Advanced Air Mobility

Background

In 2020 Census, the U.S. Census Bureau reported that 80% of nation's population lives in urban areas, an increase of 6.4% from 2010.[1] This increased urbanization is expected to create a need for new ways to move people throughout the urban landscape as ground transportation infrastructure becomes ever more congested. The Minneapolis-St Paul Metropolitan Statistical Area, the Census defined urbanized area of the Twin Cities covers 3.7 million residents within over 8,000 square miles. Recent advancements in the automotive and aviation industries continue to be made in electric motor propulsion, battery capacity, hydrogen fuel cell technology, and charging infrastructure. In addition, flight control and avionics automation have advanced to the point that General Aviation (GA) aircraft can operate without a pilot directly on-board a craft.

The transportation sector is a major contributor to greenhouse gas emissions (GHG), making up 28% of total GHG emissions in the U.S.[2] Any new transportation technologies should provide safe and sustainable solutions while minimizing impacts to the natural and urban built environment across the shared National Airspace System (NAS). As all AAM aircraft are being planned and designed with electric or other power sources which do not burn fossil fuels, this technology provides an opportunity to reduce emissions in the aviation sector as the technology matures and is further integrated into the NAS.

To address the predicted desire for and growth in the use of advanced, highly automated aerial transportation that can provide point-to-point and other services, Advanced Air Mobility (AAM) is a rapidly emerging aviation sector. Under the umbrella of AAM, Urban Air Mobility (UAM) is focused primarily on passenger and freight transportation in urban areas and is the focus of this paper.[3] Several manufacturers are constructing and testing novel Vertical Takeoff and Landing (VTOL) aircraft that can operate without relying on a traditional runway. Also known as powered lift aircraft or multirotor aircraft, and similar to helicopters in operation, VTOL AAM aircraft will require designated spaces for takeoff/landing, known as vertiports. Since existing and proposed VTOL aircraft use more sustainable electric propulsion derived from battery or hydrogen fuel cell technology, these aircraft are known as eVTOLs, requiring vertiport design integrating new charging and/or hydrogen fueling facilities. Initial AAM aircraft regulations in the U.S. will require a pilot onboard during operations, but manufacturers are already introducing production ready aircraft that use advanced automation to operate without an operator.[4]

Highlighting the rapid growth and importance of AAM, the FAA Reauthorization Act of 2024 contains specific provisions addressing its safe and orderly incorporation in the NAS.[5]

1. In keeping with its history as leading the development of aviation, the United States should take an active role as a global leader in AAM.
2. Congress has tasked the FAA with prioritizing rulemaking in the certification of powered-lift aircraft and pilots, and publishing policies necessary to begin commercial operations. This is to include work with global policy makers, namely the International Civil Aviation

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[1] Nation's Urban and Rural Populations Shift Following 2020 Census, U.S. Census Bureau, Dec. 29, 2022
[2] Fast Facts on Transportation Greenhouse Gas Emissions, U.S. Environmental Protection Agency
[3] Advanced Air Mobility, Aeronautic Information Manual, Chapter 11, Section 6 Federal Aviation Administration (FAA)
[4] EHang Secures Production Certificate from CAAC, Clearing Path for Mass Production of EH216-S Pilotless eVTOL Aircraft, GlobeNewswire, Apr. 7, 2024
[5] Securing Growth and Robust Leadership in American Aviation Act, H.R.3935 – 118th Congress (2024)

Organization (ICAO) and international aerospace corporations to coordinate AAM regulations and promote AAM aircraft adoption.
3. To incorporate AAM into the existing NAS to the greatest extent possible.

The Reauthorization Act also requires the FAA to coordinate with the Agility Prime program of the U.S. Air Force. Part of the Air Force Research Laboratory (AFRL), this program is tasked with bringing regulatory and manufacturing stakeholders together to advance the development of eVTOL technology as rapidly and safely as possible.[6] Based on research conducted by the National Aeronautics and Space Administration (NASA), Agility Prime envisions powered-lift aircraft operating in both civilian and military roles including search and rescue/medical evacuation (Medevac), disaster relief, firefighting, humanitarian aid, logistics and personnel movement.[7]

eVTOL Aircraft in Development

A majority of the manufacturers developing AAM eVTOL aircraft are new startup companies with support from legacy fixed-wing and helicopter manufacturers. A few designs have begun manned flight testing. For regulations of AAM aircraft, two key types of aircraft are described below.

- Multicopter – a type of aircraft that has more than two rotors for lifting and looks similar to a regular helicopter.


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- Powered-lift – a term which includes two different types of aircraft design that are considered the same for regulatory purposes.
    - Lift & Cruise – an aircraft that has special rotors for lifting straight up and down, and different rotors and wings for flying like a traditional airplane.

[6] AFWERX Agility Prime – A New Era of Aerospace, Air Force Research Laboratory, Nov. 21, 2021
[7] NASA Electric Vertical Takeoff and Landing (eVTOL) Aircraft Technology for Public Services – A White Paper, NASA Technical Reports Server, Aug. 2021
[8] Volocopter VoloCity (prototype), Electric VTOL News, Nov. 11, 2024


[9]

- Vectored Thrust – an aircraft that has several rotors that can point up for lifting straight up, and then can move horizontal to help it fly forward.


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eVTOL Economics

As this technology is still in relative infancy, predictions of eVTOL economics, from the cost of individual aircraft to the cost of passenger service vary widely based on source and area of study. The cost per passenger-mile estimates range between $2 and $11, depending on the source.[11] Manufacturers of aircraft now entering initial production are reporting prices between $190,000 and $334,000 for small single and dual seat models.[12] The cost of larger aircraft are expected to cost over $1.2 million.[13]

The probability that manufacturers' cost estimates underestimate the actual economics of eVTOL transportation has led some analysts to view AAM aircraft as eventual replacements for existing helicopters. Traditional helicopter usage entails a high operational cost due to mechanical complexity, maintenance costs and large fuel consumption. As such, AAM aircraft would reap the benefits of lower maintenance and crewing costs, reduced environmental

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[9] Beta's Alia Makes Historic Transition Flight, Electric VTOL News, Nov. 11, 2024
[10] Joby Aviation S4 2.0 (pre-production prototype), Electric VTOL News, Nov. 11, 2024
[11] How Much Will It Cost to Fly On eVTOL Air Taxis, Flying, Nov. 8, 2021
[12] Helix eVTOL Flying Craft Starts At $190,000, Deliveries Start June 10, Autoweek, Jan. 8, 2024, EHang Prices Its Two-Seat Autonomous eVTOL Aircraft At $334,000, AIN Online, Feb. 2, 2024
[13] How Much Does It Really Cost to Run an Air Taxi?, eVTOLInsights.com, May 8, 2023

impacts through electric and/or hydrogen powered propulsion, yet fall short of the vision of expanding VTOL mobility to a significantly wider portion of society beyond the reach of existing helicopter usage.

Infrastructure and Facility Development

Aside from aircraft development and airspace regulations, vertiport design standards are needed to support eVTOL operations. To that end, the reauthorization act directs the FAA to update the 2022 memorandum titled “Engineering Brief (EB) 105, Vertiport Design”, with the ultimate goal of publishing a full vertiport design advisory circular no later than the end of 2025.

Figure 1

FAA’s vertiport engineering brief highlights high-level facility requirements to safely support future AAM operations an example of which is depicted in the above graphic.[14] These include:

- Designated takeoff/landing areas that separate vertically moving aircraft from fixed facilities, other aircraft, and people.
- Aircraft parking spaces that include charging/refueling equipment for proposed electric and hybrid/hydrogen power eVTOL aircraft under development.
- Designated aircraft loading areas that minimize the interaction between passengers, charging/fueling equipment, and moving aircraft
- Landside facing Arrival/Departure building connecting the Vertiport to surrounding land uses, vehicle parking, multi-modal transportation, and pedestrians.
- Security fencing and barriers to protect against inadvertent access to airside areas and moving aircraft.

Vertiport Land Use

For AAM to be of value, it is likely that vertiport construction will be required in multiple locations within urban areas, surrounded by high density land uses such as business centers,

[14] Engineering Brief No. 105, Vertiport Design, Federal Aviation Administration, Sept. 21, 2022

sports/entertainment venues, cargo/freight distribution centers, and intermodal transportation hubs.[15] This connection to higher intensity uses lends vertiports to integrating within existing built environments with conducive surrounding land uses rather than in greenfield sites without existing activity drivers. Many of the land uses associated with these industries are already zoned favorably to mitigate the negative consequences of aircraft operations including noise and privacy concerns, however the versatility of these facilities could see them proliferate in many areas of a region as the mode becomes more integrated into regional transportation networks.

Generally, urbanized areas are likely to include larger and taller buildings, including high-rise structures and skyscrapers, that will conflict with airspace requirements in approach and departure corridors for AAM aircraft. Also, many major cities already have a large number of commercial, passenger, and general aviation fixed wing aircraft and helicopters operating within the airspace. Any future vertiport siting criteria will have to include provisions to safely integrate AAM aircraft into occupied airspace around existing airports.

AAM and vertiports can also be viewed as a sustainable solution to connect metropolitan regions that suffer from surface traffic congestion.[16] A focused view of the San Francisco Bay area sees multiple communities, major cities, and economic centers separated by large bodies of water, requiring land transportation to funnel over numerous bridges and freeways, leading to extensive traffic congestion. Similar congestion exists in all major metropolitan area as legacy road networks have prioritized large corridors with condensed vehicular travel. Ideally, AAM may connect population and urban centers, which could provide a more reliable high speed connection between locations where congestion on the surface transportation system is heavy. Widespread AAM use could reduce response times for critical emergency services, local freight and passenger needs and complement surface transportation systems to reduce the burden on overextended systems.

New vertiport construction in residential areas could help to connect the rapidly expanding demand for housing with job and recreation centers. AAM operations within residential areas and around sensitive public land uses such as schools, parks, nature areas, and religious facilities could, however, be accompanied by noise and privacy complaints, and concerns over safety to private property and "visual" airspace congestion. An early study of eVTOL noise levels suggest that, while these aircraft will be significantly quieter than helicopters in all regimes of flight, AAM takeoffs and landings will still produce noticeable noise within a distance of several hundred feet.[17] AAM generated noise may be able to be mitigated by incorporating Transit Oriented Development (TOD) principles into residential neighborhood design or advanced land use planning to ensure compatibility between vertiport facilities and neighboring uses. As such, planning of AAM corridors and areas of low altitude operations can be focused on land uses amenable to potential noise impacts within the immediate vicinity of the vertiport. Vertiport siting criteria may be based on a set of prescribed distances from land uses deemed sensitive based on aircraft size and noise profile.[18] As the technology matures and federal guidance evolves, strategies to incorporate AAM into regional transportation networks and

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[15] Advanced Air Mobility Vertiport Considerations: A List and Overview, Nancy Mendonca, James Murphy, Michael D. Patterson, Rex Alexander, Gabriela Juarex and Clint Harper, American Institute of Aeronautics and Astronautics (AIAA) Aviation 2022 Forum, Jun. 20, 2022

[16] Land Use Analysis on Vertiports on a Case Study of the San Francisco Bay Area, San Jose State University, Mineta Transportation Institute, May 2023

[17] NASA Acoustic Testing Puts Real Numbers on Joby's eVTOL Noise Signature, New Atlas, May, 10, 2022

[18] Final Programmatic Environmental Assessment, Mitigated Finding of No Significant Impact, and Record of Decision for Drone Package Delivery in North Carolina, FAA, July 2024

impacts from operations are mitigated should be pursued to ensure this new technology benefits communities.

Existing Vertiports and State/Regional Level Planning

Still in nascent development stages, few vertiports are in operational status. Located roughly 2 miles from the Loop in downtown Chicago, Vertiport Chicago[19] follows a layout very similar to the FAA **Figure 1** above with a single takeoff/landing area and six parking spaces for AAM aircraft. At roughly the size of three city blocks, smaller than the neighboring Costco, it is located less than a mile from major hospital and health campuses, a large warehousing and shipping district, and is next to a mass transit rail line, combing multiple potential AAM use cases with additional multimodal flexibility. The Dallas CBD Heliport/Vertiport is described as the world's largest elevated Heliport/Vertiport, accommodating parking space for up to five aircraft and has two takeoff/landing areas. It is located within the Central Business District (CBD) of Dallas above a parking structure next to the large convention center complex.

These examples highlight a signature of vertiport design. A relatively small allotment of land or the top of a building or parking structure is sufficient to accommodate AAM operations. This allows for a multitude of potential vertiport sites within the already built environment. These examples also take advantage of an existing variety of surrounding potential AAM users, with access to a multimodal transportation network, boosting the potential economic vitality of these sites within a notably nascent, but growing industry.

In a desire to remain at the forefront of the aerospace industry, Ohio, the home of the Wright Brothers, developed the Ohio AAM Framework through the Ohio Department of Transportation's DriveOhio initiative.[20] A comprehensive guide to AAM aircraft, needed infrastructure, land use controls, vertiport siting, and future steps, the Ohio AAM Framework aims to present a how-to guide for integrating AAM. The City of Orlando published its Advanced Air Mobility Transportation Plan in 2021,[21] also contributing to discussions of novel AAM development and vertiport design.

Of note, these studies acknowledge the authority the FAA exercises concerning the NAS. Outside of federally obligated airports, however, state and local land use controls through planning and zoning, municipal ownership of landside facilities, and intermodal connections, have the greatest influence on the location of vertiports and AAM corridors. Aside from air tourism, AAM flight paths are likely to be designed to connect two points in the shortest possible distance. Land use regulations pertaining to safety and security, obstruction mitigation, and noise and congestion sensitivity, will dictate the course of potential flight paths. As such, the location of vertiport investment will revolve around the likely best arrival and departure points along those corridors with the lowest negative impacts and highest operational efficiencies.

MnDOT Aeronautics has begun to evaluate AAM and the challenges and opportunities of incorporating the potentially transformative technology into the existing state aviation system, including proposed future airport and vertiport design standards and the infrastructure improvements needed to accommodate the safe and efficient operation of eVTOL aircraft. See the trend paper on alternative fuels and power sources for more information on MnDOT's initial analysis on AAM integration.

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[19] Vertiport Chicago, Aug. 20, 2024
[20] Advanced Air Mobility, DriveOhio, Ohio Department of Transportation, Jul. 2022
[21] Advanced Air Mobility (AAM) Transportation Plan, City of Orlando, Feb. 2021

Conclusion

Advancements in electric battery and propulsion technology, and the growth in adoption of advanced navigation, avionics, and control automation, have led to the rapid growth of Advanced Air Mobility. Long considered science fiction, and perpetually ten-to-twenty years distant, this technology is now moving toward near-term adoption. One of the goals of AAM, at least in its vision, is to lower the cost of entry in VTOL mobility. Existing helicopter travel is extremely expensive and thus limited in use. Should the lofty predictions of favorable eVTOL economics come to fruition, there may be an expansion in VTOL mobility to a much wider swath of society.

Legacy aerospace manufacturers are joined by small newcomers, together contributing a diverse collection of aircraft in various stages of design and development. Federal, state, and local agencies are attempting to craft new regulations and ordinances for a technology that is brand new and not thoroughly tested. In addition, the market for these aircraft and the eventual facility and infrastructure needs are cloudy estimations. What is clear, however, is adoption of AAM at even minor levels will require land use regulation at, and surrounding vertiports, safe integration within the national airspace in coordination with existing aircraft, and the incorporation of an electric/hydrogen charging and refueling infrastructure network.

Areas where Metropolitan Council authority and planning goals intersect with an AAM future are detailed below:

1. **Region is Equitable and Inclusive –** Plan for a future AAM network that lowers the cost of VTOL mobility to serve more people while mitigating any negative impacts to any one group.
2. **Communities are Healthy and Safe –** Stringent safety policies and oversight, and successfully incorporating vertiports into existing communities require engagement at the local level including appropriate vertiport placement and surrounding land uses.
3. **Region is Dynamic and Resilient –** Integrate AAM access into existing transportation network to improve regional mobility, boost regional economic development and enhance intermodal resiliency.
4. **Lead on Addressing Climate Change –** Support industry and regulatory initiatives that lead to future electrification and sustainable transportation infrastructure.
5. **Protect and Restore Natural Systems –** Integrate AAM to reduce the demand for sustained highway expansions, reducing pavement construction and maintenance costs, and preserving remaining natural spaces.

The Metropolitan Council will continue to monitor aviation industry trends in relation to our regional planning goals.