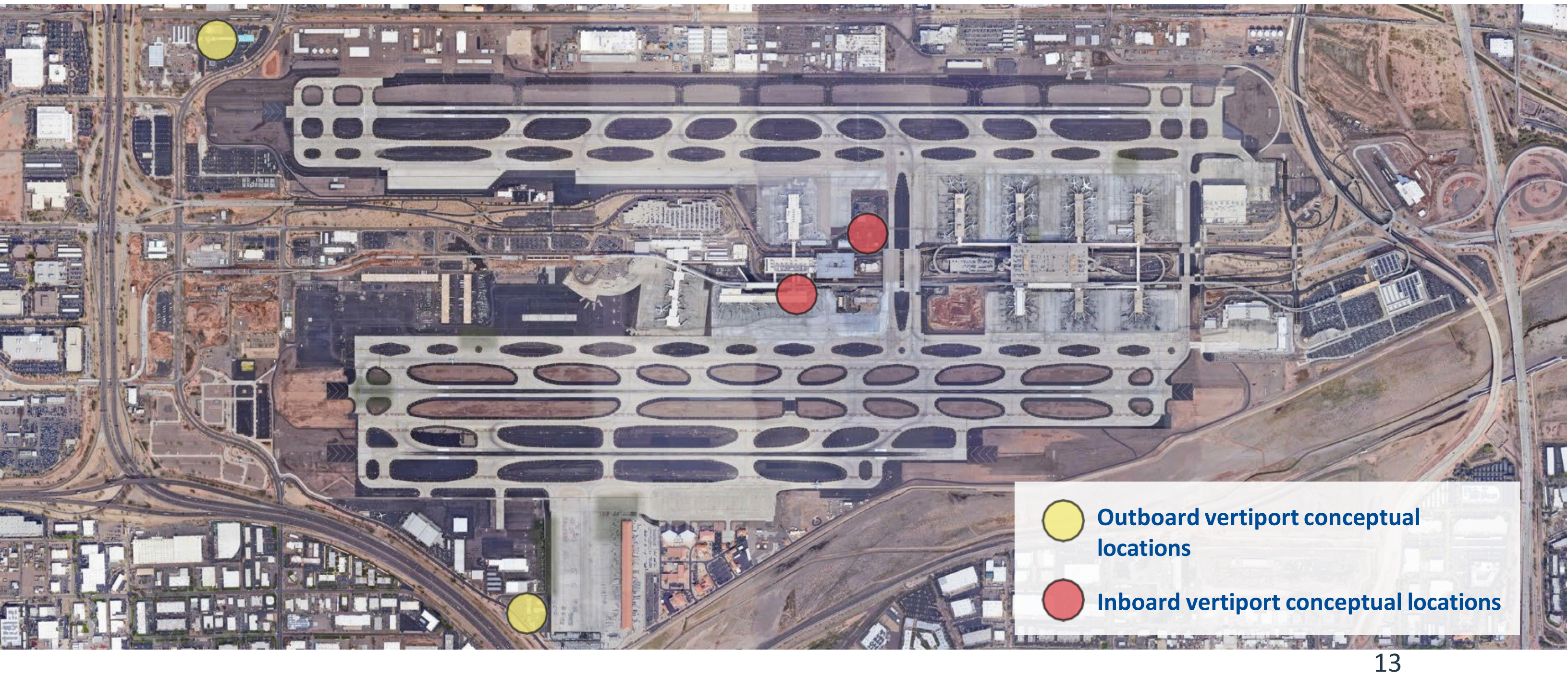
In NASA's 2022 study titled "Near Term Urban Air Mobility Use Cases in the Dallas Fort Worth Area," researchers found: some near-term UAM operations are possible without any changes to rules, policies, or helicopter routes (where available); flights in Class G and E airspace occur today without any need for controller communication, and this will continue to be possible for UAM flights in the near term; however, the placement of vertiports near active runways will pose challenges in near-term implementation. There may be traffic management challenges to overcome as the number of operations increase compared to current day helicopter traffic in the area.

NASA also notes that DFW does not experience much helicopter traffic and, thus, depending on implementation, the addition of UAM traffic is likely to result in increased workload to tower controllers. VFR helicopters carry a 20-minute fuel reserve, and there is expected to be an equivalent reserve requirement for eVTOLs.

Scalability and volume were flagged at various times in the NASA report. GAO states that a "highly automated air traffic control system, micro-scale weather sensing and forecasting, resilient communications…." will be required. It goes on to say the "many of these services could be provided by third-party companies operating under FAA's authorization, to provide information sharing between AAM operators, the aircraft themselves, and FAA's air traffic control system."



PHOENIX SKY HARBOR INTERNATIONAL AIRPORT (PHX)



Off-Airport – General Site

The Off-Airport example was examined and considered as an abstract concept and not specific to a particular airport. Since a specific location was not identified, the variables of airspace, land availability, and specific electrical capacity were not quantified.

The development of vertiports for non-airport locations will be driven by a similar market potential as at airport sites. Relatively short flight distances of less than 40 miles likely will be the first service offerings, and those that have sufficient community demand drivers to achieve a return on investment.

One major characteristic will be dense urban locations that can produce a) the population of passengers traveling back and forth across a metro area, and b) ground traffic conditions that make an aerial trip a time-saver.

A secondary driver for initial use cases will be transportation around metro areas to substitute for helicopters and limousines. As eVTOLs are anticipated to have a sound signature much lower than legacy helicopters, and a significantly smaller emissions footprint, these characteristics will be attractive to the high-end transportation market. These services could be funded privately using private facilities, and depending on the potential for time-savings, may create the demand for the initial vertiport facilities.

These off-airport locations certainly will consider airport shuttle services as a possible route. These trips likely will use an FBO as a destination at first, with an interest to move the destination as close as possible to airside access.

The power availability considerations of an off-site location are the same as for airports. A specific analysis of each considered site along with an assessment of the costs of installing new power access points and recurring energy unit costs will be necessary.

Recommendations

Airspace

The airports considered in the case studies vary, as does their airspace classification. The primary assumption was that eVTOLs would be able to interact with other aircraft and air traffic control at least as well as low-speed fixed wing or helicopters. This means the part 91 requirements of two-way radios and a form of electronic transponder (likely ADS-B) would be necessary. Traffic Collision Avoidance System (TCAS) considerations also need to be evaluated in each case based on the proximity of flight paths to legacy flight paths in order to avoid nuisance TCAS alerts. The June 2022 NASA document “Near Term Urban Air Mobility Use Cases in the Dallas-Fort Worth Area” called for pre-arranged transponder codes in several cases, however, there are not enough beacon codes available in the legacy transponder system to utilize for this purpose. In anything but the lowest volume of operations, ADS-B transponders are a more functional option.

Use Cases

As the subgroups considered the variations of the different markets within the case studies, conversations with manufacturers helped to inform the initial use case discussion. Environmental conditions will drive initial use cases to some extent. While some manufacturers state performance capabilities of up to 15,000 feet above sea level, it is clear that conditions such as density altitude (heat/high altitude) will diminish performance of eVTOLs just as with legacy aircraft. Additionally, as winter flight conditions require de-icing equipment and power reserves sufficient for high-wind conditions, locations with year-round mild conditions and relatively low terrain elevation will provide more favorable operating conditions for this new class of vehicle.

For these reasons, the first networks will encompass relatively lower elevation, ideally flatter terrain, warmer locations with high densities of people within a catchment area. If that type of area also has high ground traffic congestion, it likely will be an ideal first location for extensive eVTOL operations.

Airport Land Availability

Locations of eVTOL operations at any airport will be determined on a case-by-case basis, and not all airports will require added infrastructure for vertiports. The case studies found that the Non- and Small Hub airports had sufficient property to accommodate the needs of eVTOLs. The Medium and Large Hub case study airports were more constrained. Major factors in considering the location of eVTOL operations include operating in the airspace, access to sufficient electrical capacity, landside access, and ability to connect to the passenger terminal. Studying each of these areas is good practice to ensure a functional facility.

Electrical Capacity

Projections of available electrical supplies were discussed extensively by each subgroup as they evaluated the infrastructure that would be necessary to deliver the electrical capacity to charge this new class of vehicles. A baseline assumption was that eVTOL vehicles would charge similarly to commercially available automobiles at twice to three times the electrical draw currently needed for a “Supercharger” level of vehicle charging. This means a simple TLOF with parking likely would need an additional capacity of 1-1.5 MW capability. This 1-1.5 MW estimate is not yet fully determined. For example, one company estimates that a 500-kW capacity can be engineered to handle the range of electrical demand for multiple vehicles due to the variables in timing and peak draw among vehicles that arrived at different times.

As we consider the availability of this level of new demand at airports, one school of thought is that as ground vehicles become more electrified, and we assume close to full electrification of personal vehicles, airport ground service vehicles, and commercial vehicles, the additional electrical draw of eVTOLs will be a small additional load on top of those already increased ground vehicle demands. However, given the likely differing timing of these new electrical demands, and the ongoing quality and resiliency issues with the current electrical grid, some new TLOFs may need to provide local power through a microgrid or some other mechanism.

However, assuming accountability for the aviation utility footprint and considering whether an additional 1.5 MW is available at each airport, the Small Hub airports at Eagle and Eugene were determined to have sufficient electrical capacity nearby to support this demand. The cases of San Jose and Phoenix were more challenging. In Phoenix, while there is some available supply nearby, there are also significant plans that will put demands on the available capacity. While there are long-term plans for more electrical supply, the case study concluded that there likely is not an idle amount of capacity to draw on, and a detailed study of the future electrical infrastructure would need to be integrated with a long-term projection of electrical demands in the vicinity of the airport to determine the optimal requirements.

The Medium Hub subgroup determined that San Jose's West Coast location indicated a need to consider other means of providing the electrical supply. Creative means of investing in electrical infrastructure may be necessary to ensure an adequate future supply for all the increasing electricity needs in the industry.

Each subgroup reviewed a presentation from the National Renewable Energy Laboratory (NREL) regarding hydrogen-based electrolyzer systems. This concept involves using electricity during non-peak demand periods to separate hydrogen from oxygen in water, and then using the hydrogen to produce electricity during peak demand periods. Very broad assumptions of cost indicate that this type of system could be effective if a 20-50 MW capacity is needed to justify the investment that would likely be in the $1 million per MW range. While the concept appears intriguing, it was determined to be more far-reaching than the scope of the subgroups.

Lease Considerations

The general assumption of the case study subgroups was that eVTOL operators would have a cost structure proportional to their footprint. This will be a major challenge for airport managers going forward, as the initial consideration of airport eVTOL development will rely on the entity responsible for paying for infrastructure development. Further, the NASA use cases did not consider interactions between multiple UAM or vertiport operators. This speaks to the need to prove the technology and its use in as simple an operation as possible initially. As with all transportation undertakings, the need is to keep the base plan and investment simple and low-cost, while planning for flexibility and future growth. Single user vertiports likely will need to be funded by the operator, similar to the requirement that airlines fund exclusive use spaces.

FAA Reauthorizations

The funding mechanisms in the legacy aviation environment are based on a variety of fuel taxes, fees, and per-passenger ticket taxes and charges, which have reached an equilibrium of sorts in our system, resulting in the establishment and sustainment of our strong national airspace system. Practically, passengers traveling from a large airport reap the benefits of the availability of infrastructure at small airports as relievers and contributors to the overall passenger base that drives the system. However, the demands on these funds to update legacy airport operations are significant.

Funding Considerations

The emerging market of eVTOL vehicles offer new challenges. If we assume a very low operational pace, in which eVTOLs occasionally land and depart from the general aviation ramp, per vehicle charges or fees for charging services may be workable.

But as we consider a higher operational pace with larger investments to bring additional electric capacity, designing a proportional cost structure will be challenging amid considerations for additional infrastructure to handle and move people between airfield locations, security considerations, and ARFF implications.

As an example, the proportional equivalent of a fuel tax will be very different when comparing a vehicle like the Citation Longitude that carries 2,200 gallons of fuel to an eVTOL that costs less than $50 to charge. The costs of short-distance, high-frequency operations are so different from legacy aviation, so the typical cost structures may not generate sufficient revenues to support the necessary infrastructure. An appropriate follow-on study may be needed to define the fuel charges, fees, and taxes related to similar-sized vehicles such as a Bell 206 helicopter in today's environment, to state an applicable equivalency. While this may be addressed in a future FAA Reauthorization, there are still many questions that likely may not be addressed before the first eVTOLs are certified by the FAA.

The uncertainties of funding may mean the question of "general aviation side vs. commercial side" is strongly pushed towards the General Aviation side of installations. The commercial side (airside) of the airport involves significant aspects of security, services, air traffic approvals, and access. All of those are large investments and some have long lead times for analysis, coordination, and modification to current air traffic procedures and approvals. It is unlikely that an eVTOL operator will want to fund that level of infrastructure.

Another possibility of the funding uncertainties could be that eVTOL operators focus more on off-airport development than on-airport development. While this would compromise their ability to save time in connecting to longer-stage transportation, it may be the softer approach for getting started.

Reauthorization Suggestions

Funding Structure

The nature of the eVTOL service concept is to reduce costs to make short trips affordable. The vehicles use a lower-cost form of fuel, and the business models currently being proposed are all based on low-fare operations. This means the net financial flow through the system will be much lower than legacy carbon-based aviation, and that means that establishing a fee or tax percentage to support the cost of the infrastructure will be more difficult. A goal of next year's FAA Reauthorization should be to establish a funding mechanism for vertiports located on airport property. While some in the industry have expressed a desire to have eVTOLs included as an aeronautical use and included in the AIP program, the reality of this emerging market presents some challenges:

- While some vertiports will be located on airport properties, many will not. It is very possible the majority of vertiports may be located off-airport.
- Some vertiports will be established by private entities for private operations, while airports may see advantages of common-use facilities.

The structure of redistributing the FAA AIP tax from large airports to small airports is needed to operate in the National Airspace System. Practically, passengers traveling from a large airport reap the benefit of the availability of infrastructure at small airports as relievers and as contributors to the overall passenger base.

In the case of eVTOLs, these technologies provide completely local service, so redistribution of nationally set taxes may not be appropriate and will not support the development of vertiports. Trust fund revenues may be available for certain airport-related planning and air traffic control system costs. This has the benefit of encouraging minimum standards. However, it would make more sense for the infrastructure at each airport to be addressed with fees, taxes, or carve-outs of the existing passenger tax to be collected and retained locally based on local passenger volume. This would avoid the problem of over- and under-funding small and large airports, respectively.

Some manufacturers have stated that eVTOL operators should pay their "fair share" of fees and be included in Part 135 structures. It may be challenging to establish an effective fee structure with a differentiation between electric and other Part 135 operations.

Establishing a funding mechanism could require standardization and safety standards as a public good. Without such a structure, the regional variations based on funding amounts and funding sources may drive piece-meal development. A foundational step may be to evaluate the Part 135 charges that currently exist and estimate how an eVTOL part 135 structure would compare.

Minimum Altitudes

These new vehicles will operate similarly to helicopters, but not identically. Therefore, airports and private developers will need to consider the perceptions of the public. Some baseline requirements may need to be established as the public develops the natural perceptions of noise, proximity, and visual clutter. An important first step may be to consider whether minimum altitudes for flight paths need to be established over residences.

Setbacks/Zoning

While airports follow FAA guidance for runway and taxiway geometry and multiple layers of obstacle protection zones, it is important to note that these protected areas are mostly a function of federal funding. For a new, privately developed system of vertiports, these zones are not clearly established. It may be important to establish safety zones and/or setback requirements from residential areas for long-term industry viability. Without national standards, this is likely to be a litigated set of fragmented solutions.

Integrated Service Architecture

The current development plans for AAM align with the FAA’s philosophy of encouraging infrastructure development by private entities. While this may look appealing from the perspective of federal cost avoidance, it is not likely to create a smooth and integrated national system. National standards are needed for how vehicles communicate with each other and how operational items like landing pad availability are coordinated with inbound flights. In addition, there needs to be a standardized and coordinated approach to vertiport development, or else these projects will become unplanned and unfinished eyesores in the middle of our cities. Professional planning practices consistently indicate that a structured and proportional development is in the public’s best interest.

Legislation: HR 6270 and SB 516

House Resolution 6270, the Advanced Aviation Infrastructure Modernization Act, was passed by the House on June 13, 2022. This bill would create a pilot grant program for AAM. Similarly, the Senate passed Senate Bill 516, the Advanced Air Mobility Coordination and Leadership Act, on March 23, 2022, which became law on October 17, 2022.

These two legislative efforts recognize some of the items mentioned above and finishing approval of these items will be influential for the AAM industry.

Summary

AAAE, through the Airport Consortium on Customer Trust (ACT), formed a working group to evaluate the current knowledge of the Advanced Air Mobility (AAM) industry and the likely first steps that U.S. airports would encounter as the AAM industry moves forward.

The working group included members from airports across the spectrum of airport sizes. It also included representation from an Electrical Vertical Take Off and Landing (eVTOL) manufacturer.
The working group evaluated four U.S. airport locations as case studies. They organized the case studies to address:

- Airspace
- Use Cases
- Airport Land Availability
- Electrical Capacity
- Lease Considerations

Airspace access was possible at all airports. However, requirements such as two-way radios and transponders will need to be established in order to utilize legacy air traffic control procedures. The current Traffic Collision Avoidance System (TCAS) software also will need to be considered as eVTOL ingress and egress routes from airports are created. This will be on an airport-specific basis.

The case studies indicated that airports show viable locations for vertiport eVTOL operations. The case study teams assumed initial very low volume use cases being proposed as “helicopter-like” operations being described as the first operational level of capability. In most cases, coupling initial eVTOL operations with existing general aviation facilities was a perceived effective first step.

Electrical capacity at each airport was considered, and some utility providers were consulted. Some airports already have ample electrical capacity on or near the airport. Others may need to factor in specific requirements as they communicate with utility providers while these providers develop infrastructure availability to meet demand. It was noted that the first several phases of eVTOL development will create smaller electrical demand as compared to the broader electrification requirement for ground vehicles.

Establishing new uses on airport property requires new leasing arrangements, and those leases need to be created with a fair consideration for both airports and tenants. This means that new facilities established in or adjacent to general aviation facilities typically will be lower cost than the higher cost of developing facilities within the commercial airside footprint.

The case studies show that initial low-pace operations are possible at most airports. The challenge will be to design vertiports and supporting infrastructure that can be scaled up later to higher-pace operations with viable operational and financial structures.

Resources

United States Government Accountability Office, Report to Congressional Committees, “Transforming Aviation-Stakeholders Identified Issues to Address for “Advanced Air Mobility”, May, 2022

National Aeronautics and Space Administration, “Near Term Urban Air Mobility Use Cases in the Dallas-Fort Worth Area,” NASA- TM-20220009944, June 2022

Case Study: Small and Non-Hub Airports

I. Introduction and Intention

The concept of advanced air mobility (AAM) is what is known as a disruptor – a new technology that simply changes everything. The National Business Aviation Association (NBAA) defines AAM as a "new concept of air transportation" which leverage advances in battery technology, hybrid electric systems and potentially hydrogen fuel cells to propel vertical takeoff and landing (VTOL) aircraft. These new aircraft are envisioned to support mobility in dense urban centers, often referred to as urban air mobility (UAM), as well as provide connectedness to currently underserved or geographically constrained communities.[1]

This white paper presents an opportunistic exploration of what may be possible at two small hub airports with the integration of eVTOL aircraft to the national airspace system. It is not the intention of this paper to be prescriptive or offer any direct guidance or strategic imperatives for the case study airports reviewed, or any airport for that matter. The intention is rather to synthesize what was essentially a thought experiment among a small group of airport planners, engineers, and administrators in the spring of 2022. Informed by an understanding of the proposed eVTOL aircraft most likely to receive certification in the U.S., the markets they may be most apt to service, and the way in which small-hub airports can support and benefit from this type of operation, the working group established for this paper explored a variety of data related to operationalizing such a new market entrant. Specifically, this study reviews:

- AAM platforms
- Location and climate
- Operating environment and access to electricity
- Use cases for anticipated AAM platforms
- Potential route corridors
- Vertiport siting
- Operational integration

[1] https://nbaa.org/aircraft-operations/emerging-technologies/advanced-air-mobility-aam/

II. AAM Platform Considerations

Aircraft platforms being developed by Joby Aviation and Lilium were explored as part of this study. These manufacturers are both early leaders in the AAM market and poised to certify aircraft in the U.S. in the coming years. Additionally, while commercially similar, these anticipated aircraft differ in terms of operating characteristics that may result in different airfield siting or airspace integration considerations. The following sections briefly describe some known limitations and/or operational performance specifications with respect to each of these aircraft.

Performance Specifications and Operational Limitations

Joby S4

The Joby S4 is a five-seat (one pilot and four passengers), vectored- thrust aircraft using six tilting propellers to enable vertical takeoff and landing that is said to be 100 times quieter than a helicopter and nearly imperceptible during an overflight. The distributed electric propulsion system can achieve speeds up to 200 miles per hour, and its batteries provide a range of 150 miles.

Lilium Jet

The Lilium Jet is a seven-seat (one pilot and six passengers), ducted electric vectored-thrust aircraft that integrates electric jet engines into the wing flaps to enable very efficient thrust vector control to maneuver in all phases of flight. The aircraft is said to have a range in excess of 150 miles and a 10,000-foot service ceiling.

Electrical Requirements and Other Considerations

Most early concepts of operation for AAM activity indicate the use of electric propulsion by VTOL, the electrical needs for which very based on design manufacturer and are likely to change significantly over time with technological advances and vary greatly based on use-cases and overall demand for AAM services. As of Spring 2022, no consensus has been achieved regarding classes of charging or connections standards, charging speed, battery chemistry, battery cooling systems, fixed or removeable battery systems, and much more. Further, purpose-built batteries for the eVTOL market, which require a high energy density and high-power output capabilities for vertical takeoff and landing, are likely in their infancy in terms of technological advancement.

Some project the level of infrastructure necessary to electrify a legacy commercial gate for ground support and pre-conditioned air would be roughly equivalent to a vertiport electrification effort.

Joby S4

In a fall 2021 interview, Joby executive Bonny Simi explained the Joby S4 is designed for a "very quick charge," meaning about the amount of time it would take to cycle passengers and prepare the aircraft between hauls, about 5 to 7 minutes for a typical stage length of about 25 to 50 miles. Longer flights up to about 150 miles could take up to 45 minutes to charge the aircraft.[2]

Lilium Jet

Lilium proports that when coupled with a fast-charging system called the Megawatt system, which enabled DC charging of up to 1,000 kW, the Lilium Jet can be fully powered from no charge in only 30 minutes,

[2] https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/rideshares-in-the-sky-by- 2024-joby-aviation-bets-big-on-air-taxis

reaching 80 percent charge in only 15 minutes. Such turn-around time will be critical to ensure the aircraft can remain profitable while keeping fares attractively low to passengers and competitive with other AAM solutions.[3]

Electrical Charging

With the electric aircraft market still in a state of development, it is most useful to utilize some general guidelines for electrical requirements. We used the following:

- GA type electric aircraft – Similar to an automobile DCFC – 150 kW per charge point
- eVTOL shorter range (up to 150 miles) – Similar to an EV Truck DCFC – 900 kW to 1 MW per charge point
- eVTOL longer range (over 150 miles) – DCFC – 1.5 MW per two charge points (currently the most common configuration)
- eVTOL – DCFC 1 MW per charge point.

These are reasonable planning values for a single or dual charger installation at an FBO or an existing helipad to support occasional on- demand operations.

Upscaling Considerations

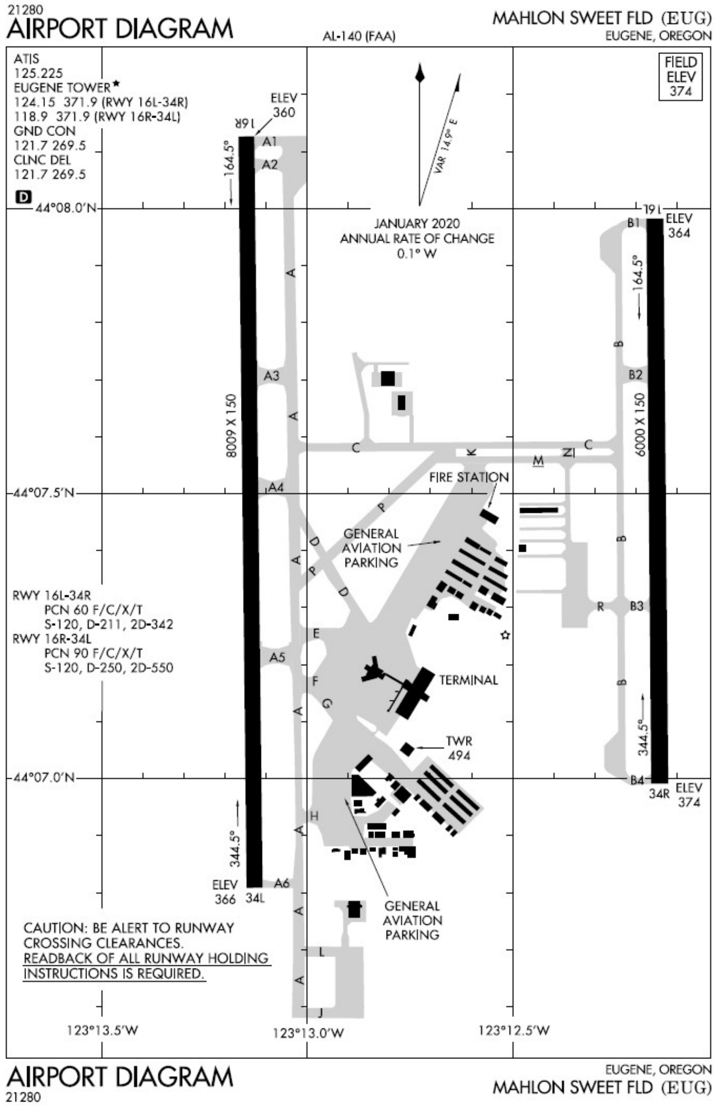
As eVTOL activity increases, segregating traffic to an on-airport vertiport could allow for continuously scheduled operations by eVTOL operators. This presents additional electrical complications. When discussing charging with an early vertiport developer, it was explained that an operator will never charge at each parking location at the same time. Early guidance suggests planning for five (5) MW of power for eight (8) parking positions. For a vertiport with fewer parking positions, the MW to parking position ratio goes up as the likelihood of charging concurrently goes up – a four (4) parking location vertiport may require 3.5 MW.

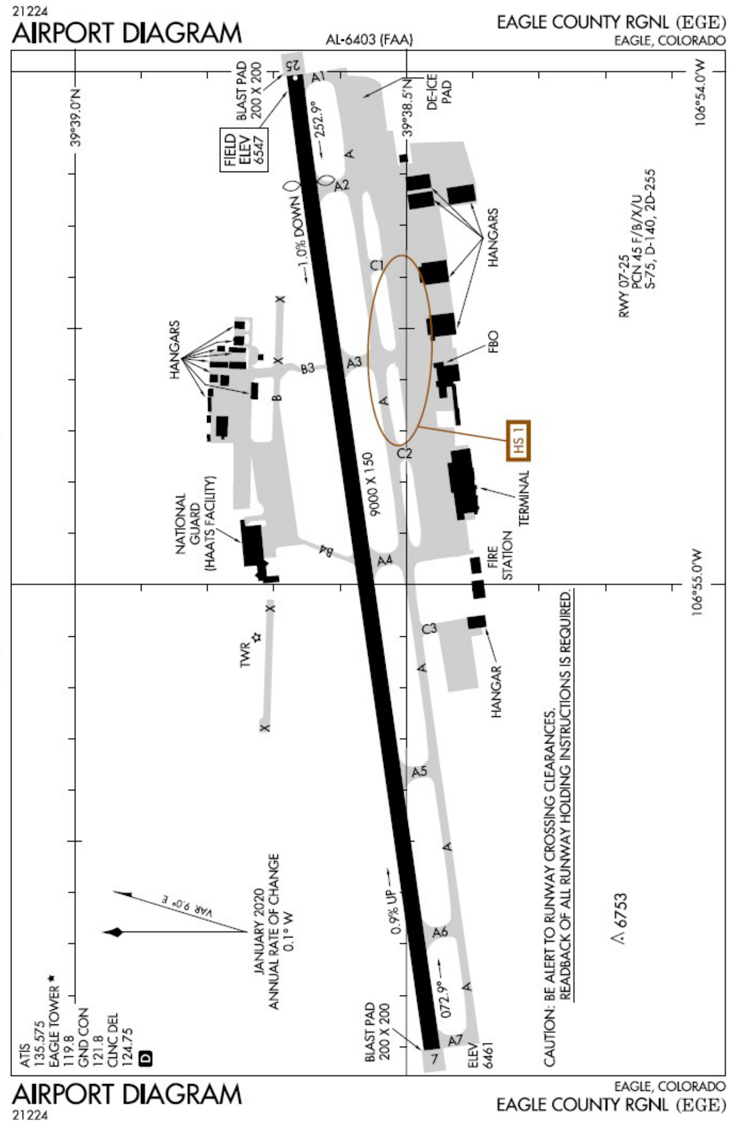
[3] https://interestingengineering.com/flying-taxis-got-a-major-boost-from-a-new-ultrafast-charging- system

III. Case Study Airports

The airports to serve as case studies for this paper were selected from public-use commercial service airports identified to be in the small hub category. Small hub airports receive 0.05 to .025 percent of the annual U.S. commercial enplanements and represent approximately 17.5 percent of all primary commercial service airports in the U.S., totaling 69 across the country. The two case study airports chosen provide significant variation in geographic location, operational patterns, seasonality, and community needs, allowing for a thoughtful consideration of some of the unique advantages or challenges one airport may have with respect to another. The table below provides critical airport information for the case study airports that are further described in the following pages.

	Case Study Airport	
	EGE	**EUG**
Airport Elevation	6547.5’	373.7’
Runway(s)	7/25	16R-34L / 16L-34R
Runway Length	9,000’	8,009’ & 6,000’
Runway Width	150’	150’ & 150’
Runway Equipment	ILS/DME RW25	ILS/DME RW16R/L
Based Aircraft	89	119
Avg Ops per Day	126	176
Notes	Cold Temp Airport	Helicopters not to overfly terminal
	Military Helicopter Activity	


21280
AIRPORT DIAGRAM
AL-140 (FAA)
MAHLON SWEET FLD (EUG)
EUGENE, OREGON
ATIS
125.225
EUGENE TOWER
124.15 371.9 (RWY 16L-34R)
118.9 371.9 (RWY 16R-34L)
GND CON
121.7 269.5
CLNC DEL
121.7 269.5
FIELD ELEV 374
ELEV 360
16R
164.5°
44°08.0'N
JANUARY 2020
ANNUAL RATE OF CHANGE
0.1° W
VAR 14.9° E
16L
ELEV 364
8009 X 150
6000 X 150
FIRE STATION
GENERAL AVIATION PARKING
44°07.5'N
RWY 16L-34R
PCN 60 F/C/X/T
S-120, D-211, 2D-342
RWY 16R-34L
PCN 90 F/C/X/T
S-120, D-250, 2D-550
TERMINAL
TWR 494
44°07.0'N
34R
ELEV 374
344.5°
ELEV 366
34L
CAUTION: BE ALERT TO RUNWAY CROSSING CLEARANCES.
READBACK OF ALL RUNWAY HOLDING INSTRUCTIONS IS REQUIRED.
GENERAL AVIATION PARKING
123°13.5'W
123°13.0'W
123°12.5'W
NW-1, 21 APR 2022 to 19 MAY 2022
AIRPORT DIAGRAM
21280
EUGENE, OREGON
MAHLON SWEET FLD (EUG)


21224
AIRPORT DIAGRAM
AL-6403 (FAA)
EAGLE COUNTY RGNL (EGE)
EAGLE, COLORADO
BLAST PAD 200 X 200
FIELD ELEV 6547
252.9°
39°39.0'N
39°38.5'N
DE-ICE PAD
106°54.0'W
HANGARS
1.0% DOWN
RWY 07-25
PCN 45 F/B/X/U
S-75, D-140, 2D-255
FBO
HS 1
9000 X 150
NATIONAL GUARD (HAATS FACILITY)
TERMINAL
FIRE STATION
106°55.0'W
TWR
HANGAR
CAUTION: BE ALERT TO RUNWAY CROSSING CLEARANCES.
READBACK OF ALL RUNWAY HOLDING INSTRUCTIONS IS REQUIRED.
VAR 9.0° E
JANUARY 2020
ANNUAL RATE OF CHANGE
0.1° W
0.9% UP
6753
072.9°
ATIS
135.575
EAGLE TOWER
119.8
GND CON
121.8
CLNC DEL
124.75
BLAST PAD 200 X 200
ELEV 6461
SW-1, 21 APR 2022 to 19 MAY 2022
AIRPORT DIAGRAM
21224
EAGLE, COLORADO
EAGLE COUNTY RGNL (EGE)

Eagle County Regional Airport – Gypsum, Colorado

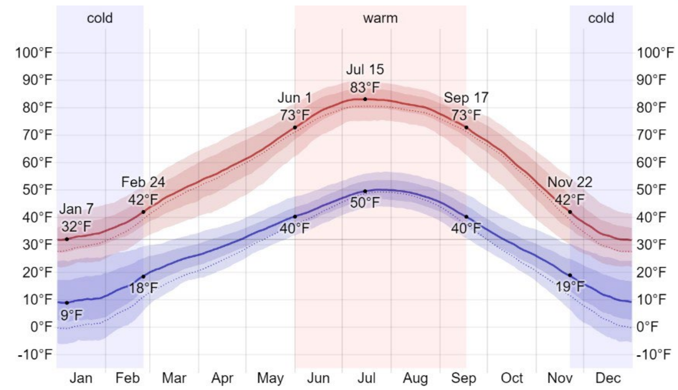
Eagle County Regional Airport (EGE) is known as the gateway to the heart of the Colorado Rocky Mountains, providing access to some of the nation's top ski resort towns – Vail, Beaver Creek, and Aspen. Although the winter season historically has been the busiest time of year for the local area, the summer recreation activities have started to attract a warm weather crowd as well.

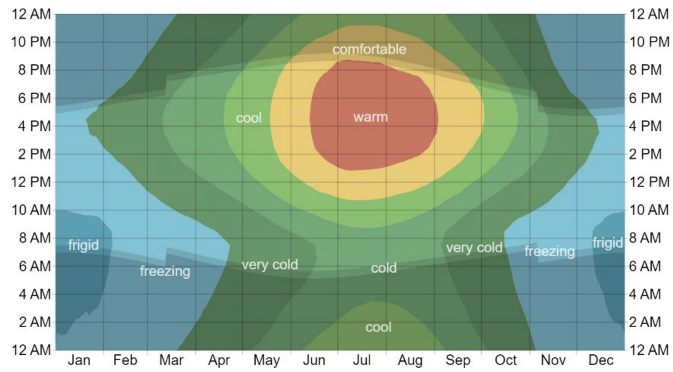
EGE's airfield consists of one active east-west runway, designated as 7/25 and measuring 9,000 feet in length and 150 feet wide and supported by 25-foot paved shoulders. The established airport elevation for EGE is 6,547.5 feet above mean sea level (MSL).

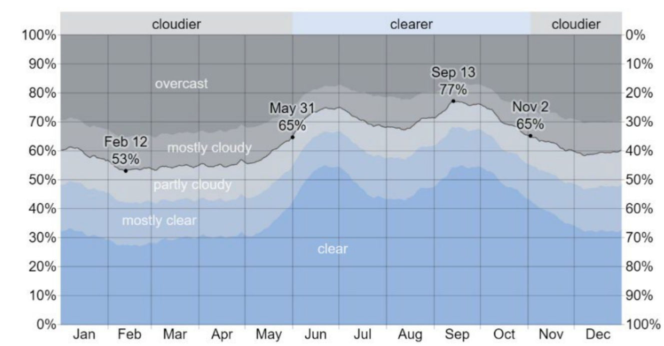
The airspace surrounding EGE is quite complicated and in the vicinity of numerous other mountainous airports with heavy traffic. The airport environment is protected by Class D and Class E Airspace depending on ATCT service availability.

Eagle County Regional Airport – Climate

The climate of Eagle County Regional Airport is generally characterized as hot and dry in the summer and freezing, snowy and partially cloudy in the winter. The area receives approximately 15 inches of rain and 47 inches of snow per year. On average the airport enjoys 247 sunny days per year, and according to the airport's most recent master plan, only operates in Instrument Meteorological Conditions (IMC) 2.42 percent of the time, primarily in the winter months December to March.







Eagle County Regional Airport – Electric Utility

The local electric utility at Eagle County is Holy Cross Energy. Discussions with Holy Cross were conducted early in our site investigation. We were pleased to learn that the power lines at the front of the airport have about 6 MW of spare capacity available. We also learned that across the street from the airport is a Holy Cross electrical substation fed by both power lines and a Biomass Generation Facility. The substation has about 7 MW of excess capacity when the Biomass Facility is off-line and about 19 MW when it is on-line.

These levels of power availability are sufficient today to service the eVTOL/eCTOL needs of Eagle County, but there are other considerations. The first is that the area around the airport is constantly growing, and additional residential and commercial/industrial development is always consuming power reserves. The second and arguably more critical concern is the overall electrification of the transportation system and, therefore, the airport. Short term electrical needs will likely include:

- EV chargers for Rental Car Companies - Level 2 and DCFC
- EV chargers in Short Term, Cell Phone, and TNC /Taxi /Limo parking and staging areas (DCFC)
- EV chargers in Long Term and Remote parking areas - Level 1 Level 2
- Airport and regional bus charging (DCFC)
- Airport Ground Service Equipment (GSE) charging (DCFC)
- Air Cargo chargers for UPS, Fed-Ex, DHL, Amazon, etc. (Charge levels not yet defined)

Eagle County Regional Airport – Future Expansion Plans

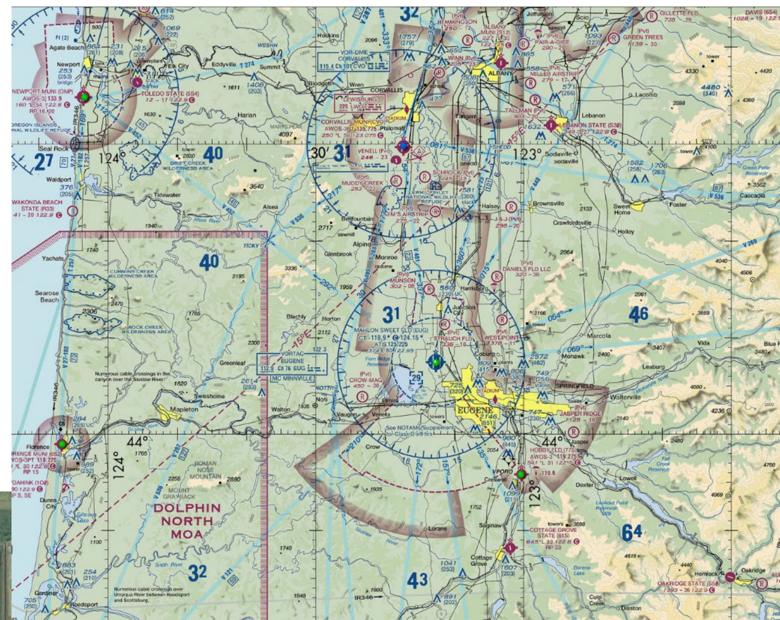
- New Entrance Loop Road for terminal ingress and egress
- New Front of house for terminal (non-Secure), baggage claim
- FBO and private hangar expansions
- Northwest property development, potential additional aviation uses
- CBP Federal Inspection Station (FIS) and international arrival terminal
- New parking garage or additional parking lots
    - Site for VTOL Op
- Major HAATS (Military) expansion on the north side
- New northside parallel taxiway “B” (2025)

Eugene Mahlon Sweet Field Airport – Eugene, Oregon

Eugene Airport is the second largest airport in the state of Oregon and located along the I-5 corridor near the mid-point of the state. EUG serves an area encompassing 91 zip codes with a population a little over 730,000. Currently, six airlines serve EUG with nonstop service to multiple destinations along the west coast, as well as Chicago and Dallas.

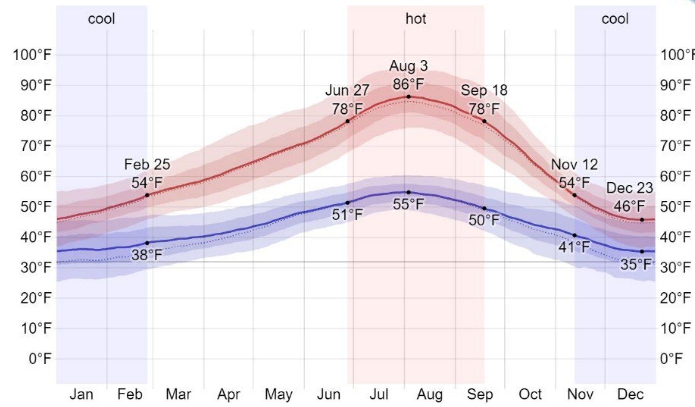
EUG's airfield consists of two bi-directional and parallel runways oriented north to south and designated as 16R-34L and 16L-34R measuring 8,009' and 6,000', respectively.

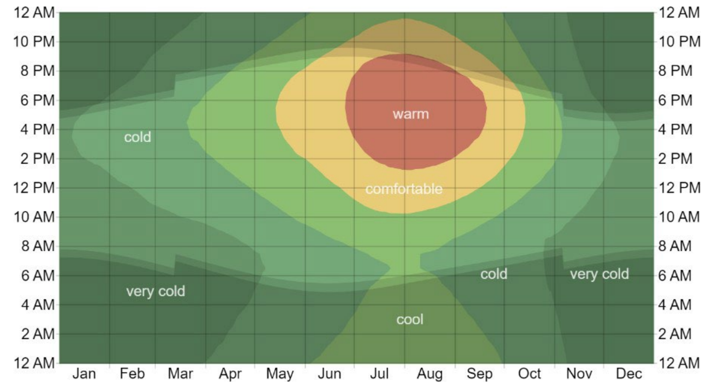
The airspace surrounding EUG is not overly complicated with nearby airports, military operations areas (MOA), or challenging terrain. One large MOA is located west of EUG's airspace, the Dolphin North MOA supportive of the 173rd fighter wing. However, its floor of 11,000MSL provides ample airspace below for traversing GA and potential AAM- use aircraft.



Mahlon Sweet Field Airport – Climate

zThe climate of Eugene, Oregon, is generally characterized by short, warm and dry summers with clear skies, while the winters are cold, wet and often overcast. The area receives approximately 47 inches of rain and three inches of snow per year. On average, the airport enjoys 155 sunny days per year, and according to the airport's most recent master plan, operates in IMC 17 percent of the time, primarily in the winter months.

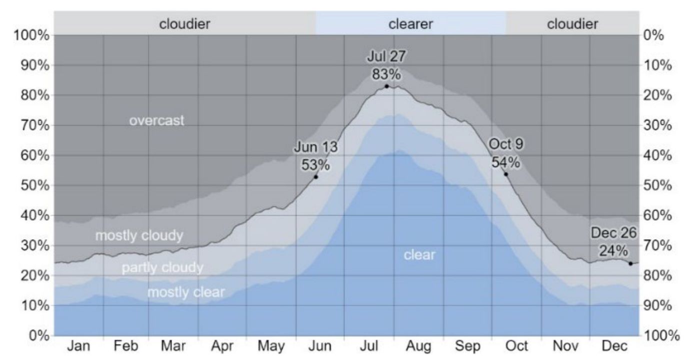




Mahlon Sweet Field Airport – Electric Utility

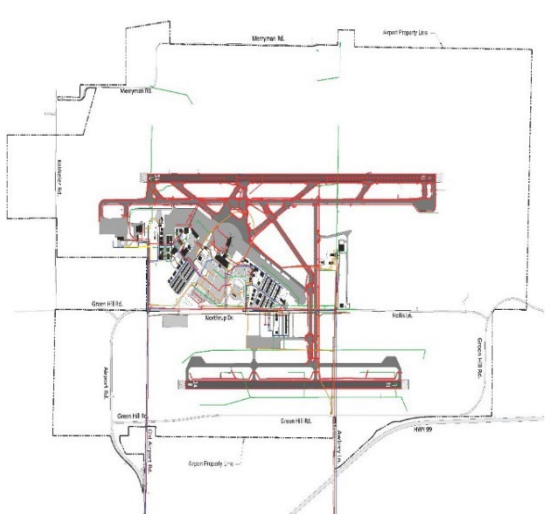
Electric service is available from several companies at various locations around the airport. Eugene Water and Electric Board covers most of the airport with the exception of portions of the north side. The airport also falls within the Director District of Lane Electric Cooperative, Inc. The NE portion of the airport is located within District 3 of Blachly-Lane Electric Cooperative, where Emerald People's Utility District also services the airport.

Main electrical power lines at Eugene run East/West along Northrup Drive and North/South along Old Airport Road and Awbrey Lane. At this point, it is difficult to determine how much power can be drawn from existing lines but an upgrade of the electrical utilities at the airport might be necessary to handle the general electrification of transportation systems at the airport.



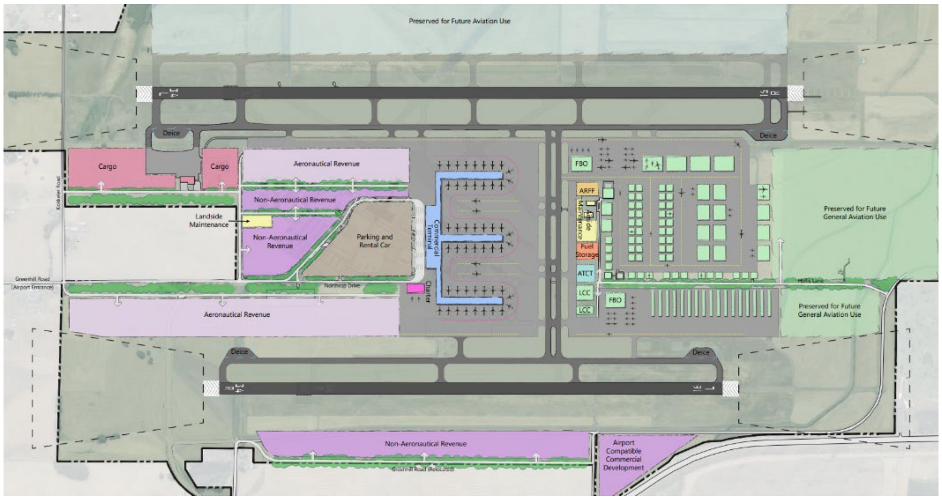
Short term electrical needs likely will include:

- EV chargers at parking facilities for rental cars and general public cars
- Airport Ground Service Equipment (GSE) charging (DCFC)
- eVTOL and GA Aircraft charging stations requiring up to 900 kW power



Mahlon Sweet Field Airport – Future Expansion Plans

- Status quo maintenance of existing facilities
- Trying to get interest in an air cargo facility in the cargo /charter Ramp area by 34L
- New terminal concourse and associated apron
- North general aviation/corporate area



IV. Use Cases and Potential Routes

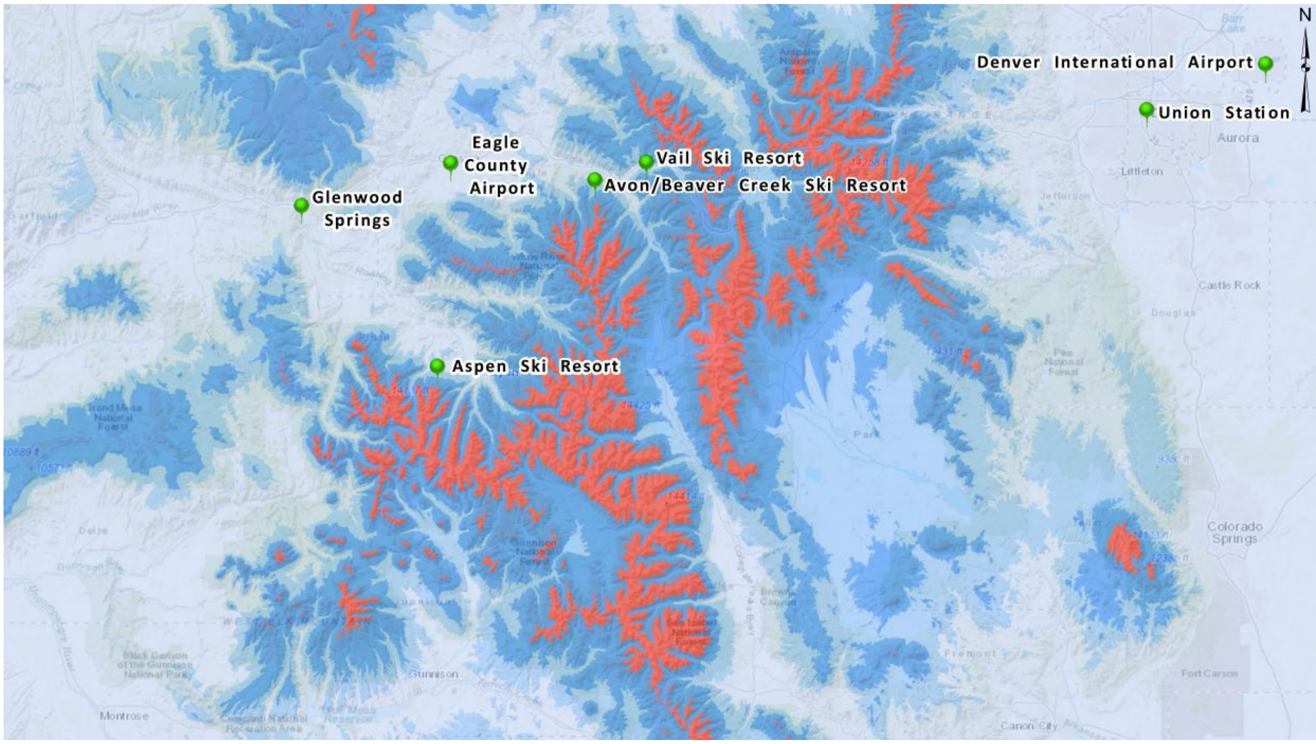
A 2018 study commissioned by NASA explored potential markets and use cases for AAM that identified 36 potential UAM markets across 16 market categories including both broad and narrowly focused application.5 Of these, NASA selected three broadly focused markets to further their study that present a diverse set of barriers, operational models, market sizes and dependency on other modes of transportation, these include:

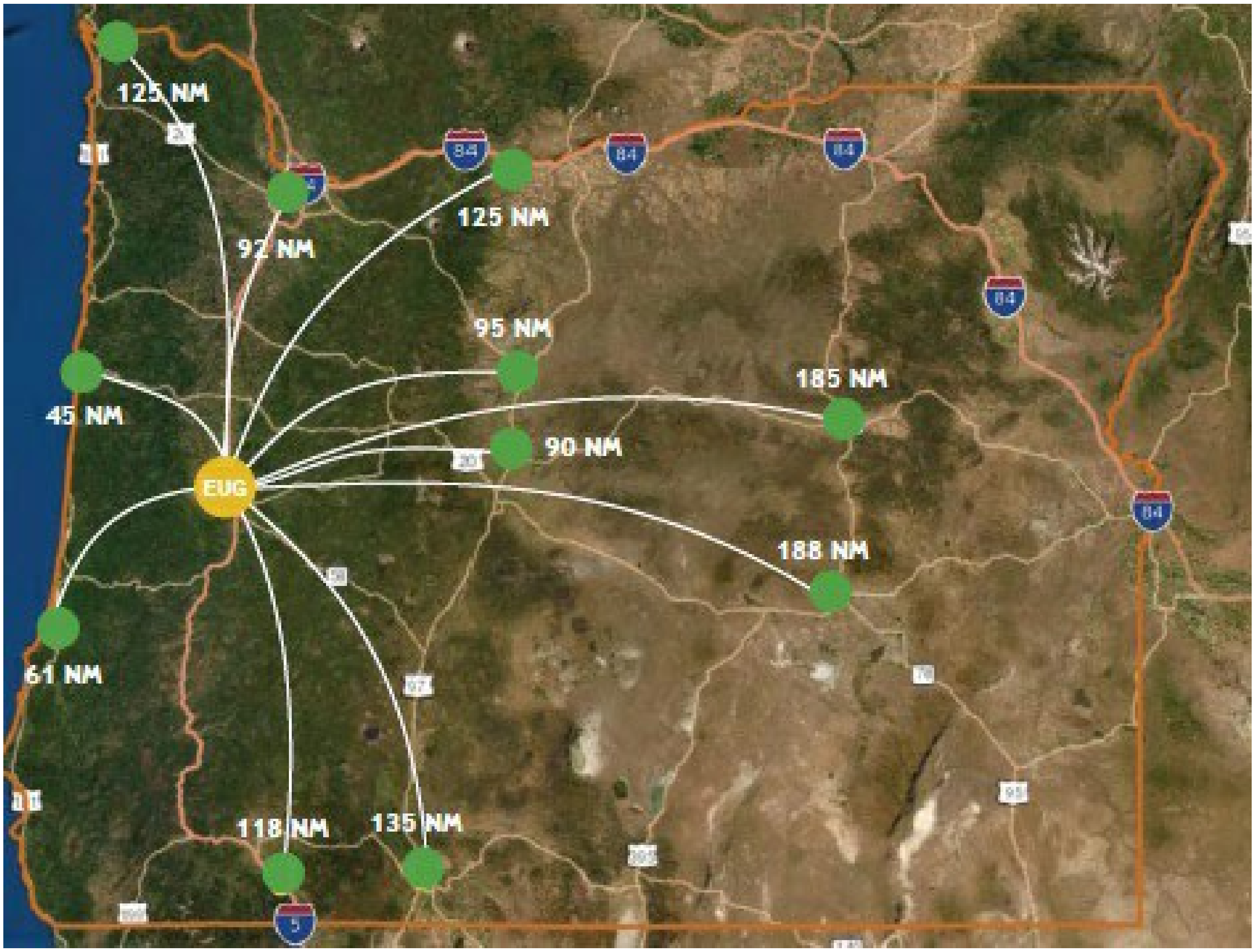
- Airport Shuttle
- Air Taxi
- Air Ambulance

For this analysis, the complex and relatively regionally concentrated market of Air Ambulance was not considered as air ambulance services likely are to be impacted by external factors not relevant to this study such as healthcare legislation and insurance policy coverages.

Additionally, the air taxi market which is largely focused on point-to- point and on-demand connections of people to places, also was not considered in this study as an individual’s travel to/from the airport to connect with another mode of travel would not support the real intention of the air taxi market.

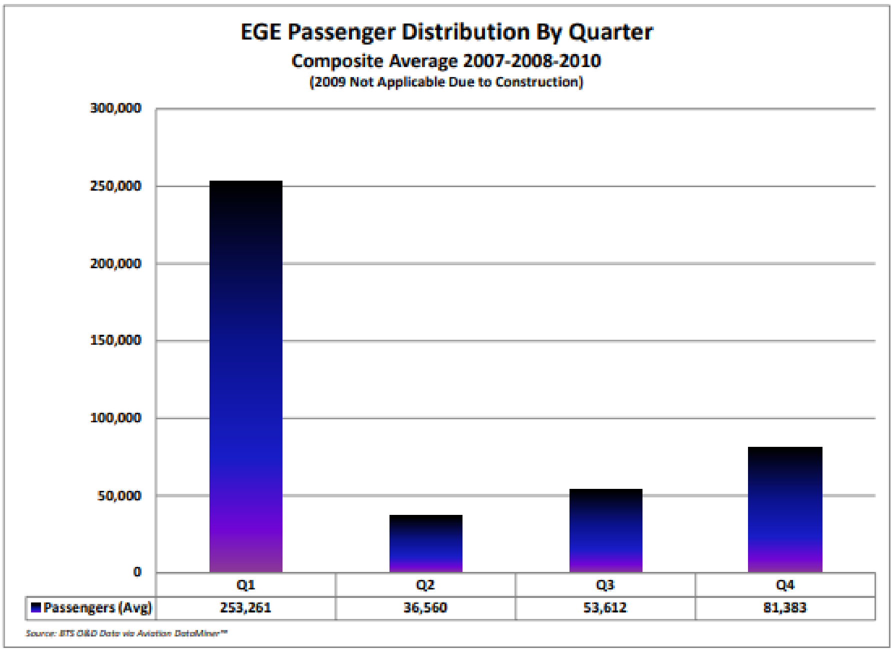
The airport shuttle market, therefore, was identified as the preferred and most likely use-case for an impactful and scalable AAM operation at the case study airports.


N
Denver International Airport
Union Station
Aurora
Eagle County Airport
Vail Ski Resort
Avon/Beaver Creek Ski Resort
Glenwood Springs
Aspen Ski Resort
Littleton
Castle Rock
Colorado Springs
Gunnison
Montrose
Fort Carson
Canon City


125 NM
92 NM
125 NM
95 NM
45 NM
185 NM
90 NM
EUG
188 NM
61 NM
118 NM
135 NM
84
5

Eagle County Regional Airport – Tourism-Driven Use

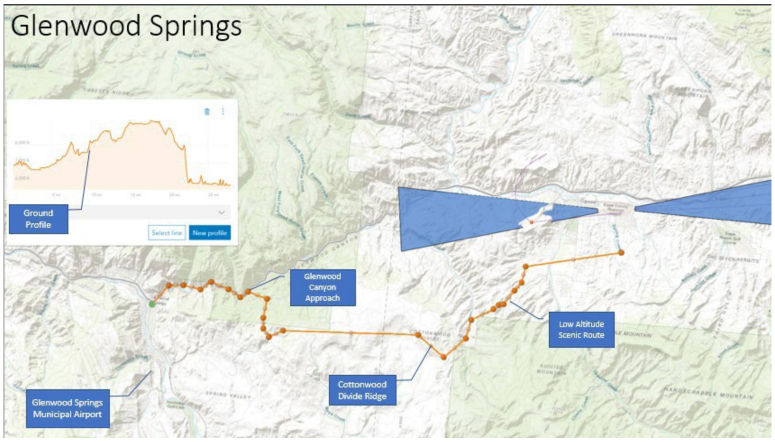
Eagle County Regional Airport is in the heart of the Rocky Mountains and in near proximity to several ski resort towns. The significant majority of EGE's traffic is related to recreation and tourism which is evident by the significant seasonality in EGE's passenger enplanements.

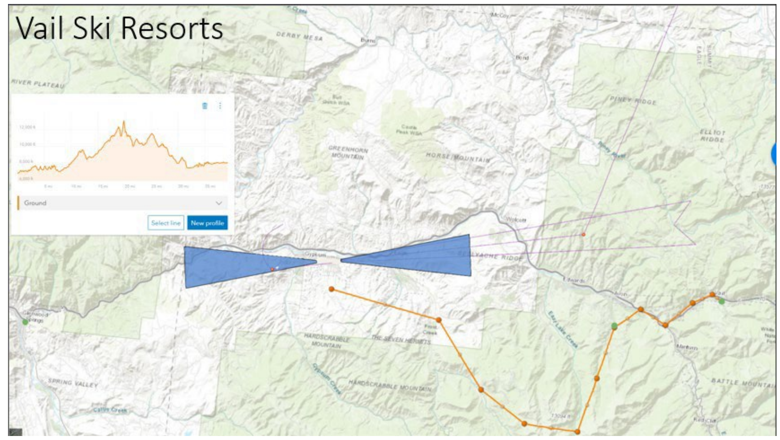


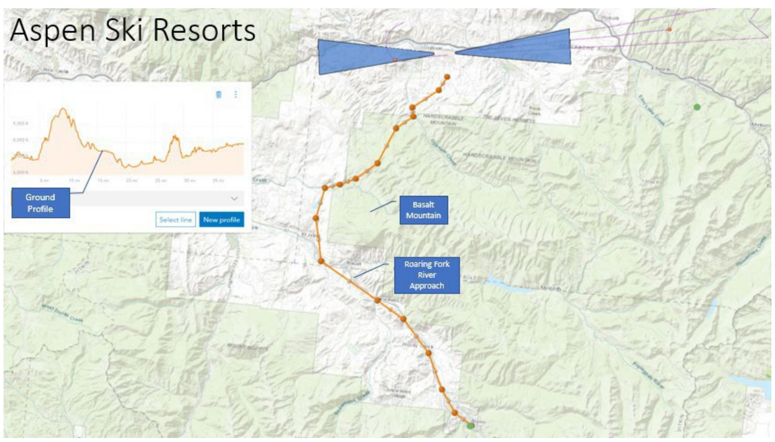
AAM Destinations

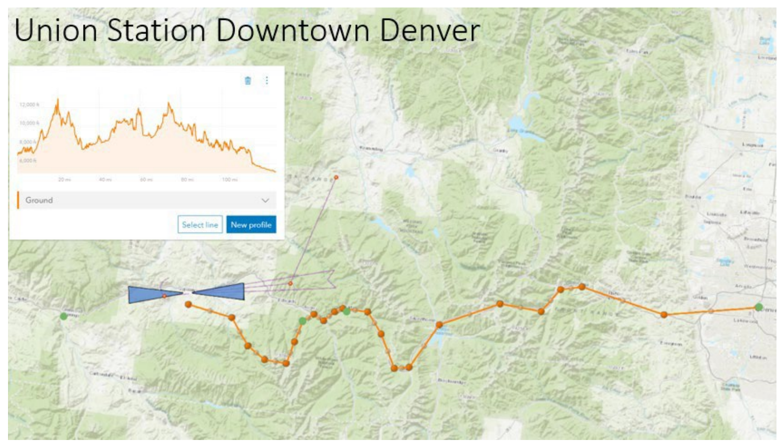
An AAM entrant to EGE largely is envisioned to focus on the tourism and leisure travelers looking for a fast and fun connection to their ultimate destination. However, service to/from the city of Denver and Denver International Airport could be attractive to a wide variety of travelers. For these reasons, the following locations were identified for potential AAM connections with EGE:

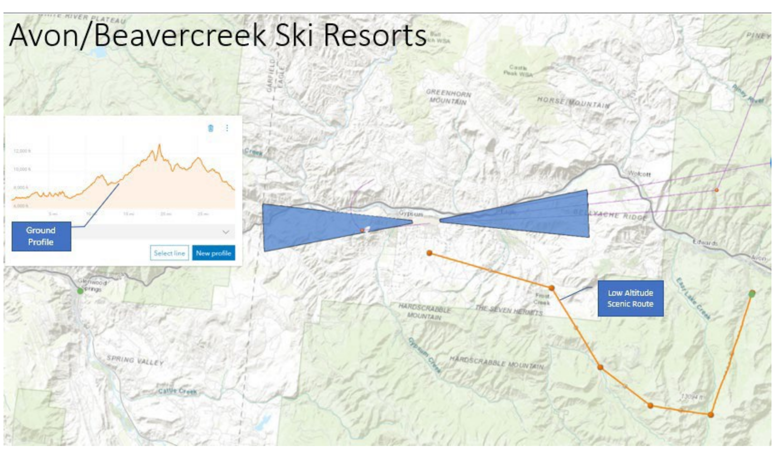
- Glenwood Springs
- Aspen Ski Resort
- Avon/Beaver Creek Ski Resort
- Vail Ski Resort
- Denver Union Station
- Denver International Airport

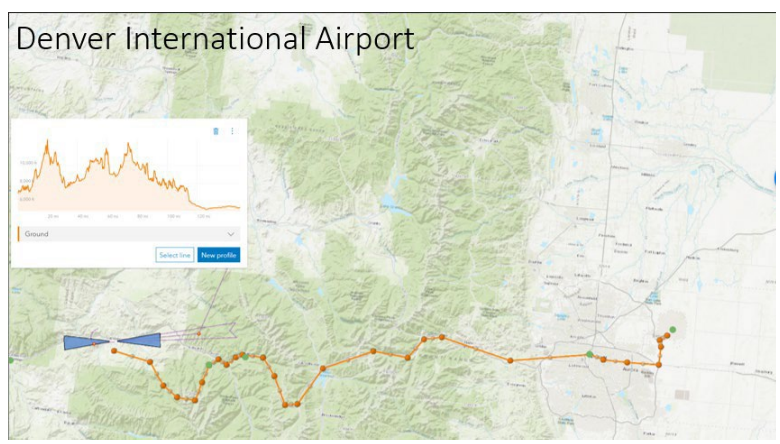

Glenwood Springs
Ground Profile
Select line
New profile
Glenwood Canyon Approach
Low Altitude Scenic Route
Cottonwood Divide Ridge
Glenwood Springs Municipal Airport


Vail Ski Resorts
Ground
Select line
New profile


Aspen Ski Resorts
Ground Profile
Select line
New profile
Basalt Mountain
Roaring Fork River Approach


Union Station Downtown Denver
Ground
Select line
New profile

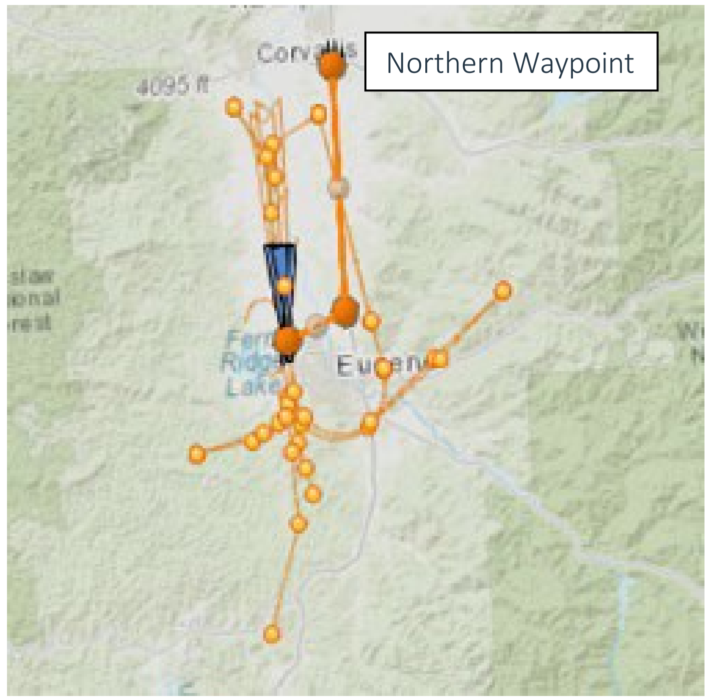

Avon/Beavercreek Ski Resorts
Ground Profile
Select line
New profile
Low Altitude Scenic Route


Denver International Airport
Ground
Select line
New profile

Eugene Mahlon Sweet Field Airport – Airport Connectedness Use

Mountain passes in Oregon create an “acute” transportation problem, particularly to remote areas. Several areas are served only by two-lane roads that can require significant maintenance in winter to remain passable. Centrally located in the state along the I-5 corridor positions Eugene well to provide significant regional connectedness to coastal and eastward communities alike.

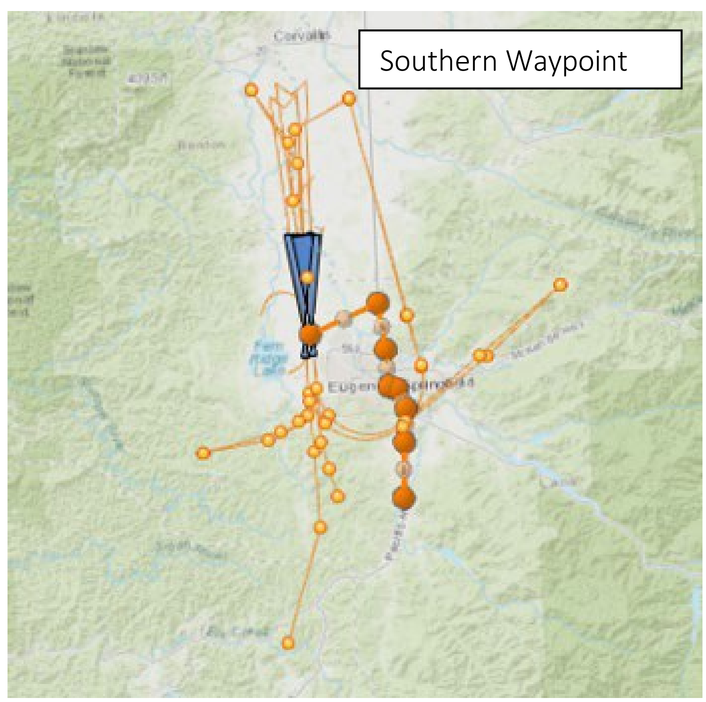
Unlike Eagle County, which has significant mountainous terrain impacting potential route corridors, Eugene and proposed routes to AAM destinations do not have limiting terrain that could impact AAM activity. As such, a focus was put to an ingress/egress corridor to ensure eVTOL aircraft can easily and safely enter and exit the terminal airspace.



A northern point and a southern point were considered to facilitate integration of the eVTOL traffic at the airport. The flight corridor will then extend along the I5 interstate with access to/from the airport along an Eastern/Western route. All arriving/departing eVTOLs can converge towards these two waypoints according to their origin/destination. The elevation of the flight paths can be defined to avoid interaction with existing ground and instrument approaches at Eugene.

Eugene Mahlon Sweet Field Airport – Vertiports Location

EUG Airport is a good example on how to integrate multiple aircraft activities such as helicopters, GA, and commercial. The dual runway system with adequate separation makes it easy to segregate traffic and improve efficiency. The surrounding airspace not being congested makes it easier for AAM to develop and use the airport.



Looking at future development at EUG and the general geometry of the airport, it will be ideal and cost effective for AAM aircraft to operate near proposed GA development to the north with easy access to Runway 16L-34R and the associated taxiway system. This part of the airport will segregate initial AAM activity from airline activity at the airport. It also has the potential for using FBO facilities and access to utilities while allowing for future development of dedicated vertiports away from the traditional commercial activity.

The main drawback of developing AAM near GA infrastructures is the location between the two runways making it impossible for AAM aircraft to operate without crossing either of the runway centerlines.

For a better segregation of AAM in terms of departures and arrivals, it would be ideal to locate future vertiport facilities east of Runway 16L- 34R with dedicated flight paths. However, this will imply the need to develop utilities and dedicated facilities in that area, which will increase the costs. Yet, this area of the airport is ideal to consider for future development if AAM becomes a big part of the airport's activity. In the meantime, AAM should operate and use existing GA/FBO facilities, as well as Runway 16L-34R.

V. Facility Siting and Operational Integration

Operationally, AAM platforms will for the most part operate in an airport's terminal environment much the same way helicopters do today. It is likely that AAM operators seeking to provide point-to-point shuttle services from an airport to regional destinations, however, would value operating from a vertiport facility where aircraft can takeoff directly from its location as opposed to flying established airspace approach and departure corridors and hover-taxiing while moving about the airfield. The FAA's draft Engineering Brief No. #105, Vertiport Design, speaks directly to the integration of vertiport facilities to enable VTOL aircraft to safely access the national airspace system. This document explores:

- Vertiport design and geometry (including safety critical elements)
- Marking, lighting, and visual aids
- Charging and electric infrastructure
- On-airport vertiport installations
- Site safety elements

For both airports, we considered a short-term adoption case and a Vertiport case. The goal of the short term was to have the ability to have electric aircraft use the facility in small numbers. In general, this consisted of placing an electric aircraft charging station (one or more) at an existing FBO or in a location that would be easily reachable. Electric aircraft would arrive and depart the airport using existing approaches and procedures and would either taxi conventionally or hover taxi to the charging location or the passenger pickup/drop-off location.

For the Vertiport case, we looked at finding an airport location that would lend itself to a vertiport without significant disruption of airport operations or the need for complicated and expensive airport improvements.

Considerations:

- Widespread use of electric aircraft not likely until 2025 or 2026.
- Power availability is critical. Power is expensive to move long distances both with cost of copper conductors and the cost of trenching across developed areas.
- Electric capacity will become a concern first with ground-based EV charging. Do not forget about electric aircraft charging when addressing ground-based and build capacity for both at the same time.

- Include an electrification component into master plans.
- Both airports are not likely locations for initial adopters due to:
    - EGE – altitude/elevation; cold weather; IFR common,
    - EUG – not a strong initial use case for AAM
- FBOs best equipped to initially service electric aircraft in low volumes and continue to service privately owned or charter uses.
- Charging station must be convenient to runway in short term use case because taxiing uses power, which is precious. If no convenient FBO location, like EUG, site a ramp area and add a charger.
- When looking for a vertiport location, approach and departure surfaces need lots of area at ground level (loss of lease revenue). When vertiport is elevated, can have development under the approach/departure that is not downwash sensitive.
- Determine if electric aircraft operation requires a mode- transfer connection to air carrier or corporate and be sure it is a very close/quick connection. A wealthy skier arriving in a G650 wants to walk down the airstairs and into the eVTOL. They will not tolerate a shuttle bus ride. Someone arriving by air carrier will tolerate more inconvenience getting to the eVTOL and then to the ski area, but if it takes 20 minutes, the eVTOL time savings over a bus or rental car goes away. Adjacencies are critical (a part of terminal planning with air carrier terminals).
- Remember that a vertiport developer can develop 10' off the airport property, if the airport makes it too difficult or expensive to develop.

Eagle County Regional Airport – Vertiport Considerations

Facility Siting

Short-Term Use Case: FBO
Vertiport-Use Case: On top floor of possible parking garage

Airspace Integration

Short-Term Use Case: Existing fixed wing approach/departure
Vertiport-Use Case: Vertiport on south side of Runway Ingress/Egress via Spring Creek Road

Downwash/Rotorwash Impacts

Short-Term Use Case: None
Vertiport-Use Case: Remain over Spring Creek Road 50'+ AGL

Lease Considerations

Short-Term Use Case: On existing FBO lease
Vertiport-Use Case: Lease top floor of parking deck (or parking lot) or airport operate

Mahlon Sweet Field Airport – Vertiport Considerations

Facility Siting

Short-Term Use Case: Air Cargo/Charter Apron. Charger may be Airport installed and maintained.
Vertiport-Use Case: Facility south of Air Cargo/Charter Apron

Airspace Integration

Short-Term Use Case: Existing fixed wing approach/departure

Vertiport-Use Case: Initial eVTOL infrastructure near proposed northern GA development
Ultimate vertiport on south side of Runway
Ingress/Egress along Interstate 5

Downwash/Rotorwash Impacts

Short-Term Use Case: None
Vertiport-Use Case: Vast open space over proposed location

Lease Considerations

Short-Term Use Case: Airport installed/operated charger
Vertiport-Use Case: Lease to developer most likely with airport developed less likely

Case Study: Medium Hub Airport

Background

More than 250 companies worldwide are reported to be in the process of developing eVTOL aircraft, with expected dates of service as early as just two to three years from now: https://spectrum.ieee.org/evtol-air-taxi-industry

As with all emerging markets, some consolidation in the industry is expected to occur. However, several of these manufacturers are backed by large amounts of funding from well-established corporations worldwide, such as Toyota, Airbus and Boeing, along with private investors from established technology companies such as Google, LinkedIn, and others.

The proposed timelines for these aircraft to enter service may be considered optimistic by some people, but the investments in these companies continue, and test flights of these aircraft are taking place worldwide to ascertain their viability for entry into the commercial service market and regular passenger-carrying operations. The AAM Reality Index https://aamrealityindex.com/, developed by SMG Consulting, assesses funding, the development team, vehicle technology, certification progress and potential for full-scale production of thousands of these aircraft per year.

Companies such as Wisk, Joby Aviation and Kitty Hawk report their first test flights took place in 2018, with expected in service dates in 2024.

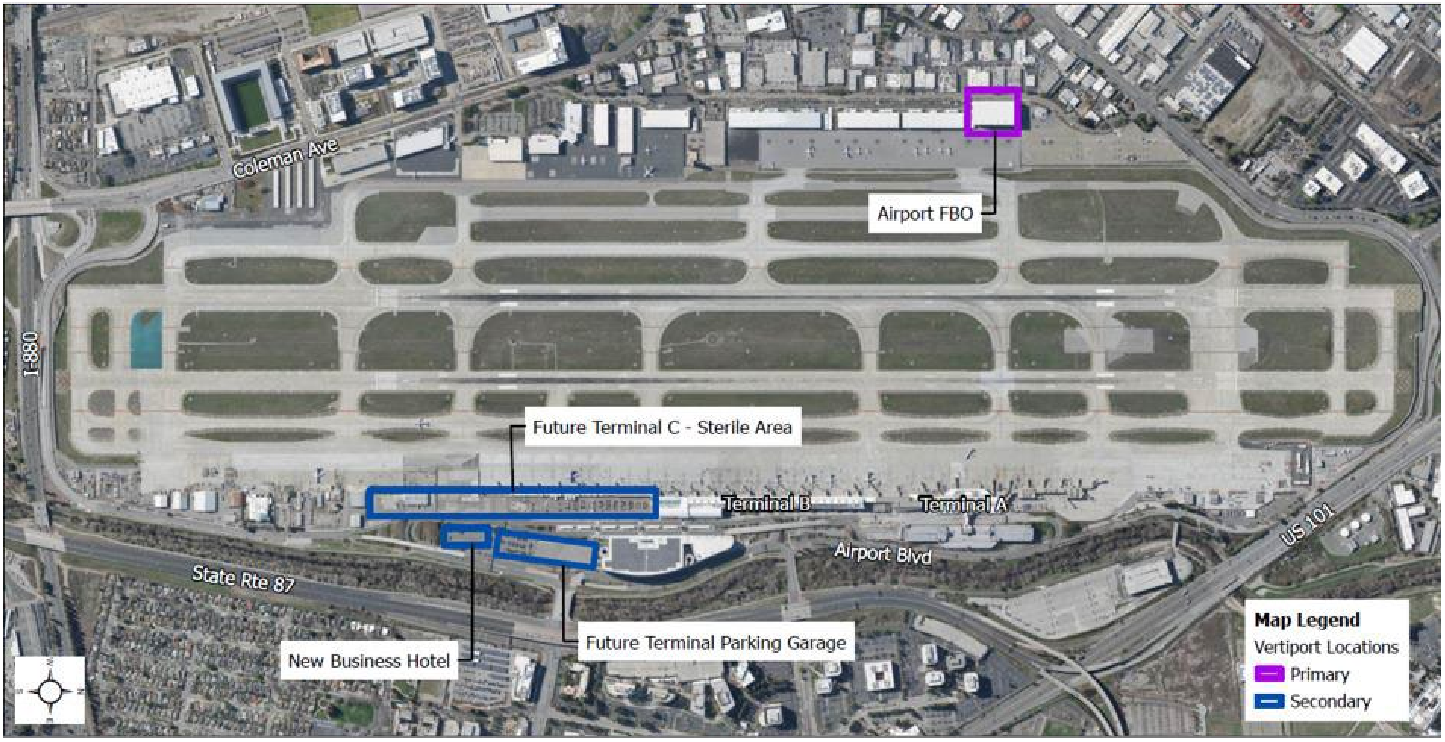
Given these timelines, it is no longer a matter of if eVTOL aircraft enter service and blend in with the already-existing technologies in the National Airspace System, but when they enter service, and if the airports will be ready for them. This case study looks at one medium-hub airport, Norman Y. Mineta San José International Airport (SJC), in San José, California, to discuss components of that airport readiness, but many of the topics would be applicable to other airports of any size.

Technical Needs and Infrastructure

With vertiports having all required infrastructure for support of eVTOL aircraft charging and vertiports being only a landing site, in our case study review, we discussed the likely use cases of these types of aircraft in our market. We currently have chargers for electric cars of various types in our passenger and employee parking lots. However, we do not have sufficient electrical infrastructure at this point for large-scale charging of airline Ground Support Equipment (GSE), so setting up charging facilities for any eVTOL aircraft would require a large capital investment. It is not known at this point if battery types will be able to be swapped between different eVTOL manufacturers' equipment and a bank of batteries could be kept on a charger and installed into each eVTOL upon its arrival at SJC to prepare it for the next flight. A quick turnaround of eVTOL aircraft is very desirable and that requires fast charging. A high level of power is only available near a power company substation. Power station spare capacity likely will need to be in the range of 5 to 10 megawatts at a minimum at 5 kV to 13.2 kV. This electrical capacity should be sufficient to support two touchdown and lift-off areas (TLOF) and up to eight parking pads.

For SJC, we looked at three potential locations for vertiports: on the ramps at our fixed based operator (FBO) locations; on our terminal landside area, most likely on top of an existing or newly constructed public parking garage; and longer term after our terminal development, integrated into the airline terminal rooftop with direct access into the Sterile Area for passengers connecting to departing airline flights. Departure points with passengers enroute to SJC would need to be in dense, urban locations to provide more potential passengers, possibly at a location with connections to other modes of transit such as commuter train or light rail.

With those three locations, the first and most likely scenario is that the FBOs would set up a location on their leased areas of the airport. SJC already has a handful of local executives who commute to their business jet via a private helicopter, and it seems this would be an easy transition to eVTOL technology after these aircraft are in service. Several of the local technology executives already are investing in the



eVTOL companies and may be early adopters of this technology to ensure ROI on their collective investments in this new technology.

Departure points for these flights could be the executive's office location or home, with higher pricing of the eVTOL flight to reflect the exclusivity of this arrangement.

If the FBOs do provide that initial vertiport location, they would take on the costs and development of any infrastructure needs, including charging, painting of landing location, clearance around their ramp areas to provide for safety of nearby users, and other supporting needs. SJC would need to verify that our Operations team and Aircraft Rescue Fire Fighters (ARFF) are familiar with the general flight operations, battery location, and emergency response procedures for such aircraft.

The second and third scenarios would entail a large capital project by the airport to support the eVTOL operations. However, some of this potentially could be contracted out if a public-private partnership were set up, or if one eVTOL company wanted to set up a proprietary location on airport. Details of this development would need to be worked out as more information becomes known about target markets and how these aircraft will integrate into the NAS.

SJC currently has public parking garages across from our two terminals, with one of the garages built in the early 1990s by Terminal A and one built in 2010. The older of the two garages would need some retrofitting and additional electrical supplies installed to support eVTOL, so will not be considered as a potential location.

Currently, the majority of our airline passengers use Terminal B across from the newer garage. An additional garage and hotel are planned for a location to the immediate south of this garage, still across the street from the terminal. With development still to come in this Terminal B frontage area, a vertiport could be included in the planning to develop the location over the next few years and have it available when the aircraft enter service.

Any location across from the terminals would need a connector path to the ticket counter lobbies and the security checkpoint. This most likely would be a walkway and crosswalks into the terminals, similar to how passengers access the terminal now when they park in the garage or return their rental cars. SJC has a single level roadway system with no plans for a second level. However, a planned new terminal could include a bridge to the second level security checkpoint location.

A third idea for eVTOL aircraft would be to have the vertiport on top of the passenger terminal with direct access into the Sterile Area for connecting airline passengers. At SJC, such a location currently does not exist, so would have to be included into the new terminal development. This concept also raises questions about security screening of passengers per TSA requirements so they can connect directly to the departing airline flights, as well as security programs for the eVTOL operators so they can land safely on the rooftop of the terminal. If these eVTOL aircraft were departing from a smaller airport, similar to a commuter flight, TSA-approved passenger screening could be conducted at that point of departure, allowing passengers to move freely into the passenger terminal boarding areas upon their arrival at SJC. Firefighting and medical response needs to be considered for safety of passengers, aircraft, and any support personnel.

It is not known at this point how many of these aircraft may be operating at any one time, but a potential need could be for some type of technology to schedule the flights using the vertiport and alert inbound aircraft of any delays incurred by departing aircraft to ensure sufficient space is available for aircraft while at the vertiport location. For our current airline flights, the flight crew requests to taxi to the gate upon arrival, and Air Traffic Control (ATC) visually can confirm if the requested gate location is available. With eVTOL potentially landing on top of a parking garage out of line of sight of ATC, some other method would need to be used to control who has access to the facility and for how long. The airport potentially could assume this task on or contract the operation out to a third party to manage.

SJC is not subject to extreme weather, although recent years have included some days of wildfire smoke a few days over 100 degrees, and some rain and fog, calling for a possible shelter facility of some sort as passengers wait for their eVTOL flight or as they transition to the terminal area after arrival.

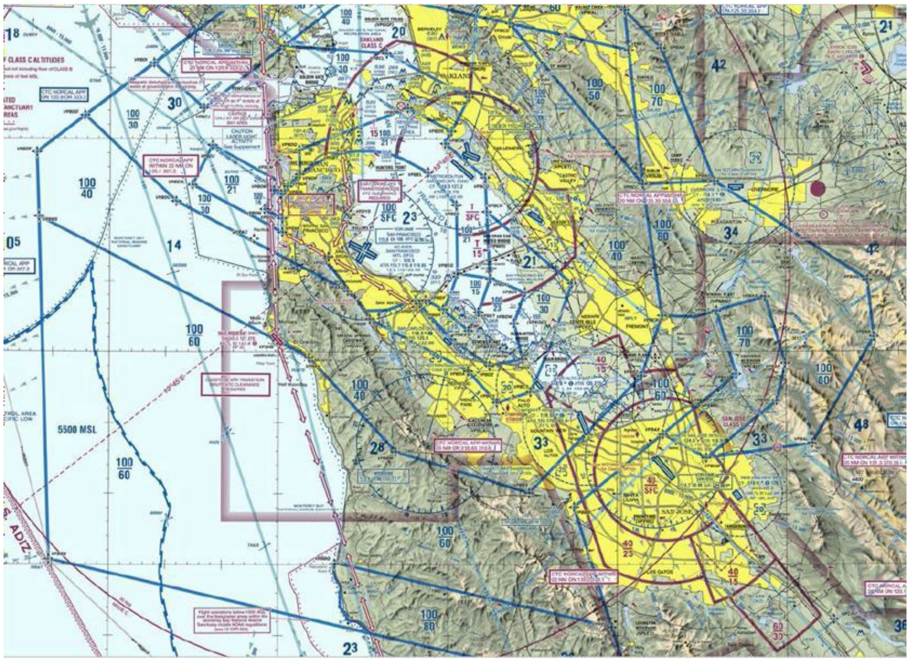
One eVTOL developer has developed a Concept of Operations in partnership with UK-based company, Skyports, and this document calls for multiple aircraft parking and charging areas with space for several employees to monitor aircraft and passengers during regular and emergency operations. https://wisk.aero/news/press-release/wisk-skyports-partnership-conops/

Airspace

Integrating eVTOL aircraft into the SJC Class C airspace would call for these aircraft to follow the flight paths currently used by general aviation light aircraft and helicopter operations. SJC has two parallel runways, each 11,000 by 150 feet, used by air carrier aircraft. Given the potential 6 to 8 minutes for an eVTOL aircraft to land and clear the runway prior to another aircraft using it, some delays could occur in our air carrier and business jet operations due to the slower speeds of the eVTOL aircraft. Wake turbulence is another consideration as eVTOL aircraft could weigh 7,000 lbs. maximum take- off weight, so would need to be considered like a small GA aircraft as far as maintaining clearance from other aircraft takeoffs and landings.

Archer Aviation envisions its aircraft flying at 2,000 to 3,000 feet, although it does not state a typical cruising speed for consideration of how the company's services will integrate with current general aviation and other air traffic. https://www.archer.com/faq

Another component of the airspace discussion is that of airport noise for our surrounding community. The immediate SJC area residential neighborhoods have been soundproofed and are already compatible with our existing fleet mix of aircraft as far as noise concerns go. However, the noise still can be an annoyance and lead to complaints to the airport. The occasional GA aircraft or helicopter currently operates with minimal concern expressed from the local community, but if large



numbers of eVTOL aircraft started to operate and flew the same flight paths repeatedly, there would need to be some outreach to the local community and possible noise and environmental studies. Joby Aviation https://www.jobyaviation.com/news/joby-revolutionary-low-noise-footprint-nasa-testing/recently reported the demonstrated low-noise levels for its aircraft. However, the response from the public to a different noise signature than the typical jet airline noise remains to be seen.

Although it was several years ago now, a nearby GA airport was subject to numerous noise complaints after the start-up of Pilatus operator Surf Air. Complainers were located several miles away from the airport and objected to the sudden increase in operations along defined flight paths with the specific noise footprint of that type of aircraft: https://www.almanacnews.com/news/2017/06/18/protesters-picket-surf-air-at-san-carlos-airport. A similar type of response could be expected with eVTOL aircraft continually flying specific flight paths into or out of SJC.

Local Market

The city of San José has marketed itself as "the Capital of Silicon Valley" for many years now. The local area is populated by established technology companies, start-ups, venture capital and other investment firms and an educated population with an income that could allow some of these individuals to become early adopters of the eVTOL services.

Prior to Covid-19, SJC was one of the fastest growing airports in the country for several years in a row, and the local economy was showing corresponding growth. This resulted in the usual byproduct of heavy traffic to and from workplaces and the airport, airport parking lots that would regular fill up and have no spaces available for several hours of the day, and congestion of cars and Transportation Network Companies (TNCs, such as Uber and Lyft) along the terminal curbs. All of this congestion leads to the old adage that "time is money," and someone with disposable income to spare potentially could take an eVTOL to the airport for their flight, bypassing all the traffic and parking woes, and maximizing use of their personal time.

Looking at investor information on eVTOL developers' websites, including Wisk, Joby and Archer Aviation, the potential passengers for these aircraft are people taking a short ride connecting from one transit hub to another, with Joby stating they anticipate pricing at $3 to $4 per mile for each passenger. https://evtol.com/news/glimpse-into-wisks-6th-generation-evtol-aircraft/.

A survey conducted by Wisk Aero https://wisk.aero/news/blog/wisk-releases-consumer-sentiment-research-on-autonomous-air-taxi-

Rank	Company	Local	Worldwide
1	Alphabet/Google	36,603	150,000
2	Apple	25,000	147,000
3	Facebook/Meta	17,000	58,604
4	Tesla	13,000	70,757
5	Cisco	12,740	77,500
6	Intel	7,143	110,581
7	Applied Materials	6,400	24,000
8	VMware	5,870	34,618
9	Linkedin	5,542	20,500
10	HP Inc.	5,000	53,000
11	SAP	4,300	102,430
12	Lockheed Martin	4,100	114,000
13	Gilead Sciences	4,000	13,500
14	Amazon	3,748	1,298,000
15	Adobe	3,731	23,000
16	Western Digital	3,712	63,800
17	PayPal	3,300	26,500
18	eBay	3,300	13,000
19	Visa	3,269	20,500
20	Advanced Micro	3,000	12,600
21	Lam Research	2,800	12,200
22	Flex Ltd	2,732	200,000
23	Intuit	2,642	10,600
24	HP Enterprise	2,400	60,000
25	Super Micro	2,396	3,987
	Top 25	183,728	2,720,677

Total tech employment of 250,000+ and global travel tied to larger worldwide employment base

services/ provided some information regarding potential “early adopters” of eVTOL services due to unpredictability of ground-based commute times. Sixty-eight percent of their respondents stated they would be likely to use an eVTOL aircraft when traveling out of town for work, and 57% would use it for commuting to or from work.

The eVTOL aircraft developers’ websites identify target markets as urban areas, including New York, Los Angeles, and San Francisco/Bay Area urban markets. Archer Aviation announced in February 2021 that its launch of initial commercial operations would take place in Los Angeles. https://s27.q4cdn.com/936913558/files/doc_presentations/2021/Updated-Archer-NDR-Closing-Deck-vF_09.07.21.pdf

Wisk Aero’s investor information had suggested making reservations for their flights, but other eVTOL developers are focusing on an app- based service. Joby’s acquisition of Uber Elevate could serve as a basis for easily calling up an eVTOL with the Uber app so an Uber car could pick up the passenger and transport them to a nearby vertiport for their flight.

Current Developments

FAA recently announced potential changes to pilot certification for eVTOL operations and it is unknown how long of a delay this may cause to eVTOL operations becoming commonplace in the National Airspace System.

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This case study was made possible through the contributions of the following San José International Airport Individuals:

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Case Study: Large Hub Airport

Introduction

Advanced air mobility (AAM) seeks to transform transportation through emerging technology for electric vertical takeoff and landing (eVTOL) aircraft. As this technology gains traction, the need for supporting infrastructure to accommodate vertical flight landing and takeoffs has become clearer. While a previous case study looked at small to medium hub airports, large hub airports offer a unique set of opportunities and challenges. Given the volume and diversity of business uses that occur at a large hub airport, service of eVTOL similarly may need to be sized to support multiple purpose uses of this type of aircraft. This case study presents the findings of a preliminary evaluation at a large hub airport seeking to explore the possibility of serving eVTOL aircraft and furthering the AAM movement.

Case Study

Phoenix Sky Harbor International Airport (Sky Harbor) in Arizona was the subject of this case study, as a representative public use, commercial service airport in the large hub category. Within the United States, Sky Harbor was the eighth busiest airport as of 2021. Considering pre-pandemic metrics as indicators of typical service, Sky Harbor experiences more than 125,000 passengers and 1,200 aircraft arriving and departing daily with 46.3 million passengers recorded in 2019. Flights at Sky Harbor serve more than 100 domestic and 22 international destinations. Daily, more than 2 million pounds of cargo are hauled, and 5,300 cars rented. As a critical economic engine for the city and state, Sky Harbor has a total economic impact of more than $38 billion per year; provides nearly 58,000 jobs and opportunities for businesses; and was ranked as the #1 airport in the United States by the *Wall Street Journal* in 2019.

Sky Harbor is located approximately four miles east of the downtown Phoenix area. The airport serves the entire Phoenix metropolitan area, including the major cities of Glendale, Mesa, Scottsdale, and Tempe, plus all of Maricopa and Pinal counties and is the only large hub airport in the state. Phoenix is a popular tourist destination with attractions including resorts, spas, professional sporting events, shopping, golf, restaurants, and nightlife, all set amidst the Sonoran Desert. The area also offers cultural and natural resource attractions such as museums and galleries, Old West and Native American history, and outdoor recreation facilitated by more than 300 days of sunshine each year. In addition to the attractions within the Phoenix area, northern Arizona is home to Grand Canyon National Park, the Red Rock Country of Sedona, the Painted Desert, the Petrified Forest, Meteor Crater, ancient Native American ruins, and the Navajo and Hopi reservations.

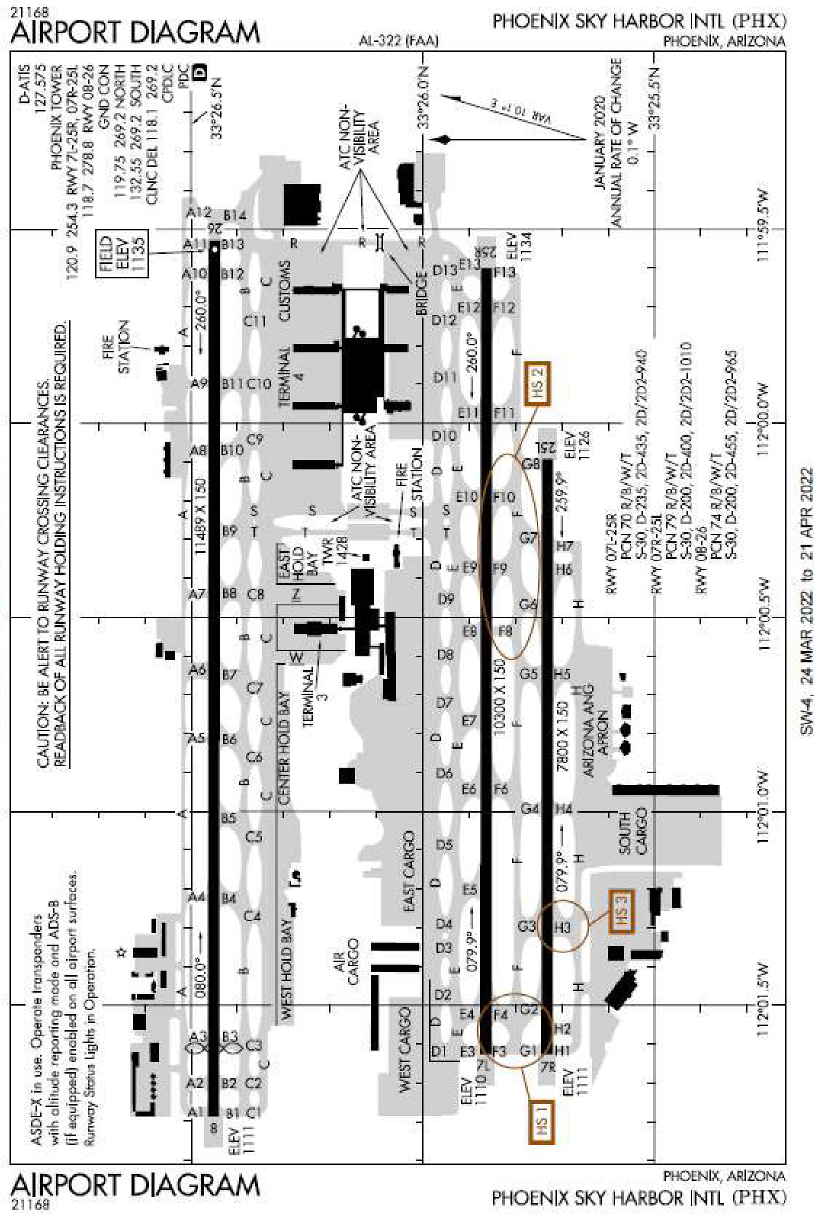
Climate

Located within the Salt River Valley in central Arizona, the Phoenix area is widely known for its arid climate with mild winters and hot summers. On average, temperatures exceed 100 degrees Fahrenheit 110 days per year with only two days in which temperatures fall at or below freezing. The area receives low annual rainfall averaging 8.3 inches per year. The average wind speed is 8 miles per hour, generally from the south/southwest.

Airport Configuration

The Sky Harbor property has a footprint of nearly 3,400 acres, featuring two terminals with 106 active gates and the following three parallel runways:

- North Runway - designated 8/26 is 11,489 feet long and 150 feet wide; highest elevation 1,135 mean sea level (MSL);
- Center Runway - designated 7L/25R is 10,300 feet long and 150 feet wide; highest elevation 1,134 MSL; and
- South Runway - designated 7R/25L is 7,800 feet long and 150 feet wide; highest elevation 1,126 MSL.



Access based on primary Visual Flight Rules (VFR) is through a split flow east and west.

Future Growth

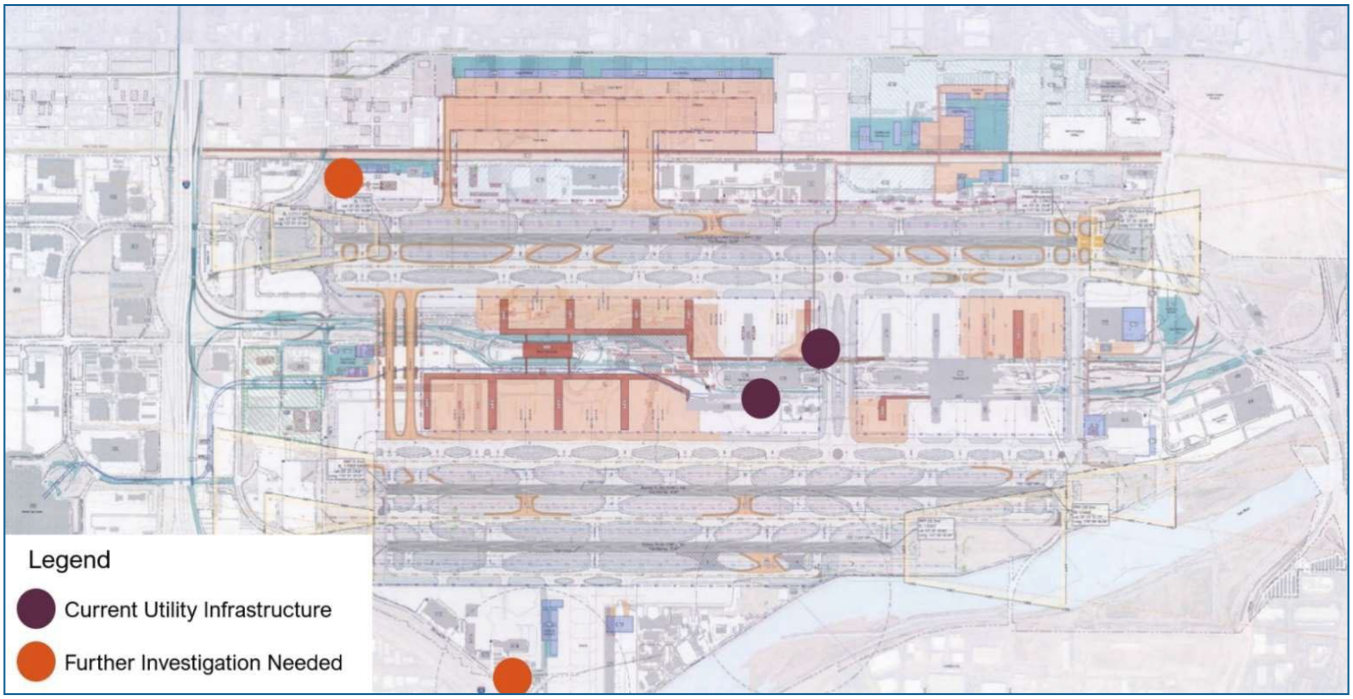
The airport maintains a Comprehensive Asset Management Plan (CAMP) that guides the airport growth and development for 20 years within a strategic framework that reflects priorities, airport operational characteristics and other relevant factors. The CAMP provides a road map for efficiently accommodating aviation demand through the foreseeable future, while preserving the flexibility necessary to respond to evolving industry conditions, the regulatory environment, and the characteristics of airport activity. The CAMP was completed in 2019 and updated in 2022. As industry conditions continue to evolve, the CAMP will serve as the framework and process for incorporating change.

Evaluation

An AAM working group was convened to conduct a preliminary evaluation at Sky Harbor to identify at least four locations on the property with potential for supporting eVTOL aircraft bases. Criteria include availability of adequate space, availability of nearby electrical infrastructure and proximity to related services (i.e., terminals for passenger access or facilities for cargo distribution). Additionally, consideration was given as to how the introduction of eVTOL aircraft might affect flight paths. The figure below shows the four possible locations, overlaid on the CAMP facility diagram.

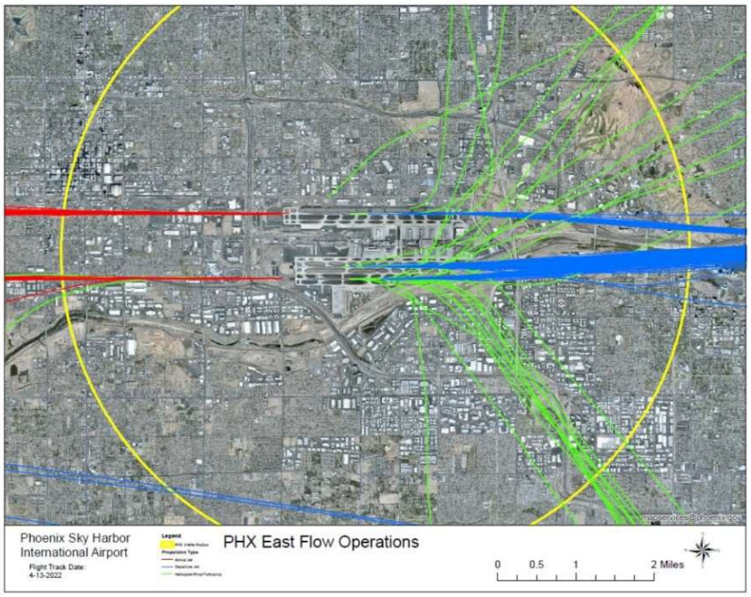
Electric Infrastructure Considerations

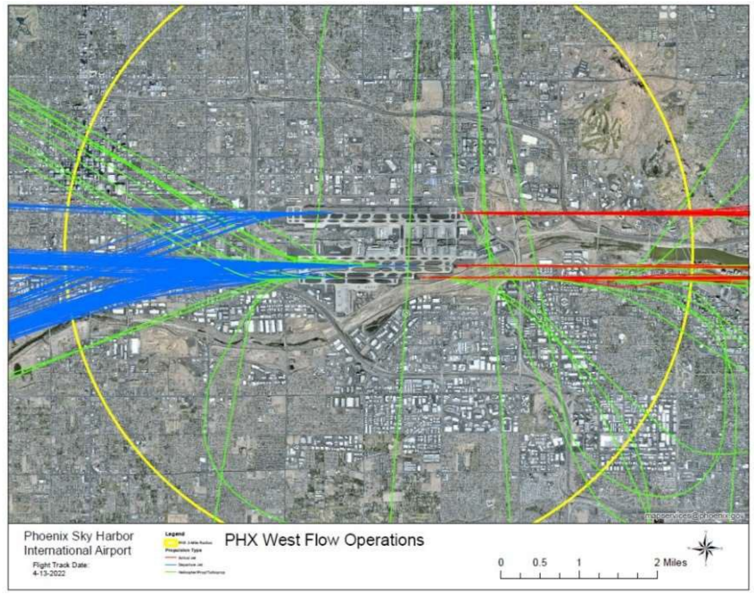
The working group evaluated existing infrastructure at Sky Harbor compared to potential electrical needs of emerging eVTOL aircraft purported to be around 1 – 1.5 megawatts (MW) for passenger eVTOL, based on information obtained on Lilium Jet and Joby S4 aircraft in the AAM small and medium hub case study. Considering the possibility that multiple aircraft may use a singular location, the working group assumed up to 6 aircraft, for a power requirement of 5 to 10 MW per location. With this in mind, the working group solicited input from the electrical utility, Arizona Public Service, to contribute to the evaluation of the electrical infrastructure capabilities and possibility of expansion in potential locations. The working group determined that the current electrical distribution was not sufficient and further evaluation and expansion will be needed. Furthermore, the resiliency of electrical infrastructure may be impacted by increased demand. Opportunities are available within existing unused conduits, which provide options to bring in additional power. Furthermore, a new substation is planned on the west side of the airport that will provide additional power. Ultimately, the need was identified for a detailed evaluation of current electricity infrastructure (i.e., a Utility Master Plan) to analyze and describe current conditions as well as inform future decisions.



Flight Path Considerations

The figures below depict the typical east and west flow operations with green lines displaying flight paths of helicopter, single piston, double piston turboprops ranging from personally owned, business, medical, and cargo flights. The working group considered that the introduction of eVTOL may eliminate some of these paths as these small cargo aircraft would take off from areas outside of the runway.





Next Steps

Through this preliminary study, the working group identified areas for further evaluation to consider including the following:

- What are the exact electrical infrastructure and capacity requirements?
- What space is needed to support eVTOL aircraft (i.e., how large will aircraft be)?
- Will there be any additional Aircraft Rescue and Fire Fighting needs due to the nature of the aircraft or supporting equipment?
- Should a landside location be investigated?

As the development of eVTOL aircraft technology continues to take shape, these and other infrastructure needs to support these aircraft continue to evolve, requiring further evaluation. The AAM working group plans to continue the case study, researching this emerging market, and developing an understanding of how to support AAM, culminating in an AAM plan for Sky Harbor, as well as the reliever airports, Goodyear Airport and Deer Valley Airport.

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