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Awareness and Preparedness Levels of Public-Use NPIAS Airports Toward Integration of AAM Technologies – A Case Study of Public-Use Airports in Ohio

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Advanced Air Mobility (AAM) operations are anticipated to transform the landscape of flight operations in the aviation industry in the near future, potentially minimizing road traffic, traffic delays, and associated transportation safety costs. Numerous use cases of AAM have been identified that could support various industries such as logistics and healthcare. However, several obstacles must be addressed to enable the establishment and deployment of AAM operations in these industries. These challenges include developing the necessary policies and regulations for AAM operations, investing in AAM vehicles and supporting infrastructure, and educating the public regarding future AAM services. Public-use airports have the potential to facilitate early AAM operations by providing landing and takeoff surfaces, storage and electric charging facilities, and space for local businesses to utilize AAM operations. The availability of public-use airports may therefore play a vital role in advancing AAM initiatives. This study analyzed the awareness and readiness levels of public-use NPIAS airports in the state of Ohio by assessing airport managers' familiarity with AAM, general preparedness of the airports, and infrastructure readiness of the airports. A total of 40 of Ohio's 97 NPIAS airports (41.2%) participated in the study. A capability maturity framework that uses a multi-level fuzzy comprehensive evaluation was employed to analyze the collected data. The fuzzy comprehensive evaluation resulted in an overall readiness score of 1.5379, indicating that the participating airports were generally between Level 1 and Level 2 of the capability maturity framework and had primarily reached preliminary levels of AAM awareness, planning, or implementation. The descriptive findings also indicate varying levels of awareness and readiness among the participating airports and a need for further education of airport operators, local businesses, and communities regarding AAM. The assessment framework developed in this study may serve as a practical self-assessment tool for airports to evaluate their individual preparation and planning initiatives toward integrating AAM services in their local areas.

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Introduction

Advanced air mobility (AAM) collectively includes state-of-the-art technologies that will facilitate air transportation services for various needs including multimodal and intermodal, cargo delivery, on-demand air passenger mobility, and other emergency and medical services (Koumoutsidi et al., 2022). This group of innovations incorporates emerging technologies and various use-cases targeting urban, rural, and suburban areas with use-cases expected to vary from a 50-mile radius to a few hundred miles in these regions (Cohen et al., 2021; Goyal et al., 2021). Depending on the region, use-cases may include passenger mobility, goods delivery, emergency services, and agricultural applications. As such, AAM is projected to revolutionize the air transport sector by bringing new means of connecting various communities, minimizing delivery times of cargo, and potentially saving lives. Since current airports serve a major role in facilitating aircraft operations, they will play a key role in helping establishing AAM operations (Wheeler et al., 2024).

Given the unconventional designs of the involved aircraft (e.g., vertical takeoff and landing, electric charging), infrastructural requirements and readiness assessments of existing airport facilities for integrating AAM operations is imperative. AAM aircraft designs (most of them being electric or hybrid) are generally classified into the following categories: electrical vertical take-off & landing (eVTOL), electric conventional take-off & landing (eCTOL), and short takeoff and landing (BAE Systems, n.d.; Mallela et al., n.d.; National Academies of Sciences, Engineering, and Medicine, 2023). Since the cargo business use case could be implemented as part of AAM operations, Small Unmanned Aircraft systems (sUAS) are also considered a segment of AAM operations (BAE Systems, n.d.). Electric vertical takeoff and landing (also known as the eVTOL) aircraft are designed to rely on electric batteries and/or hydrogen fuel cells to generate thrust (Dietrich, 2020b; Hall, 2020). With over 200 eVTOL configuration designs published, these aircraft are intended to address a variety of urban flight operations including air taxi and health response (Dietrich, 2020b). It is currently projected that initial stakeholders who may utilize eVTOL aircraft in urban settings would include transportation service providers, corporate and general/individual operators, and emergency service providers (Dietrich, 2020b; National Academies of Sciences, Engineering, and Medicine, 2023).

Introducing AAM operations will benefit communities in a variety of ways including a reduction in vehicular traffic, minimal emergency response times, increased access to urban areas, economic development along with its related opportunities, and utilization of general aviation facilities (Dietrich, 2020a, 2020c; Wheeler et al., 2024). For instance, Dulia et al. (2021) found the non-monetary benefits of AAM operations outweighed the initial investment costs in the state of Ohio. Since the year 2000, Ohio vehicular traffic has been growing at a rate of 8% annually, much higher than the rate of population growth at only 3%. The related safety costs and traffic delay costs have amounted to about $3.9 billion/year and $4.6 billion/year, respectively (Del Rosario et al., 2021). Advanced Air Mobility (AAM) could potentially alleviate some of these costs by assisting with the transport of passengers and cargo in areas that aren't currently conveniently located by land transportation and/or are underserved by the aviation network. Examples of transportation use cases areas that could be impacted by the implementation of AAM operations include passenger services, cargo operations, and emergency

services (KPMG, 2022). Recent studies by eVTOL OEMs and other aviation stakeholders analyzing the affordability of AAM operations are projecting passenger prices to vary from $2.25 to $11 per passenger per mile (Johnson et al., 2020; Patterson, 2021; Reiche et al., 2018); these projections are determined by numerous factors such as landing infrastructure. Raj et al. (2024) developed an optimization model to evaluate the integration of AAM operations to perform middle-mile transportation of high-value electronics using UAS in rural and urban areas of North Dakota. The study showed a 60% cost reduction in using UAS for freight transport comparing to traditional trucks while also helping to mitigate environmental emissions and other delay costs (Bridgelall, 2024).

With the emergence of AAM, there are potential opportunities to provide service such as point-to-point on-demand or scheduled transportation services. Given the uniqueness of demands and services for various airports, it is important for airport operators to be aware of the necessary accommodations for AAM operations (Petrie, 2023). Numerous use cases for AAM have been studied that highlight market opportunities brought forth by AAM. For instance, Goyal et al. (2021) modeled the potential for air taxi and air shuttles markets using AAM as means of transports and concluded a demand of 82,000 passengers would be served by about 4000 AAM aircraft across the US, assuming passengers were willing to pay for the service. AAM operations have also been associated with thin-haul markets since the aircraft are small and aim to transport fewer numbers of passengers (4 to 9) and small amounts of cargo, thus enhancing regional mobility and increasing flexibility (Harish et al., 2016). There are still variations in profitability depending on the region and the type of AAM operation involved. For instance, it has been shown that as e-commerce continues to grow, UAS last mile delivery operations may have a profitable market in 2030 (NASA et al., 2018). Conversely, while the air metro use-case has been shown to have viable markets by 2028, the air taxi use case is unlikely to be profitable by 2030, although some specific localized regions may present profitable markets for the latter use-case (NASA et al., 2018).

Several factors have been highlighted with the potential to impact both the establishment and reliability of AAM operations. Such factors include state and local restrictions, personnel and infrastructure availability, weather conditions and information, and turnround times (Dietrich, 2020c; Hall, 2020). Additionally, applications of AAM are expected to vary for each airport; hence, the airport operators will have to identify the market conditions specific to their areas (Derengowski, 2023). It is therefore imperative that airport infrastructure be examined as to whether it can accommodate the initial stages of AAM operations and that airport personnel are aware of AAM possibilities for their individual airports. It has been noted that current airports face several challenges. While larger airports face issues of congestion and aviation fuel consumption, smaller airports may face the issues of underutilization and other local communities' concerns (Wheeler et al., 2024). It should be noted that although AAM is aimed at integrating new technologies into the existing air transport system, AAM will not replace the current transportation systems and modes (Wheeler et al., 2024). Introducing AAM into existing airports has the potential to help these airports address some of these challenges. While it is acknowledged that not all airports will be suitable for AAM operations, it is also crucial for each airport to fully evaluate the potential cost and benefits, risks, and opportunities associated with AAM operations.

This paper aims to evaluate the level of readiness for and awareness of AAM by various public-use airports. The model developed in this study will also provide airport managers and other stakeholders with a tool that they could utilize in their planning to assess how prepared they are for future AAM operations.

Literature Review

This section presents the results of a literature review on infrastructure, stakeholder engagement, and policy as related to establishment of advanced air mobility operations in existing public-use airports.

Infrastructure

Infrastructure is considered one of the critical pillars for the implementation of UAM. Numerous metrics are being examined and developed to assess various infrastructure aspects as part of evaluating airport readiness towards adopting AAM operations. Such aspects include electric grid and charging stations, 4G coverage, air traffic quantity, and ground congestion (Helicopter International Association, 2023; KPMG, 2022). Other suggested areas of consideration for infrastructure include takeoff and landing locations (both runways and pads), landside and airside access, and emergency response facilities (Wisk, 2021). Mendonca et al. (2022) proposed an exhaustive list of different aspects that should be considered by stakeholders prior to establishment of vertiports for AAM operations.

With the US aviation industry planning to implement AAM operations by 2028 (Federal Aviation Administration [FAA], 2023a), it is necessary for airport operators to begin familiarizing themselves with AAM operational concepts in order to better prepare for the operational needs that will arise. One of the facilities that will be required is landing pads for the eVTOL, commonly known as vertiports. Vertiports (takeoff and landing areas for AAM aircraft vehicles) have been noted as one of the crucial components of the AAM system as they contain necessary infrastructure components needed for eVTOL vehicles to safely perform their landing and takeoff operations (Espejo-Díaz et al., 2023). Since eVTOL aircraft are designed to mainly operate using electricity, hydrogen, or a blend of both, proper infrastructure will be needed to support the supply of electricity and/or hydrogen at airports. Paudyal et al. (2024) studied the impact of charging eVTOL under the current grid system and found there was a significant chance of overloading the entire national grid because most of the current airport infrastructure was not designed to support aircraft charging loads. It is vital for local airports to start engaging and preparing for potential electrification and other operational needs necessary for AAM operations (Lynch, 2023). For instance, some of the aspects that airport operators ought to be informed regarding AAM include an understanding of electrical and utility locations and capabilities, potential locations and land-use considerations, and potential AAM operations' types and aircraft types (C & S Companies, 2023). Additional aspects include engagement efforts with local, state, and federal authorities on the topic and an awareness of other initiatives in their respective regions (C & S Companies, 2023). AAM vehicles' heavy reliance on electrification will necessitate the need for airport operators to assess their airports' current electrical infrastructure and engage with local electric utility providers to review potential AAM charging needs (Smith, 2024). Supporting the infrastructural efforts for the development of vertiports facilities, the FAA has highlighted key areas that airport operators

may need to consider for eVTOL operations. These include vertiports' taxiways and parking areas, energy infrastructure to support the charging of eVTOL and other related operations, safety related aspects such as security and safety, winter operations, and accommodation of people with disabilities FAA, 2024b).

In a literature review by Schweiger and Preis (2022), they noted several areas that should be addressed prior to establishing AAM infrastructure. These areas include understanding of the location of the vertiport facility, planning the design and daily operation of the vertiport, and the impact of weather on AAM operations (Schweiger & Preis, 2022). Robinson et al. (2018) identified several factors that would be considered beneficial for establishing ground AAM infrastructure. These factors included a city with sufficient undeveloped land, absence of strong public transportation network, and presence of a large commercial airport in the near vicinity (Robinson et al., 2018). Several studies have identified the need for existing airports to consider the constraints that would hinder the integration of AAM operations in the airport environment. In their study of Cologne Bonn airport, for instance, Feldhoff and Roque (2021) found that the rooftops of existing parking garages were the best locations for the vertiports that help with seamless transfer of passengers from the AAM transportation mode to other modes including traditional flights. In the process of rating which location would be ideal for vertiports establishment, several constraints were taken into consideration including noise impacts, accessibility for passengers, future expandability, and obstacle clearance (Feldhoff & Soares Roque, 2021). While requirements may differ depending on the AAM use case (i.e., commuter, airport shuttle, or cargo delivery), it is expected that there will be little deviation from those observed in airport shuttle AAM operations (Schweiger & Preis, 2022).

Unlike traditional heliports, two additional processes would be integrated for a vertiport: ground operations and charging of AAM vehicles (Schweiger & Preis, 2022). Since more than 80% of all heliports worldwide are located in the US, the FAA's heliport design guideline has been used as a basis for ongoing research on establishment of the guidelines for vertiport design and establishment (Schweiger & Preis, 2022). An analysis conducted by the McKinsey Consulting Firm categorized vertiports into three main types depending on the scale of operations: vertihub, vertibase, and vertipads. Their analysis indicated that the cost of building a vertiport would range from $200,000 for a vertipad to up to $15 million for a vertihub. Similarly, the annual cost of operating the facility would range from $600,000 for the vertipad to about $17 million for a vertihub (Johnson et al., 2020). Cost will therefore remain one of the critical factors for the viability of establishing a vertiport facility to facilitate AAM operations. In a similar study, Rimjha et al. (2021) analyzed optimal locations for vertiports at Los Angeles International Airport and estimated the network size for AAM operations. Their findings showed that AAM demand would be about 3.6% of the market share of all the trips to and from the airport suggesting that vertiports would best be established in smaller airports such as the Los Angeles Downtown Airport (Rimjha et al., 2021). Research has also shown that turn-around time will be one of the critical factors for the operation of vertiports (Preis & Hornung, 2022). Turn-around time will have significant impact on the ratio between the number of passenger gates and landing pads at a vertiport facility (Vascik & Hansman, 2019). The results may be different if a vertiport is geared toward other AAM operations such as cargo delivery or medical and emergency supplies. For use cases that will involve passengers, the processing time has been shown to be one of the most important factors that will

potentially impact the market share for AAM operations (Ploetner et al., 2020; Rothfeld et al., 2021; Wu & Zhang, 2021).

Although AAM technologies require newly established infrastructure, such as vertiports and electric charging stations, it is expected that existing public use general aviation airports would assist with the adoption of AAM operations prior to full establishment of vertiports (Antcliff et al., 2021). It is forecasted, for instance, that the state of Ohio would need about 81 vertiports over the next 25 years to further AAM operations (Judson et al., 2022). Nationwide, only about 30% of the 5000 public use airports serve 70% of all travelers; hence, there is significant potential for AAM technologies to utilize public use airports (Antcliff et al., 2021). Utilizing these public use airports may be economical given that most of them are located about a 20-minute drive from most places in the country. This scenario alone serves as a catalyst for several potential business cases utilizing AAM operations (Wisk, 2021). Also, as noted by Hagspihl et al. (2025), in order to cope with the initial higher ticket prices of AAM services, vertiports should be established near existing airport infrastructure. Once the demand for AAM services has increased and prices lower, more vertiports can be established in new locations further from current airports (Hagspihl et al., 2025). As various AAM manufacturers and operators see the potential of starting airport shuttle services, public use airports could serve to connect passengers in local communities to major airport hubs (Helicopter International Association, 2023). Additional potential benefits of utilizing public use airports include available infrastructure, connectivity to other modes of transportation, and existing community relationships (Wisk, 2021). For these public use airports to be seamlessly utilized, coordination may be needed among the FAA, airport owners, state transportation departments, and other stakeholders (Helicopter International Association, 2023). It is crucial that airport operators, engaging with other airport stakeholders, make well-informed decisions related to AAM ground infrastructure and planning investment to mitigate the significant risks associated with the early stages of implementing AAM technology (Venkatesh et al., 2020).

Depending on the area of AAM operation (i.e., city center, suburb, rural access, or hub airport access), existing heliports and general aviation airports may be utilized to transport people and goods within these zones (Dietrich, 2020c; Hall, 2020). The style of operation (i.e., scheduled, air metro, airport shuttle, on demand air taxi, or emergency services) will also influence how much private and public airport infrastructure would need to be utilized (Dietrich, 2020c). With more than 2/3 of AAM aircraft companies aiming for airports as their initial market targets, airports could benefit from AAM operations given the existing last-mile connections demand and available infrastructure for and expertise on flight operations (Brummer et al., 2021). Airspace, terminal/landside, and utilities needs will have to be considered to successfully integrate AAM operations into airport planning processes (Brummer et al., 2021). Prior to investing in new infrastructure, retrofitting of existing aerospace facilities (e.g., hangars, maintenance spaces, landing sites) and other facilities (e.g., electric charging equipment, parking garages, and other spaces) would help speed up deployment of AAM operations (Lineberger et al., 2021).
Therefore, utilization of existing public use airports would present both challenges and benefits to aviation stakeholders and communities. For large hubs, AAM operations could be an additional means to enlarge the catchment areas, diversify their product portfolios, and revive the short haul flights between large/medium hub airports and general airports (Alonso et al., 2024). With incoming AAM operations, airports will have to be aware of and know how to deal with several challenges: technical (such as electricity and air traffic management), vehicle certification,

community acceptance, and financial feasibility (Alonso et al., 2024). As part of engaging with various stakeholders, it is crucial to engage public use airport operators to gauge both the awareness and readiness levels of their airports for adopting AAM operations. To that end, an awareness and understanding of the various aspects related to AAM operations would be key to fostering safe and reliable implementation of AAM at local airports.

Stakeholder Engagement and Policy

As Johnson et al. (2020) noted, both corporate and private investment will be crucial for AAM operations to take off in various locations. It is expected that the establishment of vertiports and AAM operations will also support other industrial activities in those areas. Therefore, involvement of all stakeholder groups in the initial stages of AAM establishment are crucial. For instance, since eVTOL aircraft will be designed for short range destinations, both AAM vehicles operators and airport operators will have to decide on departure and arrivals procedures and patterns to ensure maximum efficiency at AAM facilities and around airports (Schweiger & Preis, 2022). Similarly, it will be crucial for airport operators and air traffic controllers to collaborate on addressing the planning challenges of AAM operations in order to optimize vertiport throughput while minimizing disruptions (Espejo-Díaz et al., 2023).

It is imperative for airport stakeholders to be cognizant of how each of the stakeholder groups at both the airport and the local community would benefit from specific AAM operations and seek to determine how the airport could play a role in facilitating such services for all stakeholders. For instance, Bridgelall (2024) analyzed optimal siting of vertiport networks among airports and hospitals in North Dakota with results indicating a potential time savings for patients and medical deliveries, bringing efficiency to emergency response services in the region. The results from these studies show the importance of collaboration between airport operators and other stakeholders who will need to utilize AAM services. Complexities of and benefits derived from AAM operations are expected to vary among the different use cases with common challenges such as community acceptance of the technology expected to be common throughout (Desai et al., 2021). Research has shown that local communities may be resistant to accepting the technology due to several factors including noise pollution, safety concerns, and affordability (Desai et al., 2021; Ison, 2023). However, research has also shown that regardless of their concerns, the general public may have some inclination toward AAM facilities such as vertiports due to the economic benefits brought forth by AAM operations (Ison, 2023). As such, it may be necessary for the airport operators to well prepared for how they can engage with various stakeholders during the necessary phases of introducing AAM operations in their local airports.

As part of being cognizant of and preparing for AAM operations, airport operators may consider engaging with various stakeholders to gauge the demand levels of the AAM use case in which the airport wants to establish to ensure good returns on the infrastructure investment. The levels of demand are expected to vary from one region to another depending on the AAM use case. For instance, a study to determine vertiport landing feasibility and estimated fare prices for AAM transportation of passengers in northern California found that the region would need about 300 landing sites to capture the projected flight levels of about 13000 per day (Tarafdar et al., 2019). Other regions of the country may need to focus on other use cases such as cargo, medical deliveries, and other services. A study by McKinsey & Company indicated that nearly half of all

representative consumers who were interviewed indicated they were comfortable with delivery and UAS use cases. Some of the contributing factors to the decision included safety, loss of packages, and privacy concerns (NASA et al., 2018).

It is also expected that airport operators may have to continuously and closely engage with local government authorities to help support and approve AAM operations in their locations (Hagspihl et al., 2025). Educating the public and local community regarding how they will benefit from AAM operations may also play a role in ensuring smooth introductions of such services in various regions. In a research study by Ison (2024) to determine the willingness of the public to fly eVTOL across various demographic groups, it was noted that people in urban areas were more willing compared to those in the rural areas. Understanding local consumers' preferences will not only help airport operators and local stakeholders shape the policies needed for AAM operations but also prepare the local community through outreach and education (Ison, 2024). In another research study, Yedavalli and Cohen (2022) modeled a siting of vertiports in the San Francisco Bay area in which they identified land use characteristics as one of the major constraints. In addition, the study also noted the importance of engaging with local community stakeholders to ensure optimal feasibility of establishing vertiports (Yedavalli & Cohen, 2022).

Key areas in which both regulations and policies are to be developed and established include aircraft certifications, licensing of both pilots and mechanics, infrastructure, and overall safety of AAM operations (Wiedemann et al., 2024). It has been noted that there are five (5) key categories of regulations that will need to addressed to enable successful AAM operations: air traffic management, aircraft development and production, airspace regulation, aircraft management and operations, and community integration (NASA et al., 2018). As AAM concepts continue to evolve, it is expected that most of the discussion on development of UAS will be centered on the technical and regulatory aspects (Kellermann et al., 2020). As such, further development of UAS is expected to be dependent on public acceptance (Kellermann et al., 2020). It should also be noted that various regions in the world have started the process of defining regulations and policies that will guide AAM operations. For instance, the European Aviation Safety Agency (EASA) has published several regulatory frameworks that include the registration and operations of UAS (EASA, 2022c, 2024), building of eVTOL facilities (EASA, 2022a), and future framework and policies for AAM operations (EASA, 2018, 2022b). These regulations and policies are being currently established upon recognizing potential benefits of AAM to the region which include employment, safer and efficient means of transportation, and cleaner mobility (EASA, 2021). Similarly, the Federal Aviation Administration (FAA) has been providing guidance on regulations and policies that will be utilized during the implementation of AAM operations. The second concept of operations guidance was provided by the FAA to explain the collaboration among stakeholders and the role of air traffic control (FAA, 2023b). However, several issues have been identified with the latest version of the document. Huber (2020) noted the potential for safety concerns due to different sets of navigation rules accommodating various airspace corridors for different types of AAM operations. In addition, the FAA has also released a standard to guide the establishment of vertiports (FAA, 2022). In a research study that gathered insights from key global stakeholders, certification standards for AAM aircraft vehicles and an overall regulatory framework that will govern AAM operations were identified as key essential aspects toward the establishment of AAM operations (Koumoutsidi et al., 2022). Therefore, with various regulations that cover the different types of flight operations (e.g., airlines, charter, and business aviation), it

is expected that these regulations will be expanded to include eVTOL operations (Dietrich, 2020b). One of the regulatory issues to be resolved is the applicability of federal regulations pertaining to the usage of AAM operations in state and municipal settings (where the majority of these operations will be occurring) (Wulff, 2020). Although federal aviation laws preempt state laws, indirect local laws (e.g., zoning laws, business licenses, and utility and infrastructure laws) may have an impact on AAM operations (Wulff, 2020). It is therefore essential that the FAA collaborate with the industry to establish community-based standards for the design of vertiports and other types of infrastructure for the varying types of AAM aircraft (Lineberger et al., 2021). While regulations and policies at the national level are continuously being developed, Immel and Langlinais (2020) noted that more challenges may be encountered at the state and local levels. While the FAA regulates aircraft operations and other matters within federal aviation authority, airport operators may engage with state and local stakeholders regarding areas of applicable local authority, including land use, zoning, infrastructure, and related community planning considerations, subject to federal preemption and applicable state law. The FAA has recently been working with several stakeholders to amend the Title 14 C.F.R. Part 194 regulation to incorporate key areas that will support the operations of AAM vehicles categorized as the 'powered-lift'. These areas include certification and training requirements of eVTOL pilots and instructors, operations and maintenance of eVTOL equipment, and training devices for eVTOL equipment (FAA, 2024a).

In addition, as airport operators collaborate with both national and local stakeholders in shaping the policies and regulations pertaining to AAM operations, understanding AAM demand will be key in formulating AAM policies. While the foundational policy and regulatory framework must be laid prior to authorizing AAM operations, additional policies that will help AAM sector to sustainably grow are expected to influence the market economically as has been shown in other sectors (Fu et al., 2020; Nelson, 1999; Rotaris & Danielis, 2014; Rye et al., 2008). In a study by Chae et al. (2024), the importance of tailoring the supporting policies like pricing and marketing strategies to match AAM demand in the region was shown. Tailoring these policies based on demographics may help increase public acceptance and adoption (Chae et al., 2024). While ongoing efforts to establish policies that will govern safe and secure AAM operations continue, the regulatory climate still remains a hurdle to be addressed (Mishra & Palanisamy, 2023). Sah et al. (2021) conducted an extensive analysis of the barriers to implementing UAS logistics and found security, privacy, and regulations were perceived as the top barriers. This highlights the strong need to establish regulations and policies that will support AAM operations while mitigating any potential risks including privacy concerns, data breaches, and unauthorized access.

Methodology Approach

Very few frameworks have been developed to measure the readiness of various stakeholders in adopting AAM operations. One airport that did develop a framework to measure its UAM readiness is Munich International Airport. Their framework revolves around 5 main drivers: maximum safety and security, optimal infrastructure and procedures utilization, customer experience, stakeholders' partnerships, and regulatory engagement (Garcia-Alonso, 2018). Given the need for local airports to prepare and plan for AAM operations, it is essential for airport operators to assess their awareness and understanding of the technology, as well as determine how their airport infrastructure needs to be adapted. This study aimed to develop a model which can be used to assess the awareness and preparedness of various airports. The tool is designed to either

evaluate several airports or be used by employees at a single airport to gauge their readiness for AAM operations.

The following delimitations were observed in this study:

1. Due to budget and other administrative constraints, the study was focused on the state of Ohio. In addition, the study only examined public-use airports included in the National Plan of Integrated Airport Systems (NPIAS). NPIAS airports were selected because they constitute a defined group of airports eligible for federal airport development funding and are subject to standardized FAA planning, design, and reporting processes relevant to infrastructure preparedness. Currently, the state of Ohio consists of 154 public-use airports, 97 of which are included in the NPIAS. Table 1 shows the breakdown of the airport categories and their respective passenger enplanements and/or number of based aircraft for 2022–2023. Additionally, airports that are part of the NPIAS regularly provide standardized and consistent data that may be useful in follow-up studies.
2. Due to time and resource constraints, the design of the survey instrument was focused on close-ended quantitative Likert-scale questions with minimal qualitative open-ended questions for participants. A survey was distributed to airport managers in charge of public use airports in the state of Ohio to obtain their input and recommendations on two criteria needed for the adoption of AAM operations.

Table 1
NPIAS Airports in Ohio Statistics for 2022/2023

Airport Categories	Number of Airports	Enplaned Passengers	Aircraft Based
Primary*	6	7,334,268	432
National & Regional	23	14,538	1,638
Local & Basic	68	0	1,963

*Primary airports include Medium-, Small-, and Non-hubs

Research Questions

This study intends to measure the level of awareness and readiness of public use airports in the state of Ohio for the adoption of Advanced Air Mobility operations. As such, the study aims to answer the following research questions:

1. What is the awareness level in Ohio's public use airports of AAM operations?
2. What is the readiness level of Ohio's public use airports for AAM operations?
3. What is the infrastructure readiness level at Ohio's public use airports to accommodate AAM operations?

Survey Instrument and Data Collection

The study adopted the Capability Maturity Framework (CMF) survey instrument which measures the readiness level of an airport for AAM initiatives by assessing readiness across three levels (National Academies of Sciences, Engineering, and Medicine, 2020).

Airport managers were asked to select the most appropriate level that describes the readiness level for their airport (Xian, 2010). The survey instrument consists of 5 sections in which participants were asked to provide information. The first section consists of two (2) questions designed to determine the type of airport ownership that exists at the airport and the types of flight operations that take place there. The second section consists of nine (9) questions that were intended to gauge the airport's awareness of AAM. Section 3 of the survey consists of thirteen (13) questions that evaluate the airport's general readiness for AAM while Section 4 consists of nine (9) questions that measure the airport's infrastructure readiness for AAM. Each of the questions in sections 2 to 4, consists of three statements labeled as level 1 to level 3. Thus, the survey participants were asked to respond to questions in sections 2 to 4 by selecting a level (1, 2, or 3) that they perceived to correspond to the state of their individual airport most appropriately. Section 5 of the survey consists of nine (questions) that are intended to gather the participants' opinion on various issues such as ownership of vertiports at airports, local community support towards establishment of vertiports, and airport stakeholders' access to vertiports. Other questions included in Section 5 intended to gather information regarding the current proximity of their airport from the airport's first responders, other transportation modes available at the airport, and whether there would be a need for a Part 150 study if the airport were to adopt the establishment of vertiports at the airport. Two (2) questions in Section 5 are open-ended, which allows participants to provide additional comments regarding the possibility of conducting a Part 150 study or other issues related to establishment of AAM operations at their airport.

As this study focused on Ohio public-use airports, the targeted participants were airport managers in these airports. Prior to recruitment of the participants, the survey was reviewed and approved by the Institutional Review Board (IRB) committee at the researcher's institution. The recruitment of participants involved direct message (through phone call and/or email messages sent to the airport managers) asking them if they would be willing to participate in the research study. The participants' contact information was obtained from various public sources including the Ohio airport directory, airport websites, or personal contacts. Participants were also given the option to forwarding the survey link to another employee whom they thought would be better able to complete the survey. For each survey participant who received a survey link, they were provided with informed consent in which they were given the option to either continue with answering the survey or withdrawing their participation. The airports contacted for the study included general aviation airports and Part 139 airports. Each of the participating airports are both open for public use and part of the National Plan of Integrated Airports System (NPIAS). Airports that are part of the NPIAS are eligible to receive funding from the FAA for capital projects through the Airport Improvement Program (AIP). The survey was open for three (3) weeks for the participants to complete. Upon receiving the first recruitment message, participants who had not responded were sent a follow up message one week later asking them to complete the survey.

Prior to the distribution of the survey to these targeted participants, the survey was reviewed by a team of aviation experts consisting of airports managers (both from Ohio and other states), an experienced pilot, and a collegiate aviation instructor. The comments and suggestions obtained from these experts were incorporated into the final survey instrument.

Capability Maturity Framework

The CMF concept has been applied in several industries including the Information Technology industry where a CMF is used to both assess and guide the management team in choosing strategies that will lead to optimal business results (de Bruin & Rosemann, 2005; Donnellan et al., 2011; Paulk et al., 1993). Capability maturity models resulted from the evolution of software during the early years of its development; over time, these models have been applied in other industrial sectors including transportation to help assess the capability of businesses to potentially adopt new and emerging technologies and processes (National Academies of Sciences, Engineering, and Medicine, 2020, 2023). CMFs have also been utilized in a broad array of business sectors where essential processes or practices are scrutinized across several levels of maturity (Curtis et al., 2009; de Bruin & Rosemann, 2005). The CMF was originally designed to assist software developers in identifying current processes' maturity, identifying critical issues related to software technologies, and selecting appropriate improvement strategies (Paulk et al., 1993). The optimal desired objective for the process or practice represents the maximum maturity level that can be achieved within the CMF (Scanlan, 2018). The CMF involves the utilization of a maturity questionnaire that helps the organization assess and inform where they stand on the maturity level of a process or practice. It should be noted that the CMF does not provide the specific means of achieving further maturity levels (Paulk et al., 1993). The CMF is typically designed as a multi-dimensional model consisting of distinct elements: factors, and stages of maturity. These factors serve as independent variables while the overall maturity stage of the CMF is regarded as the dependent variable (de Bruin & Rosemann, 2005).

In this study, the overall readiness of Ohio airports is assessed by using the Capability Maturity Framework proposed by the National Academies of Science, Engineering and Medicine (2020) A fuzzy comprehensive evaluation utilizes fuzzy mathematical concepts to help break down the complex multi-factor set of problems into single factor for evaluation purposes (Y. Zhang, 2024). The fuzzy mathematical method utilizes fuzzy mathematics principles and the principle of maximum membership to evaluate objects influenced by various factors (Li et al., 2024; Liang et al., 2020; Shi et. al., 2016). A typical fuzzy comprehensive evaluation decision is composed of three main elements: factors' set, evaluation set, and a single evaluation matrix (Shuai et al., 2016). The fuzzy evaluation method has also been utilized in other sectors such as assessment of wind farms and wind turbines (Cheng et al., 2024; Xiao et al., 2014), agricultural evaluation of garlic plantations (Song & Dai, 2023), optimization of fertilizer for potato cultivation (Guo et al., 2025), and construction management (Bai et al., 2021). Multi-level fuzzy evaluation theory also helps in analyzing a system that is based on one or several factors, rendering it subject to various constraints caused by the interaction of those factors (J. Zhang et al., 2025). In addition, fuzzy comprehensive evaluation serves as a decision-making approach, which helps address problems that are difficult to quantify such as expert systems and sentiment analysis (Cheng et al., 2024).

Fuzzy comprehensive evaluation (FCE) was selected because the readiness factors assessed in this study represent multidimensional conditions that are not readily expressed through precise quantitative thresholds. FCE is particularly applicable to multi-factor evaluation problems involving qualitative, uncertain, or difficult-to-quantify information because it uses fuzzy membership to transform qualitative evaluations into quantitative measures that can be aggregated

across multiple evaluation dimensions (Du et al., 2019; H. Zhang, 2023). Although FCE is frequently combined with weighting approaches such as the Analytic Hierarchy Process (AHP), AHP typically relies on pairwise comparisons to establish the relative importance of evaluation criteria (H. Zhang, 2023). The present study instead sought to derive the maturity assessment directly from participating airports' survey responses while applying equal weights to the readiness factors, thereby avoiding the introduction of additional expert-derived priority weights at this exploratory stage. FCE therefore provided an appropriate approach for converting the categorical maturity responses into membership degrees and aggregating them across the multiple dimensions of airport AAM readiness. Future applications of the framework may incorporate expert elicitation or AHP to establish differentiated factor weights as additional empirical evidence on airport AAM readiness becomes available.

The capability maturity framework utilized in this study aimed to assess the capabilities of airports regarding the adoption of AAM technologies and operations. Capability maturity framework (CMF) development does not prescribe a universally accepted minimum sample size. Rather, maturity model development methodologies emphasize obtaining sufficient empirical evidence from representative organizations within the target domain to support framework development, refinement, and validation instead of satisfying a predetermined numerical threshold (Becker et al., 2009; Mettler, 2011; Pöppelbuß & Röglinger, 2011). Likewise, survey methodology recognizes that, for finite populations, sample adequacy is determined by the extent to which the sample provides representative coverage of the target population and yields sufficient information for the study objectives rather than by a fixed minimum sample size (Fowler, 2013; Krejcie & Morgan, 1970). Accordingly, the adequacy of the sample in this study was evaluated based on its coverage of Ohio's public-use airports and its ability to capture organizational characteristics relevant to airport AAM readiness.

In this study, a weighted score, based on participating airports' input, is provided to inform upon the general landscape of Ohio airports regarding AAM. The final score was calculated using a multi-level fuzzy comprehensive evaluation method (Jun et al., 2014). Equal weights were assigned to the evaluation factors because, at this exploratory stage of AAM readiness assessment, there is insufficient empirical evidence or established regulatory guidance to support assigning greater importance to any individual factor. The use of equal weighting also minimizes the introduction of subjective researcher judgment into the weighting process and allows each factor to contribute equally to the overall readiness assessment. Accordingly, equal weighting should be interpreted as an exploratory modeling assumption rather than evidence that all readiness factors have equivalent operational importance. Future applications of the framework may refine these weights through expert elicitation or other weighting methods as additional empirical evidence on airport AAM readiness becomes available. Given the qualitative-diagnostic nature of CMF framework assessments (CMMI Institute, 2015, 2026), the sample size of the study was deemed acceptable.

According to the fuzzy comprehensive evaluation definition (Feng & Mai, 2016; Gao et al., 2009; Jun et al., 2014; Xia & Yang, 2021; Xian, 2010; Yang et al., 2010), the fuzzy comprehensive evaluation model was developed based on several factors. The total evaluation indicator (the airport awareness and readiness regarding AAM) is represented by the factor set U. The factor set U = $\{U_1, U_2, U_3\}$ consists of three first level critical success factors which are:

awareness level of the AAM operations (U_1), general readiness levels for AAM operations (U_2), and infrastructure readiness levels for AAM operations (U_3). Table 2 shows the breakdown of the first level critical success factors and second level critical sub-factors. Thus, for each of the main first level critical success factors, the factor sets for the second level factors were as follows:

$$U_1 = \{u_{1,1}, u_{1,2}, u_{1,3}, \ldots, u_{1,9}\} \quad (1)$$

$$U_2 = \{u_{2,1}, u_{2,2}, u_{2,3}, \ldots, u_{2,13}, u_{2,14}\} \quad (2)$$

$$U_3 = \{u_{3,1}, u_{3,2}, \ldots, u_{3,9}\} \quad (3)$$

Table 2

First-Level Critical Success Factors and Respective Second-Level Critical Sub-Factors

Awareness Levels of AAM Operations (U_1)	Basic Understanding
	Local Stakeholders Engagement
	OEMs and Services Providers Coordination
	Potential Funding Availability
	Smart City Initiatives
	Supporting Culture and Organizations
	Aviation Businesses Awareness
	Decrease in Petroleum-Based Fuel
	AAM as an EAS Alternative
General Preparedness of Airports (U_2)	AAM Demand from Current Tenants
	Identification of Airport Resources
	Updated Airport Master Plan
	AAM Initiatives Planning with City
	Existing Political Support
	Prohibition of State Policies/Ordinances
	Current Leases Evaluation
	Community Engagement Processes
	Curbside Location Consideration
	Sustainable Workforce Planning
	Workforce Housing Planning
	Training Programs and Growth Paths
	Airport Proximity to Economic Activities
Infrastructure Preparedness (U_3)	Overall Condition
	AAM Integration w/ other Multimodal Options
	Awareness of Adjacent Land Development
	Space Availability for AAM Facilities
	Parking Structures, Nodes, Vertiport
	Capacity for New AAM Tenants
	Electrical Loads and Capacity Assessment
	Plans for Separate Curb and TSA Ops for AAM
	Connection between AAM and Regular Terminals

The critical factors corresponded to survey instrument questions in sections 1, 2, and 3, respectively. The survey questions in each of these three sections corresponded to the second-level critical success factors that addressed various areas related to the main critical success factors. The evaluation set V = $\{V_1, V_2, V_3\}$ = {*Level 1, Level 2, Level 3*} = {*1, 2, 3*} consisted of three levels of evaluation standards. These levels included:

Level 1 – No consideration of the Critical Success Factor (CSF)

Level 2 – Some consideration, planning, or implementation of the CSF

Level 3 – Existing developed (or implemented) approach to provide CSF capability.

The weights' sets for each of the factors and sub-factors were also established. This study assumed the weight of both the main critical factors and sub-critical factors to be equal across all the factors. For the factor set U, the weight set W is given as W = $\{W_1, W_2, W_3\}$ where $\sum_{i=1}^{3} W_i = 1$. The corresponding weight sets for the second-level factors were:

$W_1 = \{w_{1,1}, w_{1,2}, w_{1,3}, \ldots, w_{1,9}\}$ (4)

$W_2 = \{w_{2,1}, w_{2,2}, w_{2,3}, \ldots, w_{2,13}, w_{2,14}\}$ (5)

$W_3 = \{w_{3,1}, w_{3,2}, \ldots, w_{3,9}\}$ (6)

A membership fuzzy relationship matrix was established using the score. $\emptyset_i\ (h)$, which was calculated according to equation (7).

$$\emptyset_i\ (h) = \frac{n(h)}{N} \quad (7)$$

where,
n = number of participants who chose the 'h' option
N = the total number of survey participants

The single-factor evaluation matrix R is then obtained, where $R_i = \left(r_{ij}\right)_{n\times m}$ where r_{ij} represents the membership degree of *j* factors to the evaluation set V_i, the fuzzy comprehensive evaluation matrix B_i is calculated using equation (8).

$$B_i = W_i\ o\ R_i \quad (8)$$

Using the three main critical success factors, the relationship matrix R and comprehensive evaluation matrix B of the general indicator are given as:

$$R = (B_1\ B_2\ B_3\ B_4)^T \quad (9)$$
$$B = W\ o\ R \quad (10)$$

Utilizing the principle of maximum membership degree, fuzzy evaluation of airports' readiness and awareness is hence calculated using the following:

$$Final\ Evaluation\ Score = B\ o\ V^T \quad (11)$$

Results and Discussions

It should be noted that the results presented in this section are descriptive and reflect the responses of the participating airports. Comparisons across airport categories are intended to identify patterns within the study sample and should not be interpreted as statistically significant differences unless otherwise indicated.

Of the 97 National Plan of Integrated Airport Systems (NPIAS) airports in Ohio, 40 airports (41.2%) participated in the study. Given the finite and well-defined population of public-use NPIAS airports within the state, this level of participation represents substantial coverage of the target population and provides an empirical basis for applying the Airport AAM Readiness Capability Maturity Framework within the study sample. A breakdown of the participating airports by airport category is presented in Figure 1. Approximately 60% of the participating airports primarily supported 14 CFR Part 61, 14 CFR Part 91, and 14 CFR Part 135 operations (Figure 2), and all participating airports were publicly owned.

Figure 1
Distribution of Participating Airports

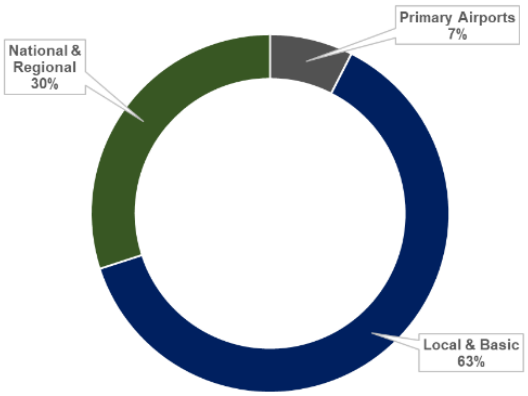
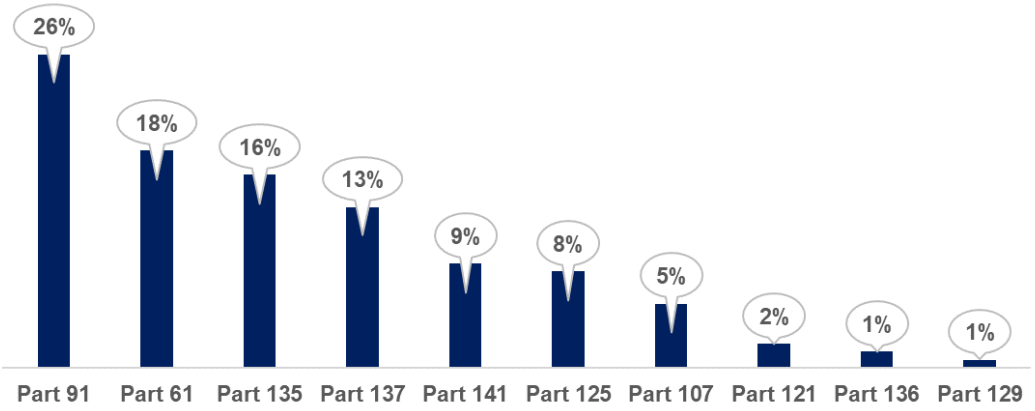


Figure 2
Flight Operations at Participating Airports

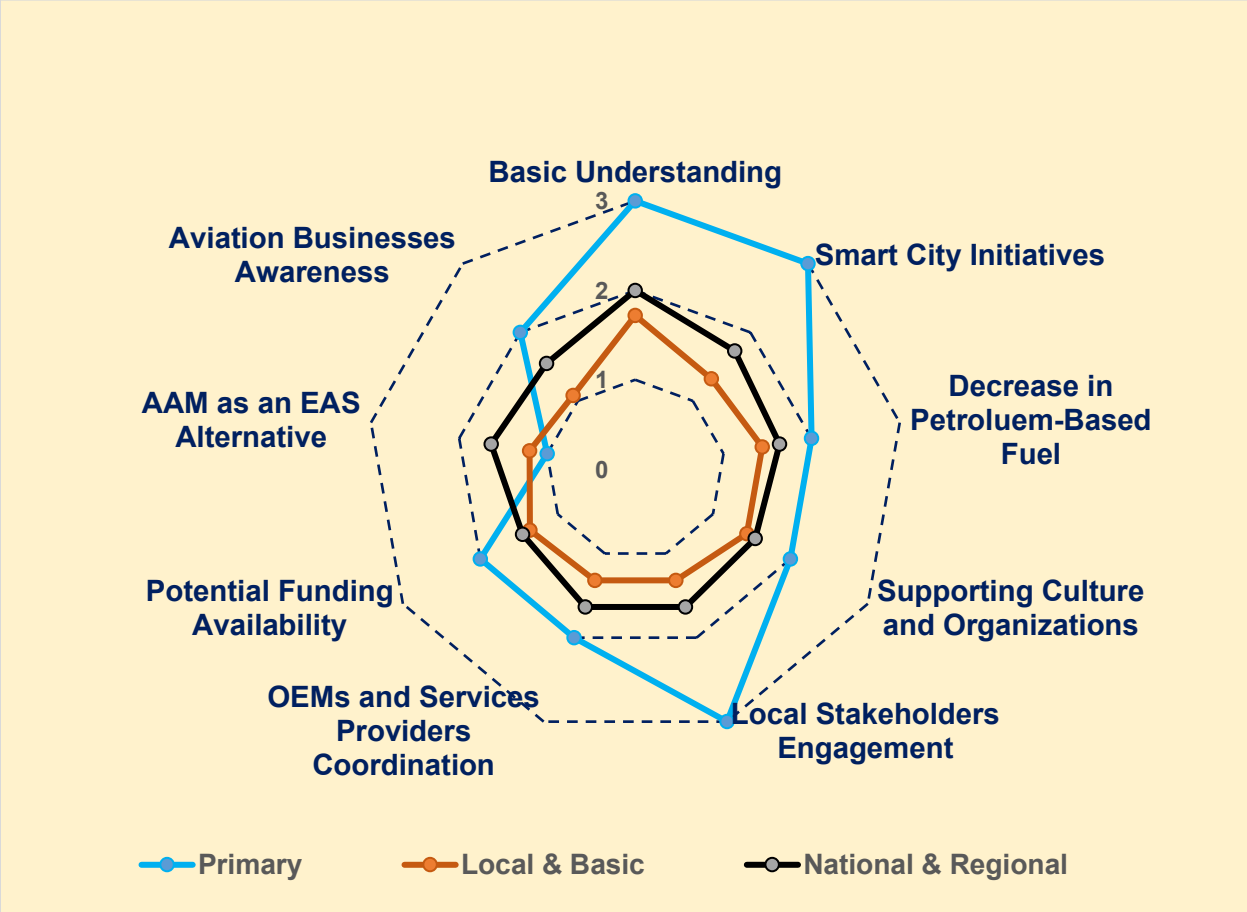


Awareness Levels of AAM Operations

As previously discussed, the study assessed the awareness of participating Ohio airports regarding AAM across nine areas. These areas included general understanding of existing AAM initiatives; coordination between airports and local authorities to identify common AAM goals; and coordination between airports and OEMs to understand potential opportunities and specific needs related to AAM planning. Other areas included identification of potential funding for AAM initiatives, incorporation of AAM into Smart City initiatives, and the presence of local organizations that promote innovative aviation technologies. The final three areas addressed awareness of AAM among local aviation businesses, discussions regarding reductions in petroleum-based fuel use, and consideration of AAM as an alternative for Essential Air Service (EAS). Figure 3 summarizes the awareness levels reported across the nine AAM awareness dimensions.

Figure 3

Summary of Awareness Levels of AAM Operations



About 67% of the participating airports indicated they had some level of awareness and moderate interest in existing AAM initiatives (e.g., FAA and NASA AAM initiatives, OEM and service provider partnerships, and electrification of aviation initiatives). The level of awareness varied among the airports' categories, however. For instance, while 67% of the participating primary airports indicated having high levels of awareness and a keen interest in closely following fundamental and applied research and development in AAM, only 18% and 16% of participating national/regional and local/basic airports, respectively, indicated a similar level of awareness. These findings indicate that although some level of AAM awareness existed among the majority of participating airports, higher levels of awareness and engagement were more prevalent among the participating primary airports than among national/regional and local/basic airports.

Few airports indicated having taken further steps towards exploring the topic of AAM with other stakeholders. About 33% of participating airports indicated at the very least some limited interactions and coordination with stakeholders beyond the airport community (city and county planners, transit agencies, and others) regarding AAM. Although 67% of participating primary airports had already established formal coordination mechanisms that tap into expertise and experience beyond the airport community regarding AAM, only 18% and 8% of participating national/regional and local/basic airports, respectively, had done the same. Thus, while some stakeholder coordination regarding AAM was reported, formal coordination mechanisms

remained limited among the participating airports, particularly among national/regional and local/basic airports.

Similarly, 41% of all the airports indicated being at least open to collaborative opportunities with OEMs and service providers prior to airport planning for AAM initiatives. All the participating primary airports indicated being open to such opportunities, while only 45% and 32% of the national/regional and local/basic airports, respectively, indicated similar openness to collaborative opportunities. The responses therefore indicate that engagement with OEMs and service providers was not yet widespread among the participating airports, although the level of openness to such collaboration varied across airport categories.

About 41% of the airports indicated having some level of potential collaboration opportunities for integrating AAM plans with smart city goals. Specifically, about 15% of the airports indicated that they were already working on collaborations with smart city initiatives to incorporate airport operations and AAM integration with smart city objectives. All the participating primary airports already had working collaborations with smart city initiatives to incorporate airport operations and AAM integration with smart city goals. On the other hand, only 55% and 28% of participating national/regional and local/basic airports, respectively, identified potential collaborative opportunities regarding smart city and AAM initiatives. These findings indicate that integration of AAM considerations with smart city initiatives was still limited among the participating airports, with primary airports reporting more established collaboration than the other airport categories.

Regarding funding for AAM initiatives, 67% of the participating airports indicated that they currently had no knowledge of how to access funding for AAM initiatives. A few airports identified potential opportunities to at least make the case for an AAM initiative as a 'special project' outside their regular budgetary processes. About 9% and 8% of the national/regional and local/basic airports, respectively, indicated having opportunities to make a case for AAM initiatives through already established budgetary and program processes aimed at encouraging innovation in their regions. The responses indicate that identification of potential funding mechanisms for AAM initiatives remained limited among the participating airports, with only a small proportion reporting established processes through which AAM-related initiatives could potentially be pursued.

About 77% of the airports indicated that none of their tenants (flight schools, general aviation tenants, or ground support equipment operators) had indicated interest in upgrading their fleet to electrical powerplants. All the participating primary airports indicated the possibility of some interest among airport tenants, with minimal goals for diversification of their fleet to electrical powerplants currently, while only 36% of the national/regional airports responded similarly. These findings indicate that reported tenant interest in transitioning toward electrical powerplants remained limited among the participating airports, although such interest was more commonly reported by participating primary airports.

However, 51% of airports indicated awareness of and some minimal to moderate planning for alternative capital sources in response to a potential decline in petroleum-based fuel revenue. This level of awareness and planning was more prevalent among the participating larger airports, as all the primary and 64% of the national/regional airports indicated having such planning in

response to a potential decline in petroleum-based fuel revenue. In contrast, 60% of local/basic airports indicated no awareness or plans regarding a potential decline in petroleum-based fuel revenue. The observed differences indicate that consideration of the potential financial implications associated with reduced petroleum-based fuel revenue was more developed among participating primary and national/regional airports, while such consideration remained limited among the majority of participating local/basic airports.

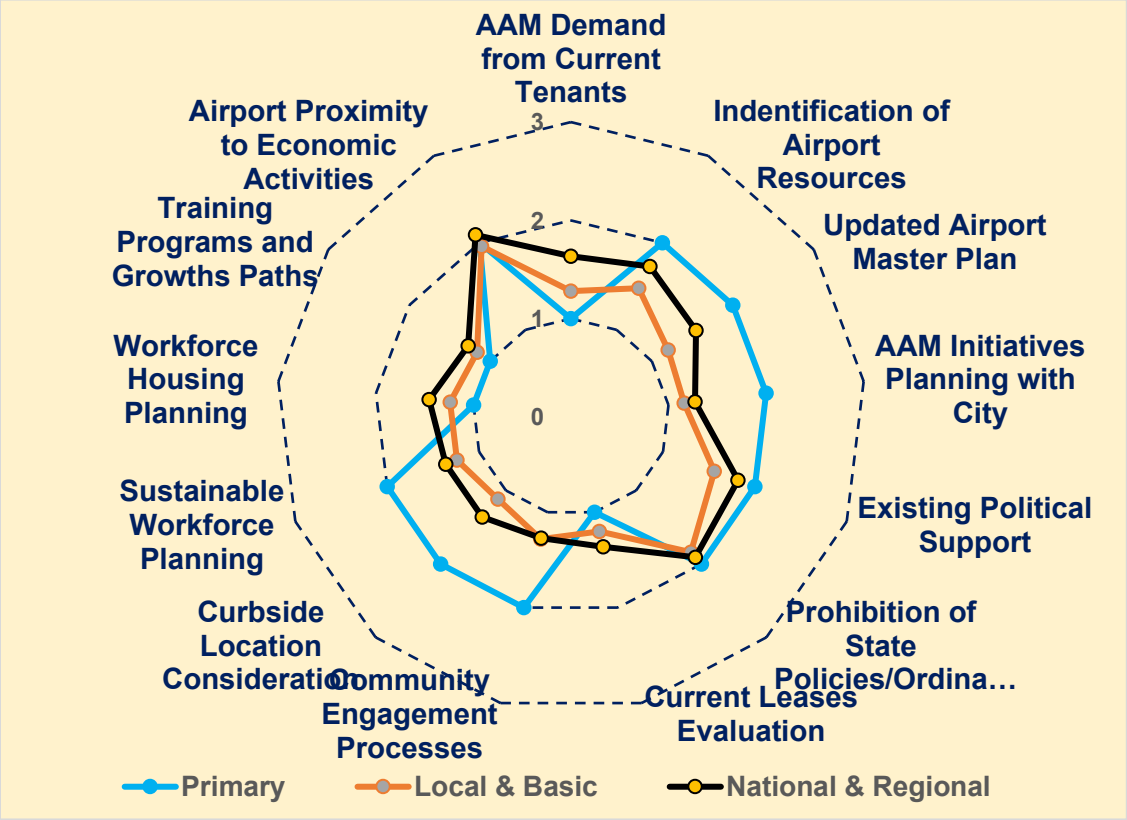
About 30% of participating airports indicated some consideration of pursuing AAM operations as an alternative to Essential Air Service, and only 2% of the participating airports indicated that they already had plans laid out and ready to implement when appropriate. This level of consideration was higher among participating national/regional airports, as 46% indicated that some discussions had been held although minimal plans had been created. Only 9% of these airports indicated having laid out plans that were ready for implementation when appropriate. Overall, these responses indicate that consideration of AAM as an alternative to Essential Air Service remained at an early stage among most participating airports, with relatively few airports reporting plans that had progressed beyond preliminary discussions.

Readiness Levels of the AAM Operations

Thirteen (13) areas were examined to collectively explore the overall AAM readiness level of the participating airports. These included local demand for AAM from the community, identification of airport resources for future growth opportunities, updating of airport master plans to include AAM or electrification initiatives, and coordination between the airport and the city for local community engagement regarding AAM. Additional areas included political support for AAM development, the presence or absence of state or local policies or ordinances that could restrict new AAM operations, evaluation and updating of current airport leases, existing processes for community engagement, and identification of curbside facilities to support AAM operations. Other areas examined included workforce availability, housing availability for new workforce entrants, training programs or growth pathways for workers supporting AAM initiatives, and airport proximity to economic activity centers. Figure 4 summarizes the readiness levels reported across the 13 general AAM readiness dimensions.

Figure 4

A Summary of Readiness Levels of AAM Operations



While 67% of participating airports indicated little to no demand for AAM services or were unaware of how AAM could serve their communities, 10% had already identified substantial potential demand for AAM services and were closely monitoring emerging practices and experiences in anticipation of potential early adoption. These findings indicate that identification of local demand for AAM remained at an early stage among most participating airports, with only a small proportion reporting more advanced consideration of potential AAM demand and applications.

More than half (51%) of the participating airports had at least identified potential resources that could support future AAM-related growth opportunities. Such resources included electrical systems, operational capacity, land-use considerations, zoning requirements, and potential modifications to lease agreements. About 10% of airports indicated having developed more comprehensive inventories of these resources and being prepared to initiate discussions with OEMs, service providers, and other industry partners. Thus, although approximately half of the participating airports had begun identifying resources relevant to AAM, relatively few had progressed to a level where those resources had been comprehensively evaluated to support external industry engagement.

Regarding airport planning, 25% of participating airports indicated having undertaken some consideration or preliminary discussion about incorporating AAM and electrification into their airport master plans. The level of planning varied across airport categories. About 33% of

participating primary airports had already updated their master plans to incorporate AAM and/or electrification initiatives, compared with 18% of national/regional airports and 4% of local/basic airports. These results indicate that formal incorporation of AAM and electrification into airport planning remained limited among the participating airports and was more prevalent among participating primary airports than among the other airport categories.

About 80% of the participating airports were located within acceptable proximity to economic activity centers or reported having existing transportation solutions that could facilitate movement between the airport and those activity centers. Compared with several of the organizational and planning dimensions examined in the study, proximity and existing connectivity to economic activity centers therefore represented a comparatively stronger area of readiness among the participating airports. However, geographic proximity or existing transportation connectivity alone does not indicate that an airport is operationally prepared for AAM services.

Community engagement and coordination with local jurisdictions also remained limited. Only a portion of the participating airports indicated having undertaken moderate community engagement or planning specifically related to AAM initiatives, with the results varying among airport categories. Approximately 25% of participating airports indicated having processes in place that could support community engagement regarding AAM initiatives. The findings therefore suggest that, while some airports may be able to build upon existing engagement mechanisms, AAM-specific community engagement had not yet become an established planning activity among most participating airports.

Approximately 60% of participating airports reported limited current discussion or political support for AAM initiatives. At the same time, approximately 60% indicated that their local environment was conducive to innovation. In addition, 85% of participating airports indicated an absence of known policy-level conflicts related to AAM initiatives, while 33% of participating primary airports indicated the existence of policies that could support advancement of AAM initiatives. Taken together, these findings indicate an important distinction between the broader environment for innovation and active institutional support for AAM. Although most participating airports did not identify existing policy barriers and many characterized their environments as conducive to innovation, this had not yet translated into widespread political engagement or AAM-specific policy support.

Regarding tenant agreements and space availability, 77% of participating airports indicated either that existing lease agreements had not yet been considered in relation to AAM operations, that substantial lease modifications would be necessary to accommodate AAM, or that suitable lease space was unavailable. Similarly, 82% of participating airports had either not identified curbside facilities for AAM or had not determined whether existing curbside facilities could accommodate AAM passengers. These findings identify leases, space allocation, and curbside planning as areas in which most participating airports had not yet progressed substantially toward AAM-specific readiness.

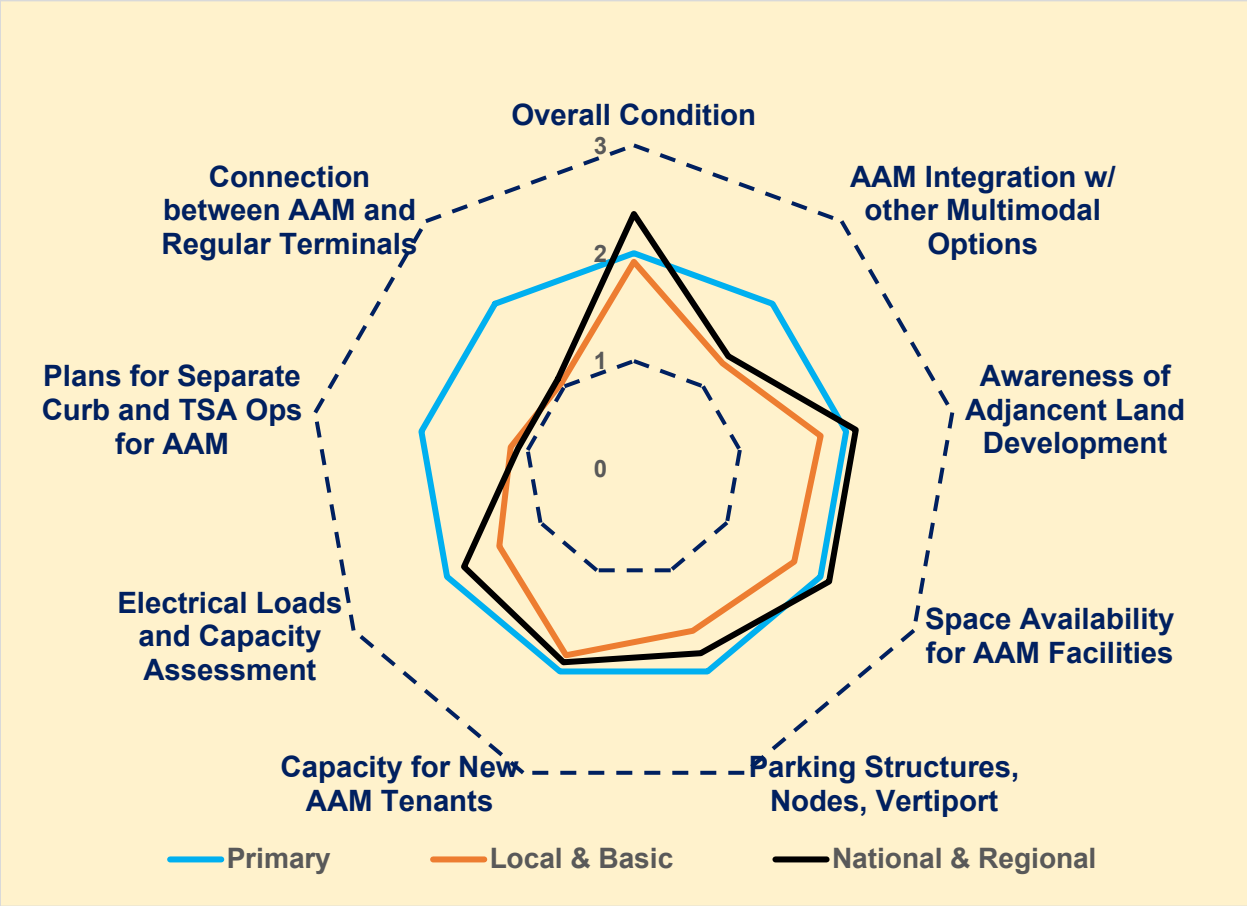
Workforce readiness presented another potential constraint. About 67% of participating airports indicated insufficient personnel capacity or expertise, either internally or through

outsourcing, to undertake AAM initiatives. This pattern was more pronounced among participating national/regional and local/basic airports, whereas all participating primary airports indicated at least some potential to increase personnel capacity or access the necessary expertise through outsourcing. The results therefore indicate that access to personnel and specialized expertise may represent a more immediate readiness concern for participating national/regional and local/basic airports than for participating primary airports. Participating airports also reported challenges related to housing availability and workforce development. Only 33% indicated having moderate housing availability at costs considered sustainable for a potential new workforce supporting AAM operations. Furthermore, 84% of participating airports reported having no programs or established growth pathways for training new workers for AAM initiatives. Among participating primary airports, however, 67% indicated that promising discussions or programs were emerging to support education and workforce development for AAM. Together, these findings suggest that workforce readiness extends beyond airport staffing alone and includes broader regional considerations involving housing, education, and workforce-development capacity. The relatively limited availability of established training pathways among the participating airports indicates that workforce preparation remains an emerging component of AAM readiness.

Infrastructure Readiness Levels to Accommodate AAM Operations

Nine (9) areas were examined to assess the infrastructure readiness of participating airports to accommodate AAM operations. These included the overall condition of existing airport infrastructure, consideration of AAM integration with other multimodal transportation options, awareness of development goals for adjacent lands, space availability for AAM facilities and operations, and availability of parking structures or other areas that could potentially serve as transportation nodes or vertiports. Other areas included capacity for new AAM-related tenants, understanding of electrical loads and future utility capacity, availability of facilities and personnel for separate curbside and security operations, and passenger-connection infrastructure between conventional airport terminals and potential AAM facilities. Figure 5 summarizes the infrastructure-readiness levels reported across the nine dimensions evaluated in the study.

Figure 5
A Summary of Infrastructure Readiness Levels to Accommodate AAM Operations



Approximately 74% of participating airports characterized the overall condition of their existing infrastructure as moderate, with plans for repair or revitalization, while only 15% indicated having relatively new infrastructure with the capacity to incorporate AAM operations and tenants. These findings indicate that although much of the existing airport infrastructure may remain serviceable, relatively few participating airports considered their current infrastructure readily capable of accommodating AAM without additional improvements or investment.

Regarding integration with other transportation modes, 64% of participating airports indicated that they had not held discussions concerning multimodal integration of AAM. Reported reasons included airport location relative to activity centers and limited knowledge of potential partners or stakeholders for developing multimodal first- and last-mile connections. In contrast, all participating primary airports reported either being in the early stages of such discussions or having already considered goals related to AAM or multimodal integration, acceptable proximity to activity centers, or existing transportation solutions. The responses indicate that multimodal planning remained limited among much of the study sample, despite greater levels of consideration among participating primary airports. This distinction is important because physical accommodation of AAM facilities alone does not necessarily provide the connectivity needed to integrate AAM services with the broader transportation system.

Regarding adjacent land-use planning, 77% of participating airports indicated having at least a general awareness of development goals for surrounding lands that could provide future opportunities for the airport. Greater levels of coordination were reported among participating primary and national/regional airports, with 68% and 27%, respectively, indicating that the airport, surrounding community, and stakeholders were already aligned and supportive of opportunities and discussions related to AAM initiatives. These findings suggest that awareness of surrounding land development represents a comparatively stronger aspect of infrastructure readiness, although awareness does not necessarily indicate that land has been formally designated or prepared for AAM development.

The participating airports also reported comparatively favorable conditions regarding physical space. Approximately 74% indicated that potential areas were available to accommodate AAM facilities or operations, while 60% reported having parking structures, aprons, or other areas that could potentially serve as transportation nodes or vertiports. In addition, 70% indicated having at least moderate space available for new AAM-related tenants, such as concessions, maintenance facilities, or package-delivery hubs. Collectively, these findings indicate that physical space availability may not represent the most immediate infrastructure constraint for many participating airports. However, the identification of potentially available space should not be interpreted as evidence that these areas currently satisfy the technical, operational, regulatory, or utility requirements necessary for AAM operations.

Electrical infrastructure presented a different readiness profile. Approximately 48% of participating airports had not interacted with utility companies to assess existing electrical loads and reported minimal understanding of their capacity for future electrical infrastructure growth. Another 44% indicated having sufficient electrical capacity to support early operations but anticipated requiring additional resources to accommodate larger-scale AAM operations. Only 8% reported having dedicated electrical capacity or plans to construct infrastructure intended to support future AAM and other airport operational demands. Thus, while some participating airports may possess sufficient electrical capacity for limited initial operations, utility coordination and planning for scalable electrical demand remained relatively underdeveloped. The findings suggest a distinction between having existing electrical service and having undertaken the infrastructure planning necessary to support potential growth in AAM operations.

Readiness was particularly limited regarding separate curbside and security operations. Only 5% of participating airports indicated having sufficient personnel and facilities to undertake separate curbside and security operations for AAM if such activities could not be accommodated within existing terminals, while 85% reported insufficient capacity in both areas. Among participating primary airports, 67% indicated having at least minimal personnel and facility capacity for separate AAM curbside and security operations. These findings identify passenger-processing and security-related capacity as one of the less-developed dimensions of infrastructure readiness among the participating airports. They also indicate that the availability of physical space for AAM facilities does not necessarily correspond with the operational infrastructure and personnel capacity needed to support those facilities.

Similarly, only approximately 13% of participating airports indicated having undertaken at least some discussion or planning regarding passenger-connection infrastructure, such as

walkways, airport people movers, or buses, between potential AAM facilities and conventional airport terminals. The limited level of planning for such connections further indicates that integration of AAM facilities into existing passenger-processing and ground-transportation systems remained at an early stage among most participating airports.

Taken collectively, the infrastructure-readiness results reveal an important distinction between physical capacity and functional readiness. Many participating airports reported potentially available land, facility space, and locations that could accommodate AAM-related development. However, substantially lower levels of readiness were observed in areas requiring coordinated infrastructure planning, including electrical capacity assessment, multimodal integration, passenger connectivity, and separate curbside and security operations. Consequently, the findings suggest that the principal infrastructure-readiness challenge among participating airports may not be the availability of physical space alone, but the extent to which that space has been evaluated, planned, and supported by the systems necessary for AAM operations.

Additional Responses

Participating airports were asked additional questions regarding potential vertiport ownership and management, community support, zoning considerations, access to potential vertiport services, and the types of AAM flight operations that could potentially be accommodated at their airports.

Regarding ownership of vertiport infrastructure, 62% of participating airports indicated that such infrastructure should be shared between the public and private sectors, while only 5% indicated a preference for ownership solely by the private sector. These responses indicate a stronger preference among participating airports for some level of public-sector involvement in future vertiport infrastructure rather than a predominantly private-sector ownership model.

Regarding potential community support for vertiport development, 41% of participating airports agreed that the establishment of vertiports would receive support from their local communities, while 44% neither agreed nor disagreed. Similarly, when asked whether the presence of vertiports would potentially further restrict zoning in the vicinity of airports, half of the participating airports were neutral on the issue while 40% agreed with the notion. The relatively high proportion of neutral responses to both issues indicates uncertainty among participating airports regarding potential community acceptance and zoning implications of vertiport development. These responses suggest that the social and land-use implications associated with future vertiport development may not yet be sufficiently understood at many of the participating airports.

Regarding access to potential vertiport services, participating airports indicated that AAM operators would have a higher likelihood of obtaining access compared with regular passengers. About 60% of participating airports agreed that AAM operators would likely obtain access to vertiport facilities at their airports, while only 43% indicated that regular passengers would be able to obtain similar access. These findings suggest that participating airports perceived fewer potential barriers to providing facility access for AAM operators than for regular passengers.

However, the responses reflect airport perceptions of potential future access rather than established access arrangements for AAM operations.

Figure 6 shows the ranking of potential AAM flight operations based on how easily participating airports believed they could accommodate them. Unscheduled services, Essential Air Service, and emergency services emerged as the top three AAM flight operations perceived as most easily accommodated. These responses indicate that participating airports perceived some existing aviation service models as more readily adaptable to potential AAM operations than others. However, the rankings represent the airports' assessment of their ability to accommodate these operations and should not be interpreted as an evaluation of the operational or economic feasibility of the individual AAM use cases.

Figure 6

AAM Flight Operations Easily Accommodated

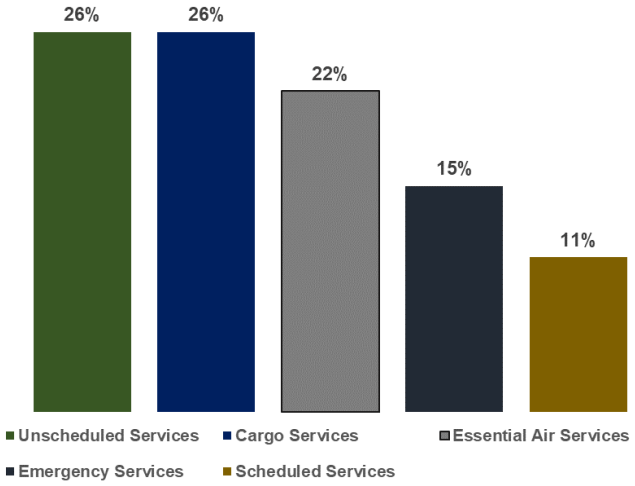
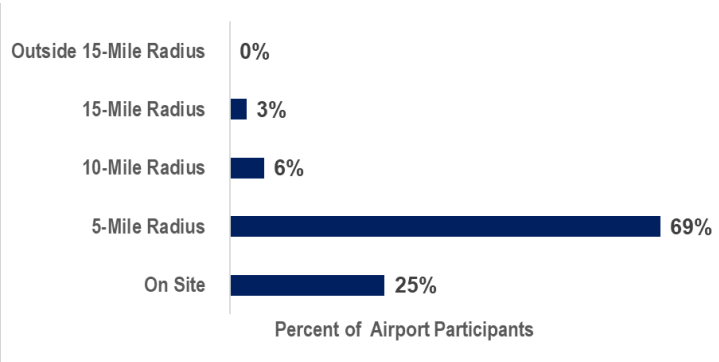


Figure 7
Proximity of the First Responders Services from the Airports

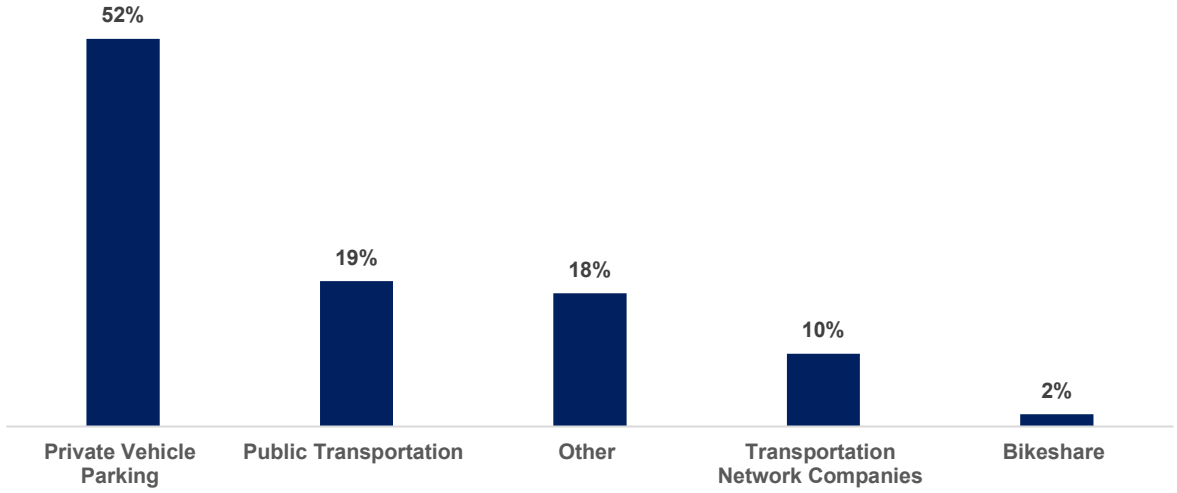


Regarding access to emergency response services, 25% of participating airports indicated having first responder services located on-site, while 70% indicated that such services were available within a 5-mile radius of their airports, as shown in Figure 7. Thus, most participating airports reported relatively close access to first responder services, although proximity alone does not establish whether existing emergency response capabilities are sufficient for the specific operational requirements of future AAM operations.

Participating airports were also asked to identify other modes of transportation currently available at their airports. As shown in Figure 8, private vehicles were the most commonly available transportation option. The predominance of private-vehicle access provides additional context to the multimodal findings discussed in Section 4.3, where many participating airports reported limited planning for integration of AAM with other transportation modes. Together, these findings indicate that broader multimodal connectivity may require further consideration as airports explore potential integration of AAM into their existing transportation systems.

Figure 8

Other Modes of Transportation Currently Available (or soon to be established) at Airports



Collectively, these additional responses indicate that participating airports generally recognized potential opportunities for accommodating AAM operations, but considerable uncertainty remained regarding how future vertiports would be owned, integrated into surrounding communities, and accessed by users. The responses also indicate that airports perceived certain existing aviation services as more readily adaptable to AAM and generally reported relatively close access to first responder services. However, these findings primarily represent airport managers' perceptions of potential future operating conditions rather than established AAM operational arrangements.

CMF Framework Analysis

The intermediate computational outputs of the fuzzy comprehensive evaluation are presented below. Membership values for each second-level factor were first calculated from the proportion of participating airports selecting each maturity level. These values were used to construct the single-factor evaluation matrices for awareness ($\boldsymbol{R_1}$), general readiness ($\boldsymbol{R_2}$), and infrastructure readiness ($\boldsymbol{R_3}$). The corresponding equal-weight vectors were then applied to obtain the first-level comprehensive evaluation vectors ($\boldsymbol{B_1}$), ($\boldsymbol{B_2}$), and ($\boldsymbol{B_3}$), which were subsequently aggregated to determine the overall maturity evaluation vector and final maturity score.

One of the 40 participating airports provided an incomplete response to the CMF items; therefore, the fuzzy comprehensive evaluation was based on 39 valid responses.
As an illustration of the membership-value calculation, the Basic Understanding sub-factor under the awareness dimension received 13 Level 1 responses, 18 Level 2 responses, and 8 Level 3 responses among 39 valid responses. Using Equation (7), the corresponding membership vector was calculated as:

$$r_{1,1} = \left[\frac{13}{39}, \quad \frac{18}{39}, \quad \frac{8}{39}\right] = [0.3333, \quad 0.4615, \quad 0.2051]$$

Thus, the Basic Understanding sub-factor had its highest membership at Level 2, indicating that the largest proportion of participating airports fell within the Level 2 maturity classification for this sub-factor. This corresponds to some awareness of or engagement with AAM initiatives, rather than either no consideration (Level 1) or a more developed level of capability (Level 3). The same procedure was applied to each second-level sub-factor to construct the awareness, general readiness, and infrastructure readiness membership matrices $\boldsymbol{R_1}$, $\boldsymbol{R_2}$, and $\boldsymbol{R_3}$.

Accordingly, the single-factor evaluation matrices were as follows:

$$R_1 = \begin{bmatrix} 0.3333 & 0.4615 & 0.2051 \\ 0.6667 & 0.1795 & 0.1538 \\ 0.5897 & 0.3333 & 0.0769 \\ 0.6667 & 0.2564 & 0.0769 \\ 0.5897 & 0.2564 & 0.1538 \\ 0.6154 & 0.2308 & 0.1538 \\ 0.7692 & 0.1795 & 0.0513 \\ 0.4892 & 0.4615 & 0.0513 \\ 0.6923 & 0.2821 & 0.0256 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 0.6667 & 0.2308 & 0.1026 \\ 0.4872 & 0.4103 & 0.1026 \\ 0.7436 & 0.1538 & 0.1026 \\ 0.7692 & 0.2051 & 0.0256 \\ 0.4103 & 0.4872 & 0.1026 \\ 0.1538 & 0.8205 & 0.0256 \\ 0.7692 & 0.2051 & 0.0256 \\ 0.7436 & 0.1538 & 0.1026 \\ 0.8205 & 0.1538 & 0.0256 \\ 0.6667 & 0.3077 & 0.0256 \\ 0.6667 & 0.3077 & 0.0256 \\ 0.7692 & 0.2308 & 0.0000 \\ 0.1795 & 0.5897 & 0.2308 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.1026 & 0.7436 & 0.1538 \\ 0.6410 & 0.3333 & 0.0256 \\ 0.2308 & 0.6154 & 0.1538 \\ 0.2564 & 0.6154 & 0.1282 \\ 0.4103 & 0.4615 & 0.1282 \\ 0.3077 & 0.4872 & 0.2051 \\ 0.4872 & 0.4359 & 0.0769 \\ 0.8462 & 0.1026 & 0.0513 \\ 0.8718 & 0.1026 & 0.0256 \end{bmatrix}$$

The first-level comprehensive evaluation vectors ($\boldsymbol{B_1}$), ($\mathbf{B_2}$), and ($\boldsymbol{B_3}$) were subsequently combined to form the relationship matrix R:

$$R = \begin{bmatrix} 0.6011 & 0.2934 & 0.1054 \\ 0.6036 & 0.3274 & 0.0690 \\ 0.4615 & 0.4330 & 0.1054 \end{bmatrix}$$

Using equal weights for the three first-level dimensions,

$$W = [\frac{1}{3}, \quad \frac{1}{3}, \quad \frac{1}{3}]$$

The overall comprehensive evaluation was calculated as:

$$B = W.R = [0.5554 \quad 0.3513 \quad 0.0933]$$

Finally, applying the maturity-level score vector (V)

$$V = [1, 2, 3]^T$$

$$S = B.V$$

$$S = B.V. = (0.5554)(1) + (0.3513)(2) + (0.0933)(3) = 1.5379$$

Finally, applying the maturity-level score vector, $V = [1, 2, 3]^T$, the overall maturity score was calculated as *S = BV = 1.5379*. The resulting score lies between Level 1 and Level 2 and is closer to Level 2. Within the CMF, this score reflects an overall maturity position between limited consideration of AAM-related capabilities and preliminary awareness, planning, or implementation. The evaluation vector further shows that 55.54% of the overall membership was associated with Level 1, 35.13% with Level 2, and 9.33% with Level 3.

The predominance of Level 1 membership and the relatively limited Level 3 membership are generally consistent with the literature reviewed in this study, which identifies infrastructure requirements, stakeholder coordination, regulatory development, community acceptance, and market uncertainty as continuing challenges to AAM implementation. The results therefore suggest that, among the participating airports, development of AAM readiness remains at an early stage rather than representing an unexpected departure from the broader implementation challenges identified in previous research.

The empirical readiness score should not be generalized beyond the participating Ohio NPIAS airports. However, the CMF structure may be transferable to other airport systems because its dimensions – awareness, general readiness, and infrastructure readiness – address planning considerations that are not unique to Ohio. Application in other states or regions would require consideration of differences in airport composition, regulatory environments, infrastructure, AAM markets, and local institutional conditions.

Conclusion

This study examined the levels of awareness and readiness of Ohio public-use NPIAS airports with regard to potential AAM flight operations. As AAM operations continue to develop, public-use airports may play an important role in hosting facilities such as vertiports and supporting associated operations. However, airports will need to familiarize themselves with the complexities of AAM and determine which business use cases may be feasible in their local areas. Given the new technologies associated with AAM operations, including eVTOL aircraft, vertiports, UASs, and other emerging equipment, it is imperative for airports to plan for and

anticipate the resources that may be needed to accommodate these technologies within existing airport environments. These resources may include hangar facilities, personnel to support additional operational processes, specialized workforce such as pilots and mechanics, and energy infrastructure for electricity and/or hydrogen. Airport operators will therefore need to remain aware of AAM developments and knowledgeable about the associated infrastructure and planning requirements while collaborating with local governments and other stakeholders to support the safe and economically feasible integration of AAM operations.

While this study examined the awareness and readiness of public-use airports in Ohio, the model developed may also be used by individual airports as a self-assessment tool as they progress toward potential AAM operations. A fuzzy comprehensive evaluation approach was used to develop the AAM capability maturity model because of its ability to assess multiple factors, including those that are qualitative in nature. By incorporating factors related to AAM awareness, general readiness, and infrastructure readiness, the model can assist airport operators in assessing their progress toward potential AAM operations. The findings indicate that additional efforts may be needed to support participating airports, particularly in areas where comparatively lower levels of awareness, planning, and infrastructure readiness were observed. Such efforts may include providing airport operators and local communities with information about potential AAM use cases, facilitating dialogue between airport owners and businesses interested in utilizing AAM services, and engaging local authorities in planning and preparing infrastructure to support future AAM initiatives.

Although this study focused on public-use NPIAS airports in Ohio, the CMF may provide a transferable framework for examining AAM awareness and readiness at public-use airports in other geographic contexts. However, the empirical findings and resulting readiness score should not be generalized beyond the participating Ohio NPIAS airports. Application of the framework elsewhere should account for differences in airport characteristics, operating environments, infrastructure, AAM markets, and community needs. The proximity of many public-use airports to rural, suburban, and urban communities may nevertheless provide opportunities for these airports to support diverse AAM operations as the sector develops.

Several limitations and assumptions should be considered when interpreting the findings. Although 40 of Ohio's 97 NPIAS airports (41.2%) participated in the study, the findings reflect only the participating airports, and the possibility of nonresponse bias cannot be excluded. The survey data were also self-reported by airport representatives and therefore reflect participants' knowledge and perceptions of their airports' awareness and readiness at the time of data collection. In addition, the CMF assumed equal weights among the critical factors and sub-factors. Equal weighting was used as an exploratory modeling assumption in the absence of established empirical or regulatory evidence supporting differential weighting and should not be interpreted as evidence that all readiness factors have equivalent operational importance. Future applications may refine these weights through expert elicitation or other weighting approaches and validate the framework across broader geographic contexts. Finally, AAM technologies, operational concepts, and associated regulatory and infrastructure standards continue to evolve. Consequently, the readiness factors and maturity criteria represented in the framework reflect the AAM environment at the time of the study and may require refinement as technologies, standards, and operational practices develop.

Ethical Declarations

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Conflicts of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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