DriveOhio
Advancing Smart Mobility

Ohio AAM Framework

July 2022

Advanced Air Mobility

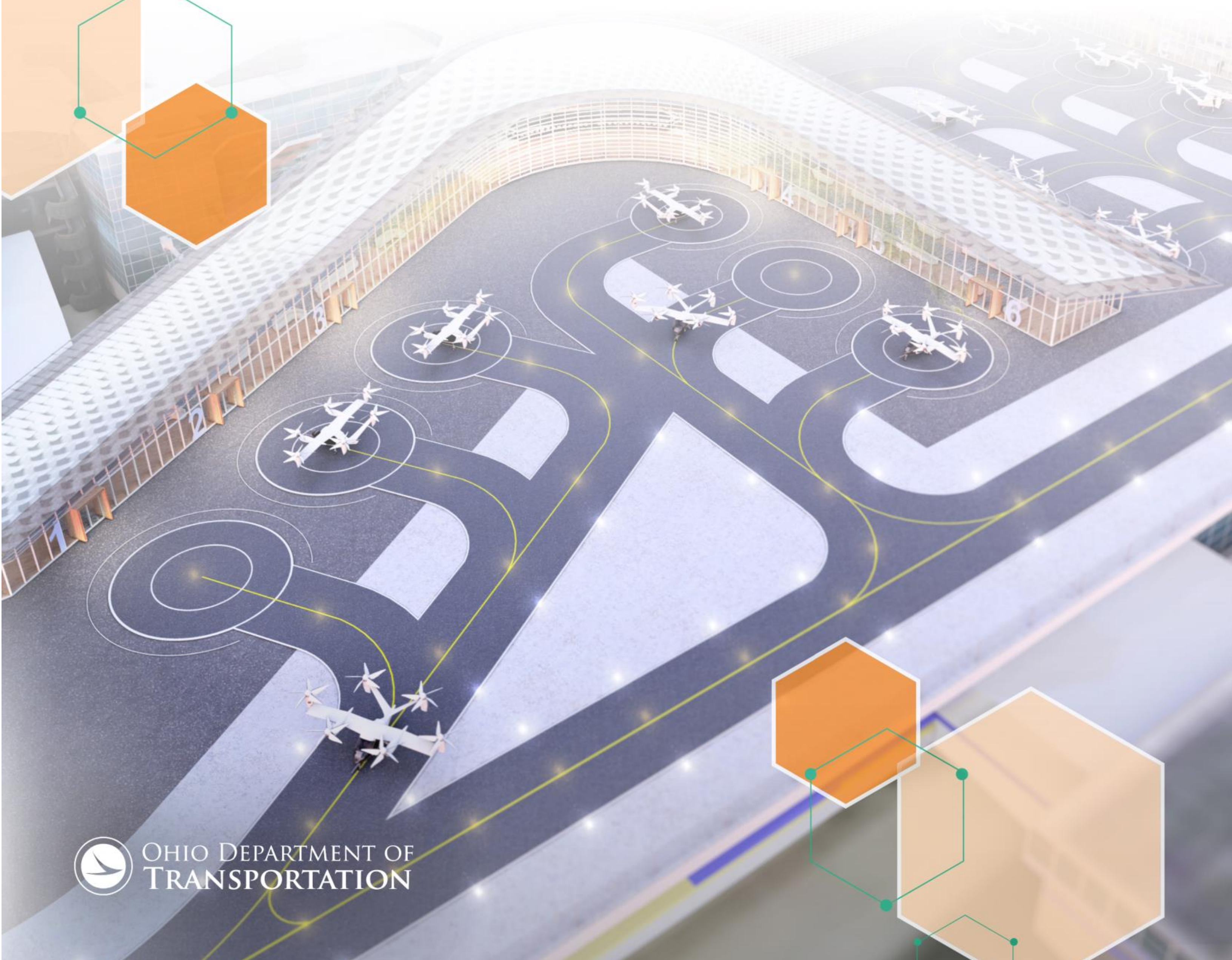

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Table 1: Acronym List

Acronym	Definition
ACAS	Airborne Collision Avoidance System
AAM	Advanced Air Mobility
AFRL	Air Force Research Laboratory
AGL	Above Ground Level (elevation)
BVLOS	Beyond Visual Line of Sight
CMH	John Glenn Columbus International Airport
CTOL	Conventional Takeoff and Landing
DOD	Department of Defense
eVTOL	Electric Vertical Take-off and Landing
FAA	Federal Aviation Administration
FATO	Final Approach and Take-Off (area)
GBDAA	Ground-Based Detect and Avoid
GSE	Ground Service Equipment
IFR	Instrument Flight Rules
LCK	Rickenbacker International Airport
MPO	Metropolitan Planning Organization
MSL	Mean Sea Level (elevation)
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASA Ames	NASA Ames Research Center
NASA Glenn	NASA John H. Glenn Research Center
OAATC	Ohio Aerospace and Aviation Technology Committee
ODOT	Ohio Department of Transportation
OEM	Original Equipment Manufacturer
OFRN	Ohio Federal Research Network
OSU	The Ohio State University
PSU	Providers of Services for Urban Air Mobility
RAM	Regional Air Mobility
SGH	Springfield-Beckley Municipal Airport
STOL	Short Takeoff and Landing
sUAS	Small Uncrewed Aircraft System

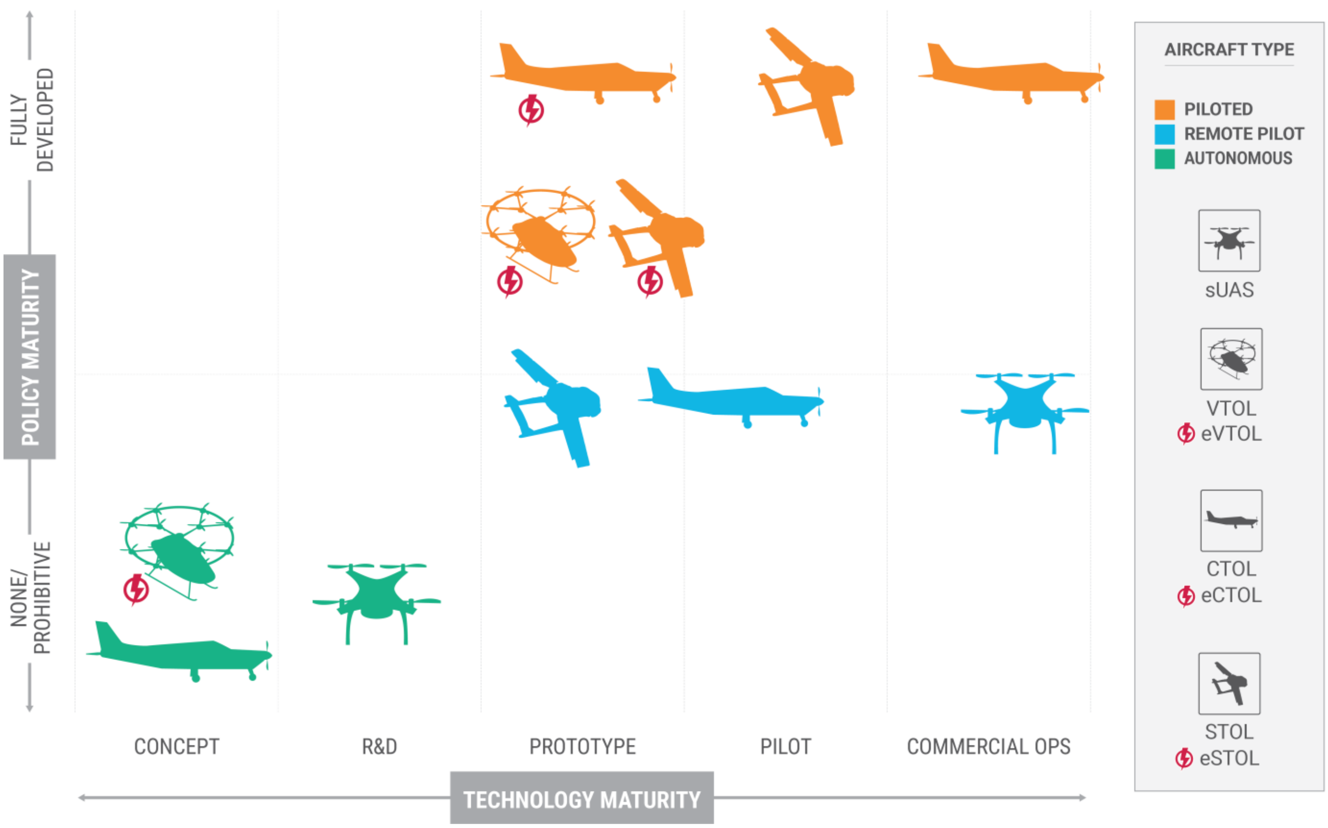
Acronym	Definition
TLOF	Touchdown and Lift Off
TNC	Transportation Network Company
UAS	Uncrewed Aircraft Systems
UAS Center	Uncrewed Aircraft Systems Center
UAV	Uncrewed Aerial Vehicle
USS	UAS Service Supplier
UTM	UAS Traffic Management
VFR	Visual Flight Rules
VTOL	Vertical Take-off and Landing

Executive Summary

As the birthplace of aviation and home to the first people to both orbit the earth and walk on the moon, Ohio is committed to staying at the forefront of the aerospace industry. Opportunities abound and are accompanied by the challenges of an emerging industry.

With 80% of the world's population[1] never having flown, AAM's lower infrastructure and operating costs[2] create an opportunity to fundamentally change air travel and overall mobility. However, the industry still requires extensive research and testing to move from concept to deployment, and later, to a fully operational ecosystem.

Informed by feedback from the AAM industry, ES 1 endeavors to approximate the level of policy and technology development for various vehicle types. As noted, some manufacturers are just beginning, others are farther ahead and many policies in varying levels of development are in play, so this is intended to provide a general indication of market maturity.



ES 1: AAM Industry Maturity

For AAM manufacturers, the business case becomes more attractive as operational costs are driven down. Automation of aircraft functions enables pilots to remotely control an aircraft or fleet of aircraft to drive costs down is to automate aircraft functions, which enables pilots to remotely pilot an aircraft or fleet of aircraft. While AAM aircraft will have a pilot onboard in early operations, manufacturers are targeting a transition over time to uncrewed, remotely piloted, highly automated, and even autonomous flight operations. To better understand the industry perspective, outreach was conducted with representatives across the sector. These representative organizations include manufacturers/operators of VTOL and other aircraft for both passenger and freight transport, as well as airports, e-commerce, healthcare, and systems integration representatives. ES 2 summarizes a few of the key takeaways for infrastructure, policy, and technology.

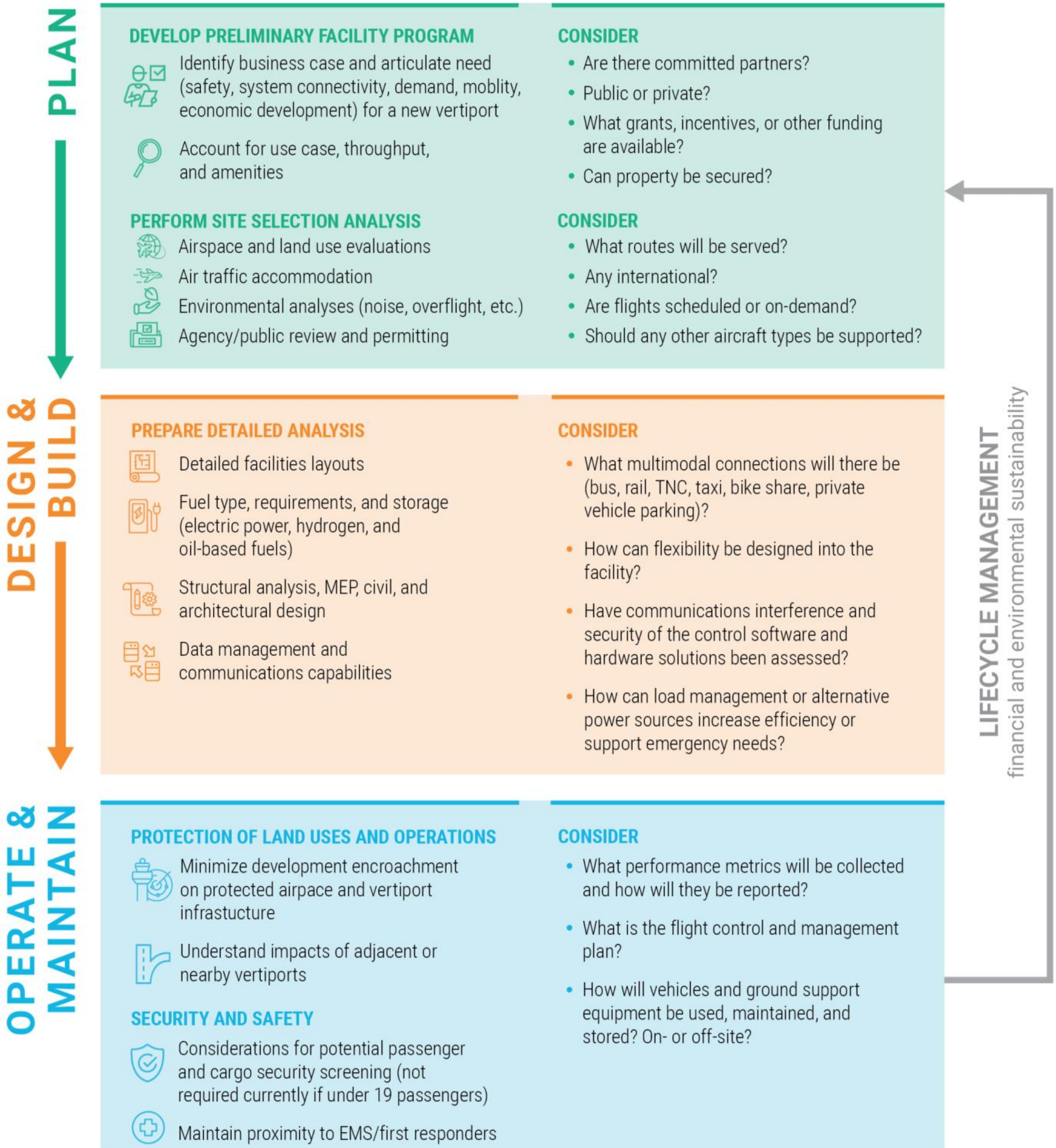
ES 2: Outreach Takeaways

Takeaways			
OEMs: Industry has been relying on legacy Heliport design standards to guide preliminary infrastructure design.	Infrastructure	Policy	
OEMs: Careful consideration of land use planning criteria and evaluation of environmental impact will maximize compatibility with existing neighborhoods and land uses.		Policy	
OEMs: Legislative action and cooperation with permitting processes are critical to OEMs ability to accurately anticipate operational timelines.		Policy	
Airports: AAM will impact all classes and sizes of airports.	Infrastructure	Policy	Technology
Airports: Community acceptance of AAM is a major concern. Industry and government need to get in front of this issue. Emphasize how AAM benefits the general public.		Policy	
E-Commerce: While small-scale deployments are occurring, technology providers and vendors need to mature their products so they can be deployed at scale.			Technology
E-Commerce: Public outreach is critical to gain public acceptance. Consider physical demonstrations and "road shows" to engage the public.		Policy	
Healthcare: Participants view the primary benefit of AAM as logistical support for the healthcare network. Transportation of medical equipment, specialty pharmaceuticals, lab samples, and personnel are the likely near-term applications. The vehicles involved in healthcare use cases will need to accommodate both cargo and people (health professionals and patients).	Infrastructure		Technology
System Integrator: States/MPOs need to be educated about what infrastructure is needed so they can provide clear but broad guidelines for the industry to ensure interoperability.	Infrastructure	Policy	
System Integrator: Data infrastructure investment is crucial to AAM's success.	Infrastructure		Technology
System Integrator: Legislators need to be flexible and dynamic for the industry to grow and develop as technology is constantly evolving.		Policy	Technology

Industry feedback was helpful in developing the AAM route planning considerations, vertiport infrastructure recommendations and framework recommendations.

For stakeholders interested in evaluating the implementation of a vertiport, ES 3 identifies many of the items to consider. In all cases, designing infrastructure (physical and virtual) and crafting legislation and incentives to facilitate growth will require close government and industry collaboration in the form of research, policy discussions, and development and streamlining of permitting processes.

Leveraging the state's history of aerospace leadership and existing aviation-related supply chain, Ohio can steer the AAM transition and scale AAM to its full potential ahead of the rest of the country. Ohio is in a strong position to lead the industry as it has shown the ability to collaborate across all levels of government and stakeholder industries. This business-friendly and safety conscious stance will help Ohio reap the related workforce and economic rewards for generations to come.



ES 3: Vertiport Development Process

The following AAM Use Cases are addressed in this framework. Each use case includes what to expect and defines, at a high level, the support needed to move the industry forward.

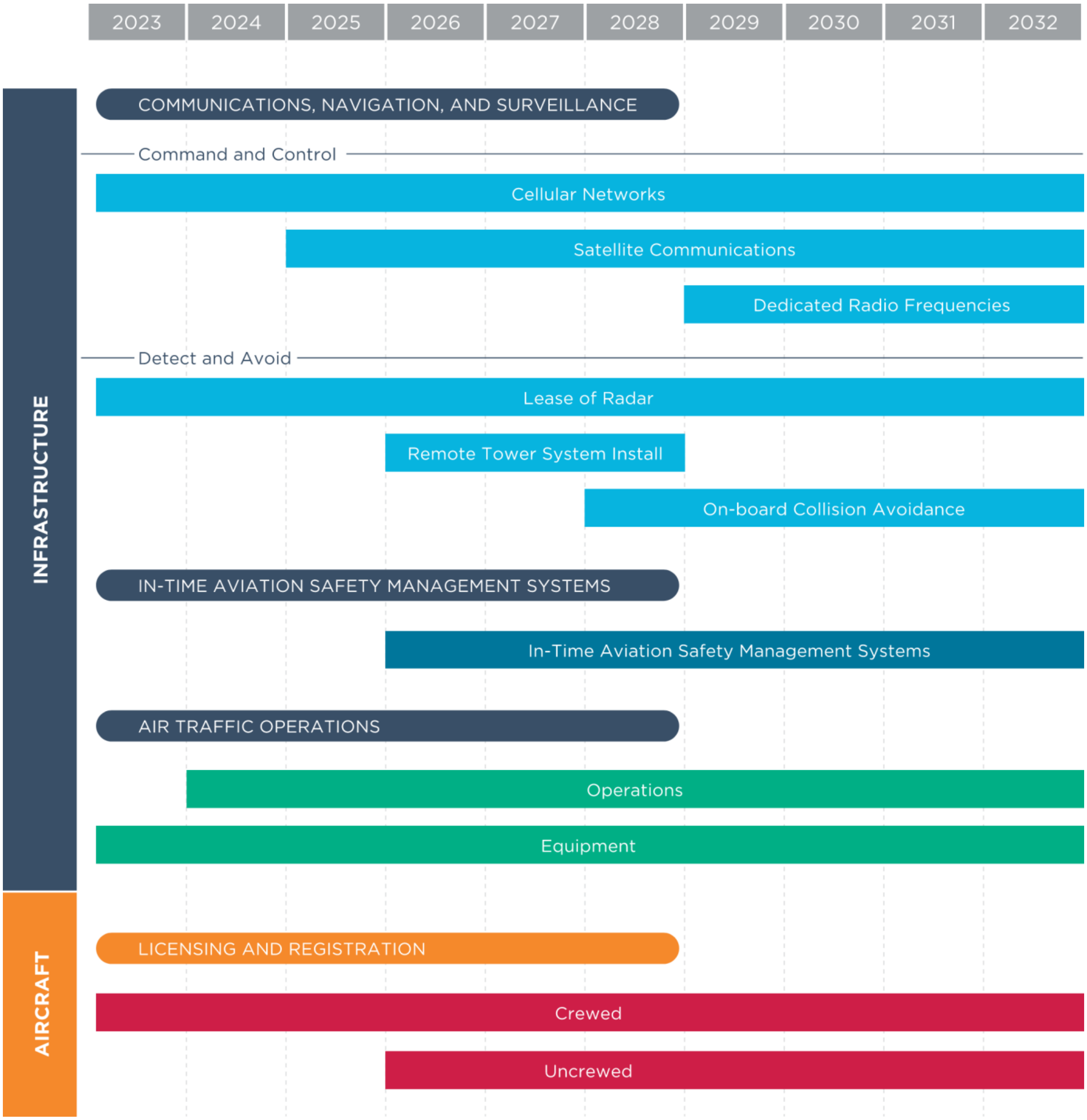
Recommendations are provided in the following areas:

- FAA and Federal policies and actions to watch, stay informed of, and influence. This includes grant funding opportunities, certification of aircraft, approval of BVLOS activities, coordination of air traffic, activation of public and private use vertiports, among many other actions.
- State actions that can be taken to enable and reduce barriers for AAM activities, create an attractive and supportive environment for AAM research, manufacturing, and workforce development.
- MPO and RTPO activities that can position regions and local partners for a successful AAM future. MPOs and RTPOs are experts in convening stakeholders around emerging topics of interest.
- County, City, and other local government considerations to position for AAM adoption and operations. Local governments can help develop regulations and ordinances to advance AAM.
- Industry considerations that must incorporate the business needs of OEMs, OEM suppliers, EV charging providers, utility companies, electrical and computer equipment installers, data providers, data connectivity needs for the supporting services, and the industry organizations that can bring these players together.
- Regulatory considerations since AAM is still in its infancy and it is critical that Ohio legislators and administrators engage in the evolving regulatory environment. Leadership in this space could help define federal regulations and attract businesses to the state that understand the value of well-organized and efficient government.
- Workforce training will be needed to create a talent pool of next-generation mechanics, manufacturing, supply chain, air traffic controllers, and electrical/software engineers to capture the 15,000 AAM-related jobs forecasted to be created by 2045.

Each use case and vehicle type will have different rates of adoption. The rates of adoption will be impacted by various factors, including location of use case, need for the service provided by the use case, local regulations, and vehicle licensing and availability.

To spur new modes of commerce and trade, DriveOhio intends to work with all stakeholders to tap the economic and efficiency benefits of lower altitude airspace. Ohio has been investing in UAS research and development for a decade and is actively collaborating with NASA, AFRL, FAA, and industry to position Ohio for the future of AAM.

To continue to lead in this space, ES 4 lays out AAM supporting infrastructure investment needed starting with communications systems and air traffic operations support. Close coordination with and support of the private sector will be needed to generate more of their investment and public private partnership opportunities. On the aircraft side, the state anticipates expanding crewed licensing programs to uncrewed within the next 5 years.



ES 4: FlyOhio AAM 10-Year Deployment Plan

1. Introduction

As the birthplace of aviation and home to the first people to both orbit the earth and walk on the moon, Ohio is committed to staying at the forefront of the aerospace industry. Opportunities abound, but these come with the challenges of an emerging industry and workspace. This study summarizes the opportunities and maps a way through the challenges to position Ohio as the leader in Advanced Air Mobility (AAM).

1.1 Scope and Purpose

The Ohio Department of Transportation (ODOT), through DriveOhio, commissioned this study to prepare a framework to support, and be positioned for, anticipated AAM growth throughout the state. Advanced Air Mobility uses next-gen technologies to move people and cargo between places not conveniently served by surface transportation or existing aviation. Common technologies include electric propulsion, short and vertical takeoff/landing techniques, advanced materials, and the ability to remotely or autonomously pilot aircraft. Ohio intends to apply AAM for the safe, efficient, and equitable transportation of people and goods throughout the state. AAM increases modality options, improving transportation resiliency and efficiency. It can also increase safety as newer aircraft are designed with redundancy in mind. This document captures the existing AAM ecosystem, Ohio specific activities, route planning considerations, recommendations for establishing vertiports, and provides a strategic framework for Ohio to support AAM.

Ohio's AAM efforts are intended to:

- Be a leader in this industry to foster innovation and accommodate it responsibly and safely.
- Create an economic advantage to attract new and high-paying jobs to the state.
- Identify key considerations and constraints to inform the planning process for the state, its partners, and their stakeholders.
- Provide a recommended policy framework to assist key decision makers (MPOs, municipalities, etc.) in preparing for, accommodating, and programming AAM into their regional plans.

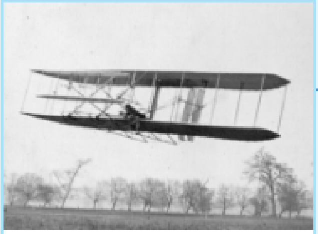
1.2 Foundation

From the Wright Brothers developing the first powered airplane in Dayton in the early 1900s to the establishment of the FlyOhio initiative in 2017, Ohio has long been a leader in aerospace innovation. This rich history and foundation in aviation makes Ohio the ideal state for AAM development. Key events and efforts that brought Ohio to this position in aviation history are shown on Figure 1.

1.3 Governance of Advanced Air Mobility in Ohio

Moving people and cargo with new, advanced aircraft presents technical as well as regulatory challenges. Ohio follows the governance set forth by the Federal Aviation Administration (FAA) as it relates to AAM. Ohio is working to support future AAM plan development by creating a statewide framework, with policy recommendations, that can cascade to local and regional partners.

1899
Wilbur Wright builds and tests his first kite, which will inform his airplane designs



1904
The Wright Brothers begin testing Flyer II at Huffman Prairie Flying Field, which will eventually become Wright-Patterson Air Force Base

11/7/1910
First Cargo Flight from Dayton to Columbus

5/21/1917
School of Aeronautics opens at OSU to train WWI pilots

10/2/1918
The first UAS, The Kettering "Bug", makes it's first test flight in Dayton

7/1/1925
CLE Airport opens with first air traffic control tower and first ground-to-air radio control system

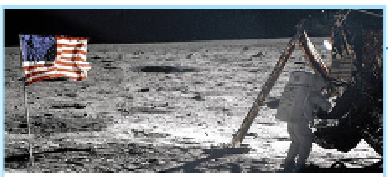
1/23/1941
The NACA Engine Research Laboratory (Future NASA Glenn Research Center) Opens

1/13/1948:
Wright-Patterson Air Force Base near Dayton, OH is established

2/20/1962
John Glenn becomes first American to orbit Earth

3/19/1964
Jerrie Mock takes off from CMH to complete the first solo flight around the world by a woman

1965
Governor Rhodes County Airport Program is funded



7/20/1969
Neil Armstrong becomes first person to walk on the moon

11/11/1982
Robert F. Overmyer pilots STS-5, the first operational space shuttle flight

12/1990
Wright/Wright-Patterson Lab is created when 13 Air Force Research Labs are consolidated into 4 "superlabs"

1997
AFRL Established and headquartered at Wright-Patterson Air Force Base

1998
John Glenn becomes the oldest astronaut, flying on the Space Shuttle at age 77

2013
Ohio UAS Center formed

2017
Fly Ohio Initiative Established

2018
State of Ohio & AFRL partnership to develop GBDAA

4/2019
SkyVision receives approval to operate BVLOS

5/27/2021
ODOT signs Space Act Agreement with NASA for AAM research in Ohio

11/10/2021
AAM Showcase Event held at SGH

6/2023
Estimated completion of $8m AAM Center of Excellence at SGH

Figure 1: Ohio Aerospace History

2. AAM Ecosystem

Creation of a comprehensive AAM ecosystem in Ohio requires strategic collaboration between industry, government, and academia. This ecosystem must ensure that technological advancements can be rapidly integrated and new policies created to support their adoption. The ecosystem must be understood by policy makers and supported by the public. Such understanding, along with market forces, consumer adoption, and trust, will spur ecosystem evolution.

2.1 Vehicles

In this report, AAM is characterized by increasing mobility and the resiliency of the air transportation system through new advances in propulsion systems, advanced materials, and the ability of aircraft to be remotely or autonomously piloted. These improvements can be broadly divided into Configuration and Autonomy categories, where Configuration is further divided into thrust, take-off, and fuel. Taken together, these advancements represent potential improvement in direct operational costs, revitalization of existing underutilized aviation infrastructure, and connection with advanced air traffic management concepts.

Figure 2: Vehicle Examples[3]

Figure 2 shows three different types of AAM vehicles. On top is a Kitty Hawk eVTOL. Bottom left is a Workhorse Horsefly Small Uncrewed Aircraft System (sUAS). Bottom right is a Lyft eVTOL. Figure 3 depicts the three different classifications of take-off and landing: Conventional (CTOL), Short (STOL), and Vertical (VTOL).

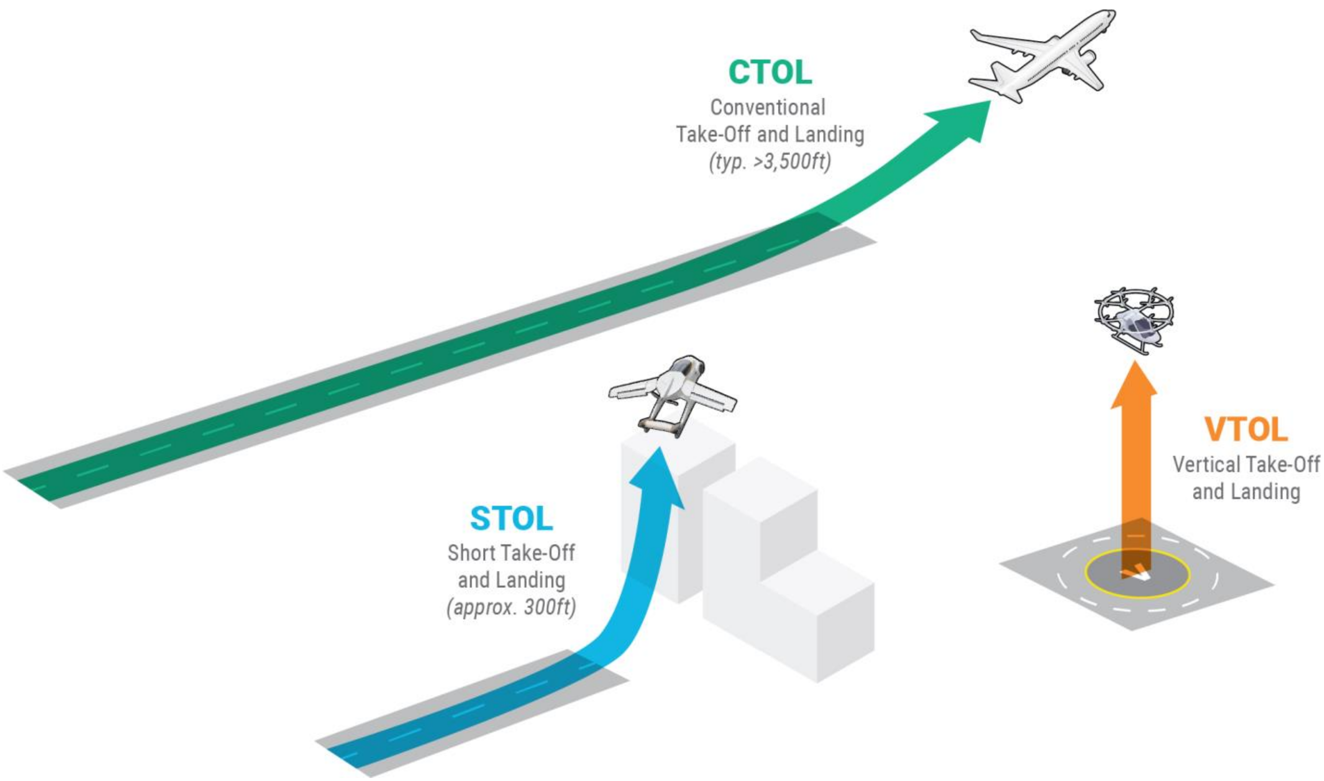


Figure 3: Take-Off Comparison for CTOL, STOL, and VTOL

2.1.1 Vehicle Configurations

AAM vehicle configuration variables include thrust mechanism, fuel type, and take-off style. Figure 4 shows many of the vehicles that manufacturers are pursuing, classified by their design configurations. Common design configurations include:[5]

- Vectored Thrust: An aircraft that uses its thrusters for lift and cruise by rotating the wing or rotating the thrusters.
- Lift and Cruise: An aircraft that uses independent thrusters for cruise and for lift without any thrust vectoring.
- Augmented Lift: An aircraft that uses distributed propulsion to create lift at low ground speeds, allowing for shorter takeoffs.
- Multicopter: An aircraft that is wingless with only thrusters for lift and no thrusters for cruise.

Common Fuel Types

The most to least common ways of fueling AAM vehicles are currently:

1. Fully electric propulsion that uses batteries to store energy onboard the aircraft to provide the necessary lift and thrust for flight.[4]
2. Hybrid-electric propulsion that combines a lithium-ion battery pack with a conventional petroleum-based generator to extend travel range.
3. Hydrogen fuel cells that are in early stages of development and still need significant research to fully address safety and reliability.
4. AvGas (Aviation Gas) is used in highly automated CTOL vehicles but is not typically considered for newer designs like VTOL.

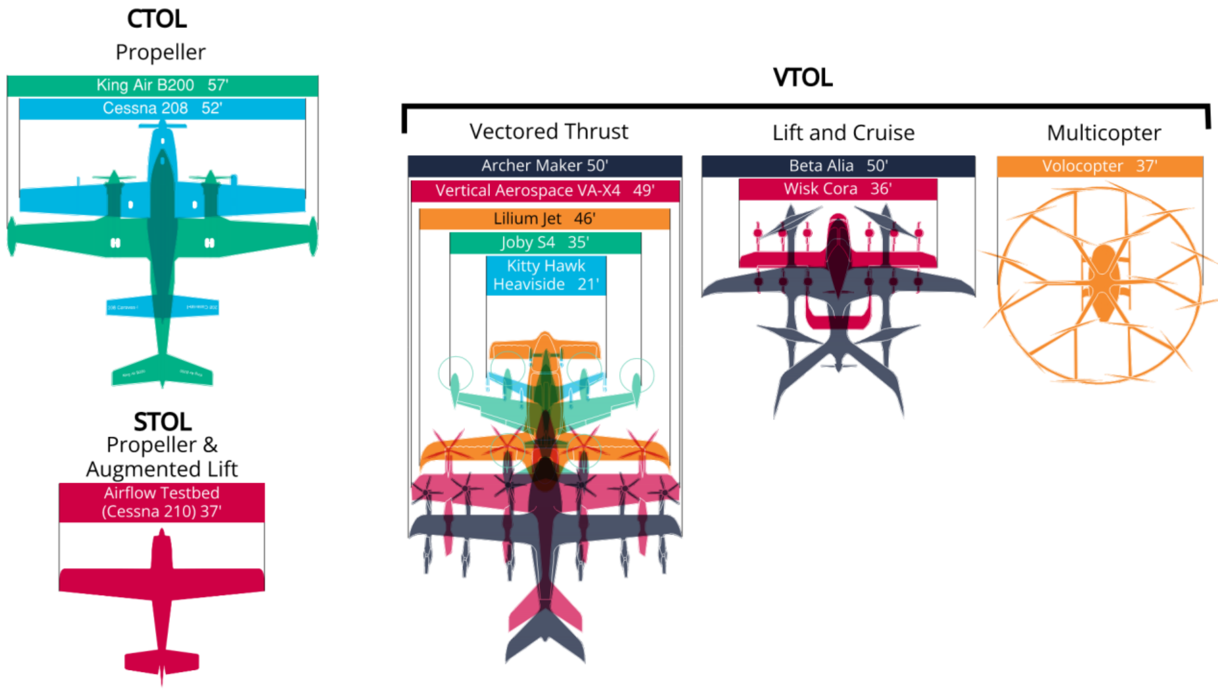


Figure 4: AAM Vehicle Types by Relative Size and Configuration

Take-off configurations include VTOL, STOL, and advanced CTOL aircraft configurations. AAM configurations also may be designated by the primary propulsion energy source (fuel type) such as electric "e" or hydrogen "h". For example, an electric propulsion VTOL aircraft would be designated as an eVTOL and a hydrogen propulsion STOL aircraft would be designed as a hSTOL. VTOL aircraft require a smaller infrastructure footprint similar to present day helicopters whereas STOL and CTOL aircraft require runways to take off and land. STOL aircraft require a significantly shorter runway and therefore vertiports may be able to integrate STOL aircraft via a dedicated small runway or by connecting varying takeoff and landing areas. AAM CTOL aircraft include highly automated and electric concepts that take advantage of the same technological innovation that has accelerated growth in VTOL and STOL.

2.1.2 Aircraft Autonomy

For AAM manufacturers, the business case becomes more attractive as operational costs are driven down. One methodology to drive costs down is to automate aircraft functions, which enables pilots to remotely pilot an aircraft or fleet of aircraft or reduces the amount of piloting skill to fly the aircraft from 40 hours to five hours or less. While AAM aircraft will have a pilot onboard in early operations, manufacturers are targeting a transition over time to highly automated, and even autonomous, flight operations. Initial automation may take the form of simplified vehicle operations where the pilot workload is reduced through enhanced automation capabilities. Alternatively, manufacturers may keep a pilot in the cockpit in an optionally piloted aircraft where the pilot performs overall mission management and oversees flight automation. Both simplified vehicle operations and optionally piloted aircraft have a pilot onboard the aircraft.

Conversely, remotely piloted aircraft move the pilot to a ground-based control center to oversee and control the aircraft. Remotely piloted operations will start with a single pilot managing a single aircraft, but over time this will grow to many aircraft per pilot. The end state is a highly autonomous aircraft system where the aircraft is capable of decision-making in nominal and off-nominal conditions, such as non-cooperative craft or adverse weather. Fully autonomous systems are foreseen in the more distant future.

Table 5, in Chapter 3, outlines which types of vehicles the OEMs are pursuing. Figure 5, below, shows expected technological pathways to achieve fully autonomous flight in support of AAM.

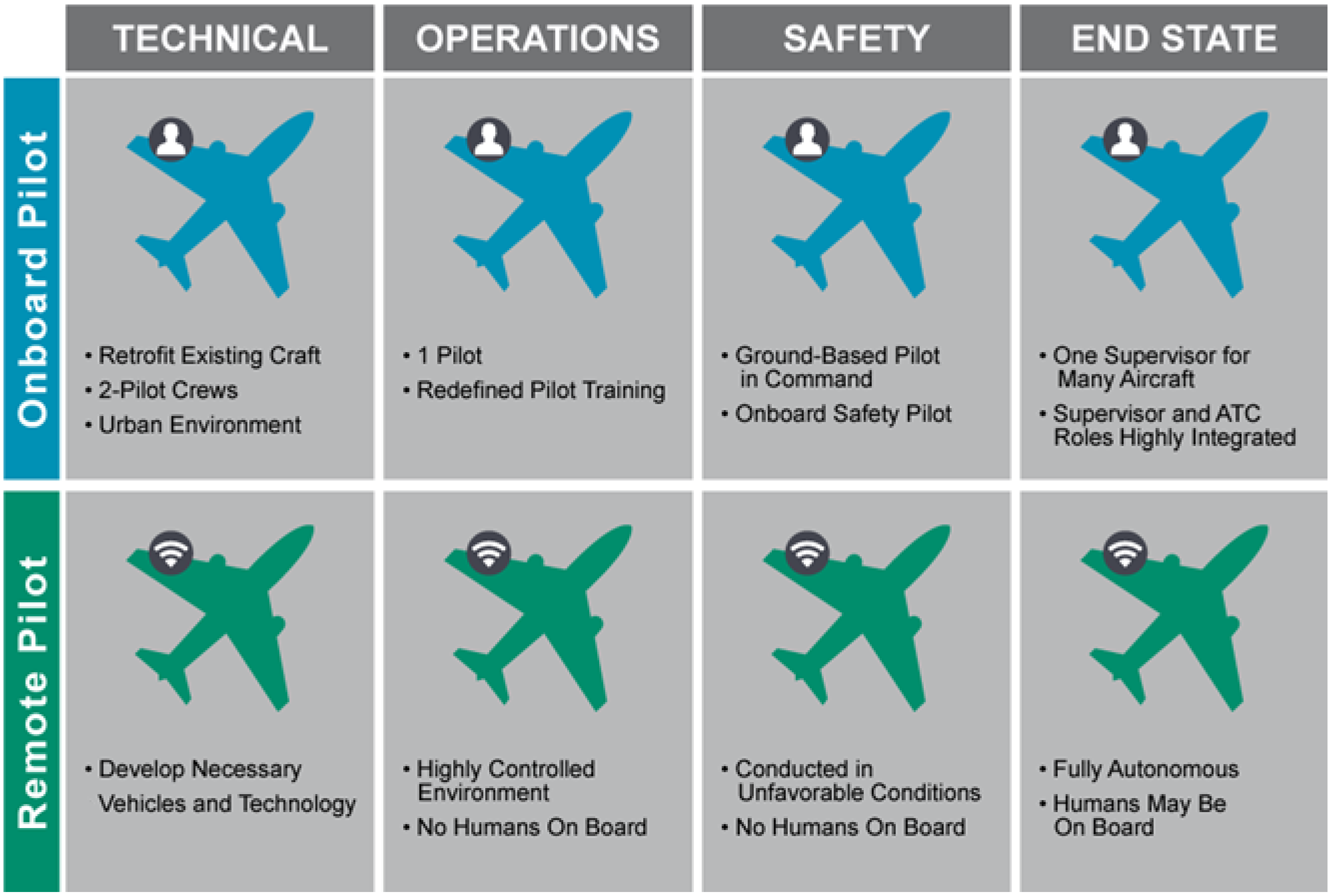


Figure 5: Aircraft Pathways to Autonomous Flight for AAM

The Onboard Pilot Aircraft Pathway is gradual and aims to gain community acceptance prior to fully scaled automated operations. It also recognizes the many technical and regulatory hurdles in place which limit advanced technology integration for larger aircraft systems. The approach suggests aircraft capabilities to operate in current state regulatory conditions while proving out flight critical technology, potentially through commercial operations shadow mode testing like that of Tesla. Aircraft will have autonomy built in from the onset, reducing the need for AAM manufacturers to rebuild or redesign aircraft. Community acceptance and regulatory advancements are critical to further enabling the Onboard Pilot Pathway business model. Mission risk and safety during off-nominal situations are prioritized when using this path. Operators and manufacturers see commercial viability in generating products which can enter the market in the near-term but have capabilities to perform advanced operations when the ecosystem is further developed.

The Remote Pilot Aircraft Pathway moves straight to remotely piloted operations without a pilot directly onboard the aircraft. For the operations milestone in controlled environment and certification milestone in unfavorable conditions, the pilot is located at a ground control center for automated testing of system technology and certification. Several of the AAM manufacturers are targeting the Remote Pilot Pathway to achieve certification and enable fully deployed operations. For this path to be successful, implementation and industry-wide adoption of an uncrewed air traffic management system utilizing Providers of Services for Urban Air Mobility (PSUs) are needed. The aircraft and technology are designed with autonomy in mind and involve frequent, secure digital datalink communication of information in real-time between aircraft or pilot and the navigation service providers. To be effective, other technology innovations must also close the gap in FAA certification ranging from the hardware and software on the aircraft to infrastructure in urban environments for takeoff and landing.

2.2 Air Traffic Management

There are several classes of airspace, as shown in Figure 6, that all fall into one of two categories, controlled or uncontrolled airspace. The rules described below currently apply to all aircraft whether they are autonomous, remotely piloted, or operated by onboard pilots.

- Controlled airspace has varying requirements for air traffic authorization to fly in the airspace depending on the class of controlled airspace. In Class A airspace all aircraft need to be under air traffic control (ATC) and need to operate under instrument flight rules (IFR). In class B, C and D airspace all aircraft need to be under air traffic control but can operate under either IFR or visual flight rules (VFR). In class E airspace aircraft do not need to be under ATC if they operate under VFR. ATC generally provides separation for all aircraft under their control and provides surveillance of all air traffic that can be observed by ATC surveillance systems. ATC generally advises aircraft under its control of the presence of nearby un-cooperative aircraft (not under ATC control) that it is able to detect or with which it is unable to communicate.
- Uncontrolled airspace is not controlled by ATC. As such, aircraft are not separated from each other by a third party. Aircraft are still required to follow the rules for VFR or IFR flight.

Another important distinction is aircraft flying via visual flight rules compared to instrument flight rules.

- Visual Flight Rules (VFR): Flying under VFR means that certain visibility and cloud height (ceiling) conditions need to be met. This is called visual meteorological conditions (VMC). There are also conditions for the distance aircraft need to be from clouds. The conditions for visibility and cloud separation vary by airspace class.[a]
- Instrument Flight Rules (IFR): Flights can generally fly in any kind of weather. This is called instrument meteorological conditions (IMC). All IFR flights need to be on an instrument flight plan. ATC provides separation services for all IFR aircraft whether they are flying in VMC or IMC.[b]

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[a] VFR flights cannot use Class A airspace. Pilots may fly VFR in both controlled and uncontrolled airspace as long as the aircraft meets equipage requirements, and the pilot follows controlled airspace operational procedures. Class B, C and D airspace require pilots to contact ATC and follow their instructions.

[b] Federal Aviation Administration Pilot's Handbook of Aeronautical Knowledge (PHAK) Chapter 15. Airspace.

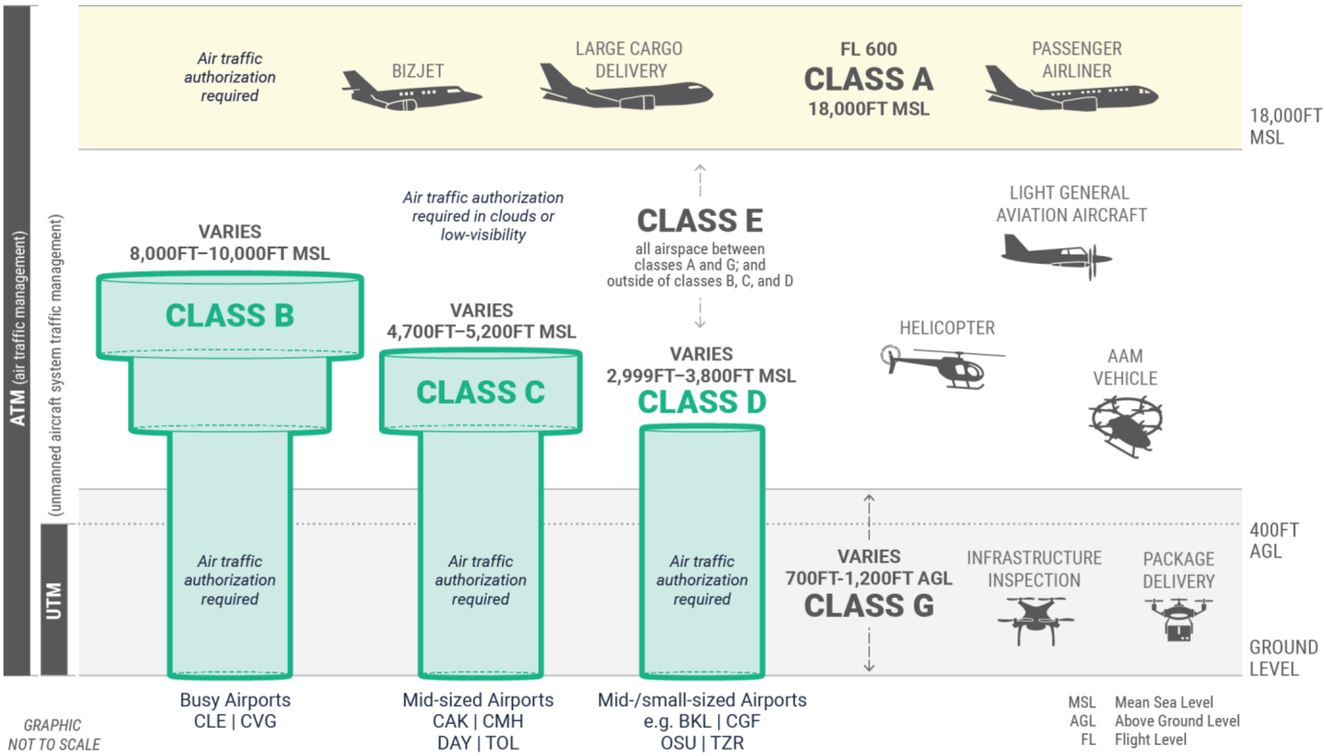


Figure 6: FAA Airspace Classifications

Note: While UAS can in theory fly in any Class G airspace, traffic management is limited to 400 feet AGL.

A new methodology of air traffic management, inspired by the UAS Traffic Management (UTM) system being developed for small uncrewed aircraft systems, embraces commercial air navigation services. For AAM, this is called Providers of Service to Urban Air Mobility (PSUs) and would provide similar air navigation services as air traffic control. The PSU ensures operator flight plans will not conflict with other operator flight plans, therefore strategically separating aircraft in pre-determined airspace. Multiple PSUs may serve a geographic region, which also differs from existing air traffic control where one facility is responsible for a geographic area bounded by altitude. PSUs therefore communicate across a broader PSU Network via discovery services for situational and domain awareness. Participating aircraft and fleet operators will be responsible for tactical deconfliction which may use onboard detect and avoid systems, such as Automated Collision Avoidance Systems (ACAS), Ground-Based Detect and Avoid (GBDAA) systems such as Ohio's SkyVision system, or primary radar.

The new commercial marketplace for private air navigation services is also supported by qualified third-party service providers that may support an operator or PSU. AAM concepts seeking to take the Remote Pilot Pathway, as described earlier, will require establishment of a UTM market. While still unclear, airspace may be segregated or integrated depending on the regulatory approach. A segregated airspace with UTM would dedicate certain airspace in the National Airspace System (NAS) for AAM or related operations. Integrated airspace with UTM would require no changes to airspace design, however, air traffic control would not have responsibility to manage separation. Instead, AAM intent and flight plans would be shared with controllers to provide awareness and there likely would be some limitations on where AAM aircraft could operate so as to not interfere with air traffic control managed IFR flights.

2.3 Government Interaction

Government involvement is a key enabler for realizing the full concept of an AAM ecosystem. Numerous national and state organizations are researching and investing in AAM capabilities, potentially unlocking valuable future technologies with a major potential impact on and need for regulatory standards and traffic management.

2.3.1 National Activities

Federal efforts are led by three agencies: FAA, NASA, and the USAF. The FAA is currently collaborating with the NASA Aeronautics Research Mission Directorate (ARMD) on their AAM National Campaign and other projects within NASA's research portfolio as well as the U.S. Air Force's Agility Prime initiative. The FAA also developed and promoted the first version of the Urban Air Mobility (UAM) Concept of Operations in June 2020 and released draft guidance on vertiport planning and design standards in February 2022.[6] Ohio has been coordinating with the FAA as they build out the statewide AAM program and administrative framework. The Ohio UAS Center currently has a technical assistant with the FAA's office of safety for UTM infrastructure. The UAS Center has an additional Technical Assistant from the Partnerships for Safety Program.

NASA's AAM National Campaign series is designed to promote public confidence in AAM safety and give prospective vehicle manufacturers, operators, and airspace service providers insights into the evolving regulatory and operational environment. The AAM National Campaign is identifying maturity levels for vehicle performance, safety assurance, and airspace interoperability with collaboration from aircraft manufacturers and service suppliers to develop and demonstrate integrated solutions for civil use. Within the National Campaign initiative, the AAM Ecosystem Working Groups (AEWG) exist to accelerate the development of AAM technologies by hosting a series of public meetings with the broad AAM community. NASA is conducting the first series of vehicle and infrastructure tests for the National Campaign (NC-1) to assist with the integration of AAM into national airspace. NC-1 will comprise flight demonstrations and simulations at test sites around the U.S. over several months in 2022.[7] NASA has several other ongoing AAM initiatives and projects within the Aeronautics Research Mission Directorate to support AAM development.

In April 2020, the U.S. Air Force launched Agility Prime,[8] a non-traditional initiative to foster collaboration with private industry to accelerate AAM adoption. A major goal of this effort is to support the national security imperative of the U.S. leadership in AAM.

2.3.2 State Activities

Beyond Ohio, there are AAM and UAS efforts in many U.S. states and territories. In North Carolina, for example, UPS Flight Forward (United Parcel Service) and Zipline are using sUAS to deliver time-critical pharmaceutical products to save lives. Additionally, Flytrex has teamed up with Causey Aviation and Chili's restaurants for on-demand food delivery. Florida cities have commitments from eVTOL operators such as Lilium, Joby Aviation, Beta Technologies, and Archer to support UAM and Regional Air Mobility (RAM) through a network of air taxi services. The City of Orlando launched their Future Ready program with UAM as a key part of an overall mobility strategy.[9] Table 2 lists some of the major AAM activities in states.

Table 2: Summary of State Activities on AAM

State	Activities
Florida	• Passenger service launching market for regional air mobility[10] • Developing vertiport networks[11] • Bringing attention to AAM transportation planning at city and metropolitan levels • UPS Flight Forward using sUAS to deliver pharmaceuticals to customers in The Villages
Massachusetts[12]	• Demonstrating emergency medical supply delivery using sUAS • Researching UAS applications to support surface transportation systems
Minnesota	• Researching future Uncrewed Aerial Vehicle (UAV) capabilities and technologies[13] • UAS being used for bridge inspections[14]
New York	• Defined and established "beyond visual line-of-sight" drone corridor[15] • Launch market for urban air mobility passenger services • Offers drone and AAM testing facilities[16]
North Carolina	• Public demonstration of AAM aircraft[17] • Early statewide drone traffic management concept[18] • Participating in FAA UAS Programs[19]
Ohio	• Demonstrations including medical supply delivery with VyrtX sUAS and Beta/Kittyhawk test flights • Robust UTM system including BVLOS drone flight area and AAM testing facilities • Coordination with NASA and FAA on multiple fronts
Texas	• Using UAS to conduct research on environmental and weather impacts[20] • Collaborated with FAA to build out a UAS testing site[21]

2.3.3 Public Acceptance Considerations

As states and communities think through the implementation of AAM, they are considering factors likely to impact public acceptance such as:

- Safety is the most important factor in the public's acceptance of AAM.[22] The introduction of new aircraft manufacturers and technologies may create 'perception barriers' when compared with traditional civil and commercial aviation due to the lack of established long term safety records (such as that acquired by conventional commercial aviation over many decades). Safety is crucial to the entirety of the AAM operation and can be delineated to in-air (vehicle) and on-ground (vertiport) considerations. Further, the location of vertiports will be a key safety consideration as their proximity to densely populated spaces increases the risk to people and property as operational density grows.
- Privacy and Property Rights are also important considerations particularly for vehicles flying over residential areas. Privacy and property rights in local ordinances will need to consider many complicated legal concepts including trespassing, general nuisances, and intellectual property rights. Careful planning and functional government oversight will be necessary to maintain public trust and avoid community backlash.
- Visual Noise may be created by low altitude flights and draw objections from communities subjected to repeated AAM operations. Even with good safety records and low noise profiles that

AAM aircraft will likely be able to offer, communities may say “not in my backyard”. This may generate demand at the local level for zoning ordinances to prevent low altitude overflight.

- Security is a consideration especially with highly sensitive facilities as well as an increased risk of terrorism from autonomous air vehicles.
- Sound Levels are a primary concern for communities experiencing regular delivery and passenger AAM flights. For electric vehicles, engine noise is nominal, but propeller noise could still be a concern during low altitude flights. Electric vehicles have been found to be quieter than helicopters, planes or even lawn mowers, but may still be loud enough to generate complaints. While industry has promised noise reduction, there is still much work to do. UAS Traffic Management (UTM) will need to organize aircraft traffic in a way that minimizes impacts. This will help avoid drawing criticism like that experienced by the outdoor advertising billboard industry when passenger or delivery vehicles congestion occurs overhead.
- Air quality impacts are not as much of a concern as they are for the general aviation industry given that AAM aircraft are expected to primarily use electric propulsion. Electrification eliminates exhaust and results in cleaner and more efficient travel than jet or propeller driven internal combustion engine vehicles. Just like with electric ground vehicles, simply converting to an electric propulsion system results in significant energy savings.
- Rural land access can be improved with AAM. Over 90%[23] of Ohio is rural land, with roughly 20%[24] of the state’s population living there. Rural communities are commonly excluded from economic opportunities in part because of geographic barriers. AAM can help reduce these barriers and improve rural/urban equity as access to employment and commercial opportunities are enhanced.
- Interoperability standards facilitate and reduce time to market for AAM aircraft manufacturers, fleet operators, physical infrastructure managers, and digital service providers while prioritizing safety. Standards for vertiports will ensure that the public can land at the vertiport closest to their destination, fully unlocking the potential time savings.
- Mobility value is an important factor for all parties but can be complicated to measure and communicate even when good data is available. Distance can be measured by direct route, road distance, or air distance (or some combination of these) and costs can be presented per trip, per passenger/seat, per passenger/seat per distance, or per vehicle. Estimates published in 2021[25,26] (see Table 3 below), indicate that eVTOL could serve trips that are time-critical, as they travel faster than ground vehicles and more efficiently (and potentially to many more locations) than helicopters.

Table 3: Cost by Mode of Travel

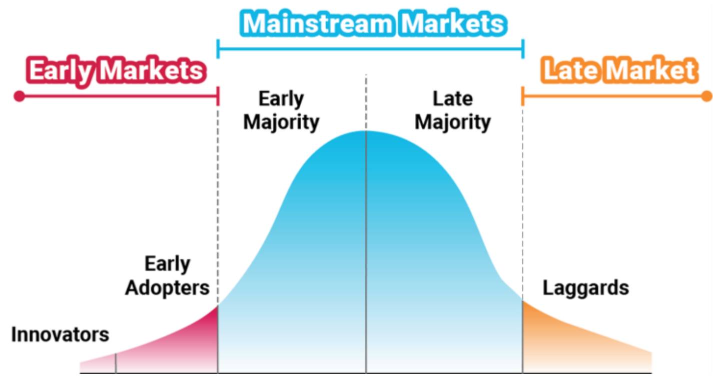
Price	eVTOL at maturity	eVTOL at launch	Taxi/TNC	Bus*	Private Car
Per trip (~9.4 mi.)	Not defined	Not defined	$22.00	$1.85	$12.00
Per passenger	$28.50	$41.00	$5.50	$1.85	$3.00
Per pax. per mile	$3.03	$4.36	$0.59	$0.20	$0.32

* Average cost of a single-ride ticket as of 3/9/22 for the six largest cities in Ohio, except for Toledo, which offers free transit.

3. AAM Market

Led by advances in the global automotive industry, trends towards electrification and automation are converging. World energy storage demand (primarily lithium-ion batteries) is expected to triple by 2025.[27] Simultaneously, the proliferation of big data from sensors and advances in software and processing capabilities have accelerated the application of artificial intelligence to increase transportation safety, efficiency and reliability while reducing emissions. Advanced lightweight materials and additive manufacturing efficiencies have also progressed significantly in the last decade. Other key drivers for AAM growth include the desire for more and faster mobility options, cost savings, and access to navigation services. AAM will benefit from all these advancements.

Still, the emerging AAM industry is in the early innovators portion (far left) of the technology adoption curve (Figure 7).



Informed by feedback from the AAM industry, Figure 8 endeavors to approximate the level of policy and technology development needed for adoption of various forms of AAM. Some manufacturers are just beginning, others are farther ahead. Many policies are in varying levels of development, so this is intended to provide a general indication of market maturity.

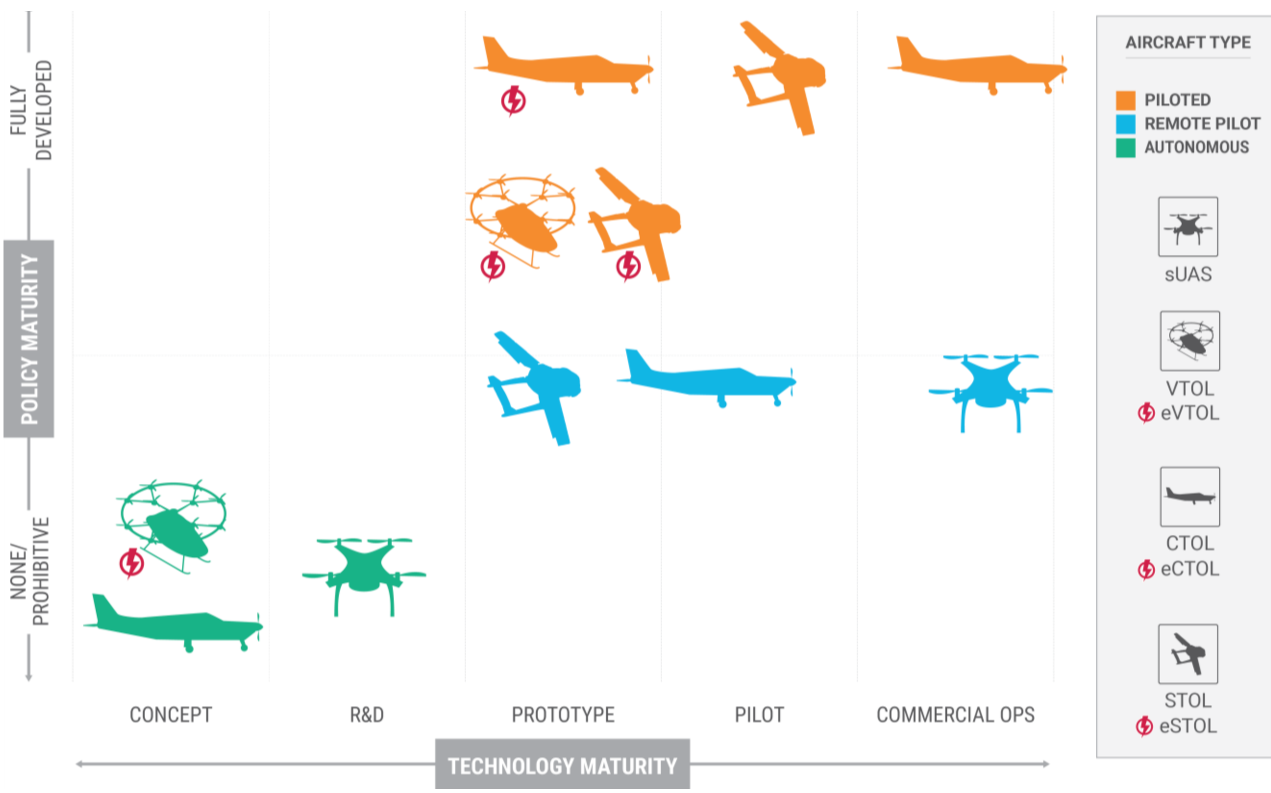
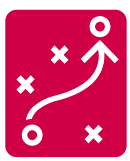


Figure 8: AAM Industry Maturity

Table 4 identifies four of the areas still requiring extensive research and testing to move from concept to deployment and later a fully operating ecosystem.

Table 4: AAM Industry Components

Type	Moving from Concept to Commercial Operations
	Physical Infrastructure: • Careful selection of vertiport location; design that ensures safety, convenience, value, and creation of a ground infrastructure network between vertiports is needed. • Standards for vertiport operational requirements, airspace integration, automation, electric charging, and siting are being studied and debated by regulatory authorities. • Planning will need to take place to ensure future AAM infrastructure is appropriately integrated into existing public and private transportation modes; can flexibly accommodate future vehicle sizes; and how regional, urban, and rural flight corridors will interact.
	Air Traffic Flow Management: • It is likely that the first AAM piloted passenger use cases will rely on the FAA's existing system of air traffic controllers to manage aircraft safely and efficiently. • As autonomous technologies and regulatory support gain traction, new innovative ways to manage AAM will be needed such as Providers of Services for Urban Air Mobility (PSUs). • PSUs will be complemented by other supplemental data service providers that provide data such as low-altitude surveillance, micro weather forecasting, and safety assessment services.
	AAM Vehicle Manufacturing: • Globally, many AAM aircraft prototypes are in advanced stages of development or operational trials. AAM aircraft designs vary widely in terms of passengers/cargo capacity, propulsion, charge speed, and operational capabilities but all are expected to be lighter, quieter, and more flexible than helicopters. • Many manufacturers, particularly those transporting passengers, will begin as piloted aircraft while some (Kitty Hawk, Wisk and EHang) intend to begin either fully autonomous or remotely piloted.
	AAM Operators: • Some operators will work like the existing airline industry, where manufacturers sell to operators who will operate the vehicles at vertiports owned by others. • Other operators will seek to be vertically integrated with their manufacturing process. • AAM operators can be independent individuals, small companies, or large players such as Amazon, FedEx, UPS, and DHL. • Their missions are diversified and range from healthcare (logistic transportation, isotope delivery, vaccine delivery, test kit delivery, blood transport, non-critical patient transportation) to package delivery, agricultural purposes, and other useful applications. • Some governments also serve as operators conducting their own bridge inspections, hurricane response, traffic surveillance and other services.

3.1 AAM Passenger Vehicles

With 80% of the world's population[28] never having flown, there is likely an enormous untapped demand for air travel. Coupled with AAM's lower infrastructure costs[29], this creates an opportunity to fundamentally change air travel. McKinsey[30] anticipates that by 2030, passenger AAM operators, while serving only 18% of the number of passengers for significantly shorter trips, "could rival today's largest airlines in flights per day and fleet size," with a forecasted demand of over 20,000 AAM flights per day compared to 2,200 flights per day for large airlines.

Table 5 highlights some AAM passenger vehicles that industry leaders are developing to capture this future market.

Morgan Stanley estimates the UAM market will be $1T by 2040.[31] To meet this market demand, progress continues to accelerate. Wisk, backed by The Boeing Company and Kitty Hawk Corporation, has already completed over 1,500[32] test flights. Archer has announced $1.0B in orders from United Airlines. Joby[33] and Lilium[34] are targeting a launch of commercial operations by 2024. In December 2021, Volocopter[35] announced a joint venture with NEOM to create the world's first bespoke public eVTOL mobility system. EHang[36] launched an Aerial Mobility Experience Center to educate the public and policy makers on operations and to work to deconflict 5G telecommunications infrastructure and flight control software components.

Table 5: Select AAM Vehicles[37]

	Certification	PAX per Veh.	Configuration	Power	Piloted vs Autonomous	Use Case	Key Partnerships
KITTYHAWK	U.S. FAA	1	Vectored Thrust	Electric	Remote Pilot	Air Taxi	U.S. AIR FORCE
ARCHER	U.S. FAA	4	Vectored Thrust	Electric	Piloted	Air Taxi	UNITED STELLANTIS
JOBY AVIATION	U.S. FAA	4	Vectored Thrust	Electric	Piloted	Air Taxi	TOYOTA
wisk	New Zealand CAA	2	Lift and Cruise	Electric	Autonomous w/ Remote Pilots	Air Taxi	BOEING
LILIUM	Europe EASA	6	Vectored Thrust	Electric	Piloted	Regional / Cargo	None
VOLOCOPTER	Europe EASA	1	Multicopter	Electric	Piloted	Air Taxi	DAIMLER
EHANG	China CAA	2	Multicopter	Electric	Autonomous	Air Taxi	None

	Certification	PAX per Veh.	Configuration	Power	Piloted vs Autonomous	Use Case	Key Partnerships
BETA	U.S. FAA	2	Lift and Cruise	Electric	Piloted	Air Taxi / Cargo	UPS
VERTICAL	U.K. CAA	4	Vectored Thrust	Electric	Piloted	Air Taxi	American Airlines
ELECTRA.AERO	U.S. FAA	7	Augmented Lift	Hybrid	Piloted	Air Taxi / Regional	None
Airflow	U.S. FAA	N/A	Augmented Lift	Hybrid	Piloted	Cargo	PIPISTREL
EVIATION	CAAI	9	Propeller	Electric	Piloted	Regional	None
RELIABLE ROBOTICS	U.S. FAA	N/A	Propeller	N/A	Autonomous w/ Remote Pilots	Cargo	NASA AAM National Campaign

3.2 International Market

For over 100 years, the U.S. aerospace and defense industry has led the world[38] in development and manufacturing. The U.S. government and industry leaders continue to innovate and navigate around the technological and regulatory challenges as AAM transforms the industry.

Outside the U.S., many countries have developed plans to incorporate AAM operations in the aerospace industry, especially Germany, China, and South Korea. In Europe, German companies are quickly advancing towards commercial AAM operations as soon as 2023. Similarly, Chinese manufacturer Ehang, has started demonstration flights and has signed agreements in Austria and Norway for future services.[39] With a roadmap in South Korea, Hyundai has entered the AAM market with plans to invest $1.5B USD over the next five years in infrastructure and aircraft development.[40]

Table 6: International AAM Activities

Country	Activities[41]
Germany	• AAM manufacturers, Volocopter and Lilium, are aiming for multiple commercial AAM operations across the globe as soon as 2023
France	• The city of Paris is partnering with AAM manufacturers and infrastructure planners to develop commercial air taxi services in time for the 2024 Olympics[42]
U.K.	• U.K.-based manufacturer Vertical Aerospace announced orders of their eVTOL aircraft to the U.S., Japan, and Brazil[43]
South Korea	• The Korean Urban Air Mobility Roadmap was published in June 2020, with the aim to commercialize AAM services by 2023–2025 • South Korean automotive group Hyundai entered the AAM sector with plans to invest USD$1.5 billion over the next five years in infrastructure and aircraft development • Volocopter conducted flight trials in South Korea at Gimpo and Incheon airports near Seoul to support concepts for airport-to-city-center connections from 2025[44]
China	• AAM manufacturer Ehang, has conducted extensive public flight demonstrations in several Chinese cities as well as Indonesia and Estonia • Ehang has signed agreements in Austria and Norway for future commercial services • Volocopter and automotive company Geely announced a joint venture in 2021 which would support operation of the VoloCity aircraft with a provisional order of 150 units
Japan	• Japan plans on a 2025 start date for AAM operations starting with flights organized around the World Expo in the Osaka-Kansai region • Japan Airlines intends to purchase up to 100 four-passenger VX-4 eVTOL aircraft under development by Vertical Aerospace for operational launch
Singapore	• Skyport is preparing vertiport plans to support AAM operations • Volocopter plans to launch services in 2024 with on-demand air taxi flights within Singapore and cross border travels to Malaysia and Indonesia[45]
Malaysia	• Volocopter announced a partnership in 2021 with Malaysia Airports to develop vertiports • Planning is underway with Skyports for a site feasibility study at Subang International Airport near Kuala Lumpur
Brazil	• A subsidiary of Embraer, Eve Air Mobility, is partnering with Australia to provide eVTOL aircraft and UAM infrastructure for commercial operations in 2026[46]
Australia / New Zealand	• U.S.-based manufacturer Wisk has been conducting AAM airspace integration trials in Australia in partnership with New Zealand[47]

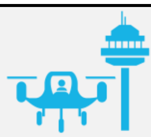
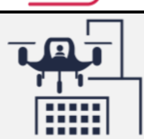
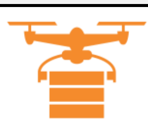
4. Ohio AAM Activities and Focus

Ohio is home to more than 550 aerospace companies and two of the nation's premier aerospace centers: NASA John H. Glenn Research Center (NASA Glenn) and the Air Force Research Laboratory (AFRL) at Wright Patterson Air Force Base (WPAFB). Ohio is the nation's largest aerospace industry supplier, supported by over 38,000 dedicated aerospace professionals,[48] plus an additional 30,000 employees at WPAFB.[49] The rapid evolution of the AAM and Uncrewed Aircraft Systems (UAS) sectors brings many new opportunities to Ohio. From low altitude airspace to retrofitting existing airfields and new infrastructure like vertiports which spur new modes of commerce and trade, Ohio intends to tap the full economic and efficiency benefits of the new aircraft technologies.

4.1 Use Cases and Projected AAM Market

In June of 2021, Ohio was one of the first states to release a market impact study for Urban and Regional Air Mobility and UTM. The June 2021 *Economic Impact Report for Advanced Autonomous Aircraft Technologies in Ohio*[50] identified six critical markets, or use cases, that present the most potential for advancing AAM and producing a positive economic impact. Table 7 identifies these use cases and provides a high-level definition for each one.

Table 7: AAM Use Cases

Use Case	High-Level Definition
	On-Demand Air Taxi: Defined as transportation within a city or within the city's metro region. They have the potential to radically alter and improve urban mobility. This new passenger mode could alleviate time lost in daily commutes or traveling across larger urban areas.
	Regional Air Mobility: Regularly scheduled or on-demand transportation between cities, more than 50–75 miles apart. Numerous studies found that going by air using AAM for short intra-regional trips (from one city center to another nearby city center, or from city center to rural proximity) could save time.
	Airport Shuttle: Scheduled or on-demand transportation between major and regional airports and between city center or suburban vertiports. Tying city centers to airports will become a high-value application of AAM. Airports will seek to capitalize on AAM to maximize the utility and convenience of their facilities.
	Emergency Services: Robust medical services transportation system, including emergency medical evacuations, hospital-to-hospital patient and equipment transportation, organ delivery, and search-and-rescue operations.
	Corporate Aviation: Inclusive of transportation between corporate campuses and business destinations, interfacility corporate transport, regional campus transport, campus-to-customer transport, and specialist team mobility. Business aviation is a global US$100 billion per year industry.
	Cargo/Freight Delivery: Transportation of heavy cargo, freight, small packages, and on-demand commerce from or between airports, distribution centers, manufacturers, and retailers to end consumers. Industries such as logistics transportation and e-commerce can realize significant efficiencies by leveraging AAM vehicles.

The study found that Ohio is well positioned to grow and sustain profitable AAM operations in urban, suburban, and rural areas over the 2020-2045 forecast period. The six use cases drove a projected $13B in commercial business activities, 15,000 full-time jobs, $2.5B in tax revenues, and the need for 81 dedicated vertiports.

To achieve this level of economic activity, an investment of $1.4 billion will be needed for ground and PSU infrastructure. This includes investments in multiports – vertiports serving multiple aircraft, potentially in different configurations, at once.

4.2 Laying the Groundwork

UAS research in Ohio began in 2013 with the formation of the Ohio/Indiana UAS Test Center and Test Complex, prior to the founding of the Ohio UAS Center in 2017. In April 2019, the FAA issued a Certificate of Waiver of Authorization (2019-CSA-3326) allowing AFRL to operate the SkyVision GBDAA system and conduct UAS Beyond Visual Line of Sight (BVLOS) flights from Springfield-Beckley Municipal Airport. This authorization allowed research and testing, paving the way for technical advancement, operational savings, and the birth of an AAM ecosystem in Ohio. The number of sUAS flights that have been conducted per year is shown in Figure 9.

Figure 9: AAM sUAS Flight Volumes in Ohio

Specific initiatives to advance the AAM ecosystem in Ohio are described below:

FlyOhio: The FlyOhio initiative is a voluntary, cooperative umbrella organization that coordinates AAM development efforts with stakeholders and other industry partners in the state. FlyOhio includes the UAS Center, Ohio Federal Research Network, JobsOhio, and the City of Springfield, among others. Work on the initiative began with stakeholders focusing on the expansion of AAM technologies in Ohio. FlyOhio partners meet regularly to share updates on individual research efforts and market intelligence and to identify opportunities for further AAM research, funding, and development.

SkyVision: At the Springfield Airport, SkyVision is connected to the FAA Air Traffic Control network. Real-time data is provided from three local radars whose overlapping coverage provides high probability of detection for piloted aircraft flying in the unrestricted airspace southeast of the airport. SkyVision's location at the airport is also strategically close to AFRL at Wright-Patterson Air Force Base and DriveOhio's UAS Center in Springfield. The SkyVision asset enables true BVLOS operations from 1,000 feet Above Ground Level (AGL) to 10,000 feet Mean Sea Level (MSL) for UAS of all classifications.

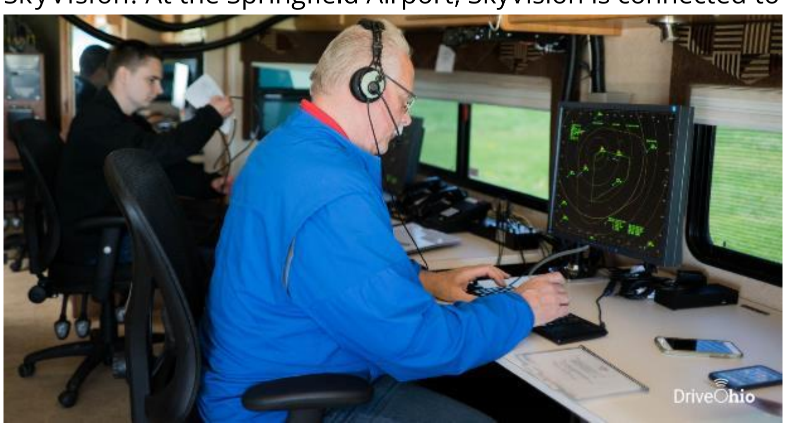


Figure 10: DriveOhio/Ohio UAS Center Team at SkyVision

Figure 10 depicts staff from the UAS Center demonstrating SkyVision in action.

UAS Traffic Management: While SkyVision provides GBDAA in the 1,000 – 10,000 foot airspace, the Ohio UTM project is a research effort to develop a comprehensive system to manage lower-altitude airspace for all aircraft, from piloted to fully autonomous. Its goal is to develop a plan for statewide implementation using the existing UTM area as a blueprint for the state. The UTM's GBDAA capabilities range only from 0 – 2,000 feet. Utilizing federal funds administered through ODOT's State Planning and Research (SPR) program, the research project is led by The Ohio State University (OSU). The envisioned UTM system is based on industry-leading radar technologies, incorporating the latest research conducted at OSU, with advanced signal processing and data optimized for UTM. The research uses three radar installations near the U.S. 33 Smart Mobility Corridor and urban areas of Columbus, with data feeds integrated with a UAS Service Supplier for flight scheduling and traffic management through a traffic operations center. Improving the robustness and cost-effectiveness of the system will allow it to scale for statewide AAM operations.

Remote Towers: The State of Ohio's strategy includes implementing remote tower infrastructure at selected airports in Ohio based on FAA criteria outlined in the 2018 FAA Reauthorization Act.[51] This will enhance the safety of crewed aircraft operations while also enabling AAM operations in more rural areas of the state that offer a cost-effective alternative to brick-and-mortar air traffic control towers. The proposed first phase includes redundant operations being established at the Springfield airport and at Kent State University to train the future air traffic control workforce and allow for testing and eventual replication of the remote towers across the state. A separate study by CAL Analytics is partnering with ODOT to develop open requirements and interface standards to detect and track lower altitude aircraft in Ohio.

Demonstrations: In 2021, testing and operations for larger VTOL began at the Springfield airport. This included construction of a vertiport (Figure 11), vehicle charging infrastructure, and demonstrations. BETA, LIFT, and Joby simulators are available for workforce training, public outreach, and VTOL simulations. Charging infrastructure was also installed at the Akron-Canton airport to support AAM operations. A showcase event was held on November 10, 2021 to highlight work done to date and coordinate with stakeholders on next steps that will be needed.

Figure 11: Vertiport at Springfield-Beckley Municipal Airport

4.3 Partners in Ohio's Strategy

In Ohio, the Governor has made it known that the state is fully supportive of Ohio being an early AAM adopter. The following are a few of the other key partners whose support is vital to Ohio's current and future success.

FAA: The FAA oversees all airspace regulations and flight rules. As AAM technology continues to advance and its uses increase, the FAA is continuing to include AAM in their planning efforts. These efforts include publishing recommendations and regulations regarding aircraft, airspace, operations, infrastructure, and community. Ohio has been coordinating with the FAA as they build out the statewide AAM program and administrative framework. The Ohio UAS Center currently has a technical assistant with the FAA's office of safety for UTM infrastructure. Through the UTM research and the research team the UAS Center has an additional Technical Assistance and in the Partnerships for Safety Program.

NASA: As the premier entity involved in aeronautics research globally, NASA's partnership is essential to Ohio's success in developing AAM as a long-term growth area for economic development and for providing services and benefits to Ohio's residents. Of special importance to the DriveOhio UAS Center is the strong history of partnering with the NASA Glenn Research Center (NASA Glenn) in Cleveland, Ohio. NASA Glenn conducts research, development, testing and engineering (RDT&E) of advanced aeronautics and space exploration concepts with an economic impact to the state of over $1.7B and more than 7,500 direct and indirect jobs.

In May 2021, the Ohio UAS Center signed a 5-year umbrella Space Act Agreement (SAA) with NASA for collaboration in the research and demonstration of AAM technologies. The first joint activity involves, as part of a cohort of four states (Massachusetts, Minnesota, Texas, and Ohio) and the City of Orlando, the Collaborative Opportunities for Community Planning and Integration (or "ACO-3") designed to:

- Promote public confidence in AAM safety.
- Give prospective vehicle manufacturers and operators, as well as prospective airspace service providers, insights into the evolving regulatory and operational environment.
- Facilitate community-wide learning while capturing the public's imagination."[52]

The objective of DriveOhio's participation in the NASA ACO-3 is to scale AAM operations beyond confined test site demonstrations into real-world operating missions that benefit Ohioans. The ODOT team is keenly aware that community engagement and integration is vital to accomplishing this objective. As part of the proposed integrated approach, ODOT is coordinating a team that includes industry representatives, economic development interests, regional and city planning committees, local and state organizations, and academic institutions. Because AAM encompasses many new technologies that are unfamiliar to the public, it is important for local planners, regulators, as well as members of the general public to be engaged throughout the effort.

Key projects where DriveOhio and NASA are collaborating as part of the umbrella SAA include:

- Working with NASA Ames vertiport analysis tool to identify potential vertiport locations in urban environments in Ohio;
- Collaborating with the Air Traffic Management eXploration (ATM-X) Project to demonstrate advanced airspace integration technologies for increasingly autonomous operations;
- Collaborating with the Air Traffic Management eXploration (ATM-X) through NASA Glenn for assessing Communications Navigation and Surveillance (CNS) to demonstrate advanced communications.

- Collaborating with the Systems Wide Safety (SWS) Project by sharing critical flight safety and ground operations data, evaluating safety arguments and safety management systems for highly automated emerging aviation operations, and evaluating the risks of emerging AAM operations;
- Collaborating with the Revolutionary Vertical Lift Technologies (RVLT) Project to obtain acoustic measurement of AAM vehicles during flight campaigns;
- Collaborating with NASA and the FAA on the future AAM workforce;
- Collaborating with NASA on healthcare AAM use cases; and
- Collaborating with NASA on public perception of AAM and Vertiport locations.

U.S. Department of Defense: The DOD through the Air Force has had a long and impactful presence in Ohio at the Wright-Patterson Air Force Base, especially through programs such as Agility Prime. Collaboration will continue with construction of the National Advanced Air Mobility Center of Excellence at the Springfield airport supported by a $6 million Defense Community Infrastructure grant from the U.S. DOD. Expected to be complete by 2023, the facility will be used for testing in cooperation with Wright-Patterson Air Force Base and Agility Prime.[53] The Ohio UAS Center will also operate out of the facility with a planned Air Operations Center supporting GBDAA activities like SkyVision, UTM, Remote ATC Tower and Lower Altitude Detection and Tracking clearinghouse.

JobsOhio: As Ohio's economic development corporation, JobsOhio leads economic development for the state of Ohio and serves as a catalyst to accelerate growth by investing in communities, helping Ohio's businesses to expand, and attracting new companies to the state. JobsOhio works collaboratively with Ohio's regional economic development partners at REDI Cincinnati, OneColumbus, TeamNEO (Cleveland), Dayton Development Coalition, Ohio SE, and Regional Growth Partnership (RGP) on AAM community integration and acceptance in the major urban cities and rural communities.

JobsOhio has identified AAM as a strategic pillar for growth in the aerospace sector. Ohio has the strength of manufacturing, ready supply chain, market access and available workforce to support AAM growth. Ohio's new branding *Accelerate Ohio* focuses on "Ohio as a living lab for advanced mobility and integrated autonomous systems on the road and in the air. Ohio is prepared to build, test, and deploy this technology in transportation and delivery." JobsOhio supports DriveOhio's AAM efforts through the collaboration with Ohio healthcare and logistics sectors and economic development partnerships across the state. JobsOhio will lead engagement and coordination with local and regional economic development entities and provide coordination with various industry organizations for planning and execution.

Ohio Aerospace and Aviation Technology Committee (OAATC): An industry organization of aviation and aerospace professionals, the goal of this committee is to develop a statewide strategy to unite aspects of both fields while ensuring Ohio remains a national leader.

Ohio Federal Research Network (OFRN): The Ohio Federal Research Network is a collaborative research hub with a focus on defense, aerospace, energy, and health. They assist partner agencies with securing funding and attract talent to Ohio. They negotiated a Cooperative Research and Development Agreement with AFRL for OFRN flight testing to take place at Springfield-Beckley Airport.

Local Governments and Planning Organizations: As a home rule state, Ohio's local governments lead critical land use and infrastructure decisions. Metropolitan and rural planning organizations serve in a regional coordinating capacity. Together, these institutions will ultimately shape how AAM functions in each region and local jurisdiction, according to factors such as geography, existing transportation systems, public input, and political preferences. In Ohio's system of governance, it is reasonable to expect different local preferences for AAM routes and vertiport facility locations. Local planners will keep educating around zoning for vertiport facilities; multimodal planning; vertiport building safety codes; noise ordinances and enforcement; and airspace management.

Airports and Heliports: Ohio has a total of 176 public use and 633 private use airports and heliports. Eight Ohio airports offer year-round commercial flights. Cleveland-Hopkins International Airport serves approximately 10 million passengers and John Glenn Columbus International Airport serves approximately 8.5 million passengers per year. The others are significantly smaller. While airports will not be the only locations for AAM activities, their expertise in air mobility, security, safety, and passenger movement will be the guiding light to ensuring AAM success. Smaller regional airports and existing heliports will be a springboard for early AAM operations.

Industry: Vehicle OEMs, service suppliers, infrastructure providers and use case owners all play integral roles in the AAM ecosystem. The Ohio UAS Center and their partners continue to develop relationships with industry providers to support and inform their ongoing efforts.

Many of the AAM OEM leaders currently have a presence in the State. As noted previously, BETA has established a strong presence at the SGH municipal airport where they have built a prototype vertiport, vehicle charging infrastructure and vehicle simulation capability. The setting is representative of the infrastructure that BETA expects to have throughout their AAM operations, and BETA is expected to have flight demonstrations at SGH in the future. Joby has also established themselves at SGH where they currently have a full flight simulator of their vehicles. LIFT has a full motion simulator at SGH and has been conducting regular flight demonstrations in the facility. Since 2021, Kitty Hawk has also been conducting flights around SGH with plans to extend their flights outside of the airport as part of the UAS Center collaborations with NASA. MOOG Surefly operations are housed in Ohio, where they have been conducting a series of ground and flight demonstrations obtaining important data for the integration of AAM.

5. Industry Input

To complement insights and feedback from local and regional government partners, outreach was conducted with industry representatives across the AAM sector. These representative organizations include manufacturers/operators of VTOL and other aircraft for both passenger and freight transport, as well as airports, e-commerce, healthcare, and system integration representatives.

The objectives were to understand 1) near- and longer-term growth plans, opportunities, and challenges, and 2) how the state, from an industry perspective, can best support advancing the Ohio AAM ecosystem. Each takeaway was identified as impacting either infrastructure, policy, technology, or multiple areas within the industry. The following is a summary of meetings held with key industry stakeholders.

5.1 OEMs

The following OEMs participated in outreach meetings:

- Moog Aircraft – designs, manufactures, and integrates flight control systems for military and commercial aircraft.
- Reliable Robotics – designs automated solutions for commercial operations of FAA Part 23 and Part 25 air vehicles.
- Kitty Hawk – designs, manufactures, and operates single-occupancy, remotely-piloted eVTOL.
- Joby Aviation – aerospace company designing eVTOL for air taxi service.
- Lilium – designs and manufactures eVTOL for personal mobility and air taxis.

As a diverse group, with different niches within the market and different vehicle technologies and operating systems, each OEM had its own perspective on the market. Still, several trends emerged and are summarized in Table 8.

Table 8: OEM Takeaways

OEM Takeaways	Infrastructure	Policy	Technology
Piloted and uncrewed eVTOL aircraft have very different infrastructure demands and distinct plans for their business models to succeed.	Infrastructure	Policy	Technology
Industry has been relying on legacy Heliport design standards to guide preliminary infrastructure design.	Infrastructure	Policy	
Focused fire code requirements and alignment with local Authorities Having Jurisdiction (AHJs) will be key to facilitate the development of vertiports.		Policy	
Battery charging, storage, and maintenance are key drivers for AAM activity.	Infrastructure		Technology
Careful consideration of land use planning criteria and evaluation of environmental impact will maximize compatibility with existing neighborhoods and land uses.		Policy	
Legislative action and governmental cooperation with permitting processes are critical to OEMs' ability to accurately anticipate operational timelines.		Policy	

5.2 Airports

Airports will play a major role in the future of AAM and will need to plan for the challenges and opportunities of this burgeoning market. The following airport stakeholders provided input (summarized in Table 9):

- CVG Airport – Main airport in Cincinnati/Northern Kentucky, carried 9.1 million total passengers in 2019.[54]
- SGH Airport – A Civil-Military airport in Clark County, OH, that is partnered closely with the Ohio UAS center.
- Columbus Regional Airport Authority – Oversees CMH, LCK, and Bolton Field.
- DAY Airport – Located 10 miles north of Dayton, with 892,000 enplanements in 2019.
- Ohio Aviation Association – Non-profit made up of airport managers, planners, direct service providers, students, and aviation enthusiasts committed to airport development and safety in Ohio.
- NASA – U.S. Government agency in charge of space and aeronautics research, and UAS integration research.

Table 9: Airport Takeaways

Airport Takeaway			
AAM will impact all classes and sizes of airports.	Infrastructure	Policy	Technology
Infrastructure needs and AAM impacts on finances are a major concern.	Infrastructure		
Possible AAM security requirements are a significant concern.		Policy	
Small airports do not have available staff to manage additional tasks. Oversight boards / commissions are mainly volunteers.	Infrastructure		
Community acceptance of AAM is a major concern. Industry and government need to address public perceptions focusing on broadscale AAM benefits.		Policy	
There is a need for ongoing frequent coordination between airports on AAM issues.		Policy	

5.3 E-Commerce

Another major player within this industry is e-commerce. AAM promises to bring new customers at lower cost and increased reliability. These operations are typically envisioned as uncrewed, which places more demands on infrastructure, such as GBDAA systems. The following companies participated in outreach meetings (their input is summarized in Table 10):

- Causey Aviation – Private jet charter service that also provides autonomous drone delivery services.
- UPS Flight Forward – Wholly owned subsidiary of UPS parcel delivery company that has been testing delivery drones since 2017.

Table 10: E-Commerce Takeaways

E-Commerce Takeaway	
Public entities need to increase infrastructure investment to spur growth in the private sector.	Infrastructure

E-Commerce Takeaway
Most AAM technology providers/vendors do not have products that are mature enough to be operational or capable of providing services on a scale that larger enterprises are operating at. Technology
Public outreach is important to gain public acceptance. Consider physical demonstrations and road shows to engage with the public. Policy
Education of government staff at all levels is critical to counter biases and to ensure decision makers better understand the technologies, regulatory policies, and infrastructure needs. Policy

5.4 Healthcare

Healthcare use cases relate, most frequently, to time-critical applications including delivery of small packages and key personnel. Healthcare stakeholders already operate aircraft with dedicated infrastructure, are looking for ways to streamline their logistics, provide a clear benefit to the public, and operate in a competitive space. Healthcare stakeholders are, therefore, expected to be early adopters of AAM. Long-term applications may include autonomous patient transport. The following healthcare organizations provided input (summarized in Table 11):

- Akron Children's Hospital – The largest pediatric healthcare provider in northeast Ohio.
- Cleveland Clinic – A nonprofit hospital system based in Cleveland with worldwide recognition.
- Genesis Healthcare System – The largest healthcare provider in southeastern OH, based in Zanesville.
- MetroHealth – A nonprofit hospital system in Cuyahoga County that primarily serves patients who are uninsured or covered by Medicare or Medicaid.
- Mercy Health – The largest health system in Ohio and the state's fourth-largest employer, based in Cincinnati.
- OhioHealth – A nonprofit hospital system based in Columbus consisting of 12 hospitals.
- Premier Health – A nonprofit hospital that is the second largest employer in the Dayton region.

Table 11: Healthcare Takeaways

Healthcare Takeaway
Many key healthcare stakeholders had a very limited perspective of AAM, and initially see AAM as primarily small UAS vehicles for small package delivery. Policy
A statewide approach is essential to fully leverage the benefits of AAM for healthcare. Infrastructure Policy
The primary benefit of AAM will be as logistics support for the healthcare network. Transportation of equipment, medications, samples, and personnel are the primary near-term applications. Infrastructure Technology
Transportation of critical patients is important, but it is not viewed as a near-term application of AAM eVTOLs. Infrastructure Policy Technology
Healthcare providers must be active in helping set requirements for vehicle capabilities. Their needs are complex – since they own and operate aircraft today, they would prefer to use the same vehicle for people, equipment, and other services to increase utilization and lower overhead costs. Technology

5.5 System Integrators

From micro-local weather forecasts to traditional FAA restrictions and beyond, system integrators manage the complicated process of bringing different parts of the AAM ecosystem together. As AAM transitions to uncrewed operations, these services will perform functions currently carried out by pilots, making their continued operation critical for the success of AAM. Their primary concerns are summarized in Table 12. Several system integrators participated in outreach meetings including:

- ANRA Technologies – Software company for UAS and airspace managers.
- CAL Analytics – Expertise in navigation, remote sensing, signal analysis, and information fusion.
- Flight Profiler – Provides real-time, 3D atmospheric situational awareness, including for low-altitude and BVLOS.
- OneSky Systems – Airspace assessment, operations, and uncrewed traffic solutions.
- Parallax Research – Non-profit that supports the AFRL for control of multiple UAS.
- ResilienX – Fault detection, mitigation, and recovery for advanced interconnected systems.
- TruWeather Solutions – Micro weather forecasts for drone pilots and air taxis.

Table 12: System Integrator Takeaways

System Integrator Takeaway
Additional discussion is needed with Providers and OEMs on what is needed to support their operations, and with regulators to understand what guideline they are trying to set. Policy
States/MPOs need to be educated about what infrastructure is needed so they can provide clear but broad guidelines for the industry. Infrastructure Policy
Data infrastructure investment is very important. Infrastructure Technology
Legislators need to be flexible and dynamic for the industry to grow and experiment as technology is constantly evolving. Policy Technology

5.6 Summary

Stakeholder feedback was helpful in confirming and clarifying assumptions. Their input was used to inform the actions presented in Chapter 8 at the end of this document. The various stakeholders interviewed are generally aware of the opportunities and challenges as AAM moves from research and pilot testing into production. While the promise is great, the administrative and policy hurdles are as well – not just within the sectors but between them and government entities responsible for ensuring safe and equitable operations.

Infrastructure: Despite the complex combination of use cases, airframe design, and piloted/uncrewed craft, a statewide approach is needed so that all sectors are on the same page as AAM develops.

Policy: Policies should focus on technical aspects like vertiport design, fire codes, and permitting, as well as other aspects like security, community acceptance, and outreach/education. Flexible policies will be essential due to the rapidly changing nature of the technology.

Technology: Successful vehicles will be determined by the overlap of customer needs and OEM capabilities. Other needs include logistical support and data infrastructure investments.

6. Route Planning Considerations

To better understand what route planning considerations are important, an initial list of restrictions, shown in Table 13, was developed. As noted in the left column, four categories of restrictions were mapped:

- FAA Restrictions: Airspace classifications, prohibited and restricted airspace, stadiums, and National UAS flight restrictions.
- Environmental Restrictions: National Park Service lands and U.S. Fish and Wildlife Service Refuge Lands.
- Local Zoning: Any local restrictions that could be identified, including state and local prisons.
- Physical Obstacles: Tall structures that could create a hazard for aircraft navigation.

Table 13: Base Map Flight Restrictions

Category	Restriction	Description	Requirements	Sources
FAA Restrictions	Class Airspace	• Class A: Above 18,000 ft MSL • Class B: Near busiest airports; ranging from surface to 10,000 ft MSL • Class C: Airports with control tower, radar approach, and IFR/passenger; generally ranging from surface to 4,000 ft MSL • Class D: Airports with control tower; ranging from surface to 2,500 ft MSL or as specified on charts • Class E: Controlled Airspace not A, B, C, D; altitude varies • Class G: Uncontrolled Airspace	• Class A: N/A (AAM aircraft are not envisioned to operate at these altitudes) • Class B: Need approval from ATC to fly in airspace; ATC will assign flight altitude and route • Class C: Need approval from ATC to fly in airspace; Must maintain communication with ATC while in the airspace and follow ATC instructions • Class D: See Class C • Class E: ATC permission required when weather below VFR minimums (except E2) • Class G: Only Visible Requirements	FAA's Aeronautical Data Delivery Service https://adds-faa.opendata.arcgis.com/datasets/class-airspace/explore
	MTR Segments	Military Training Routes: high speed corridors used for military aircraft, clearance is 5 miles to each side and 1000 ft high	Not illegal to fly through, but extremely dangerous if training is in session (check NOTAM first)	FAA's Aeronautical Data Delivery Service https://adds-faa.opendata.arcgis.com/datasets/mtr-segment-1/explore

Category	Restriction	Description	Requirements	Sources
FAA Restrictions	National Security UAS Flight Restrictions	In Ohio, includes DOJ federal prisons and DOD military bases	Cannot fly below 400 ft AGL	FAA's UAS Data Delivery System https://udds-faa.opendata.arcgis.com/datasets/faa::national-security-uas-flight-restrictions-1/explore
	Special Use Airspace	In Ohio, includes Restricted Areas and Military Operating Areas	Need to see if area is active and get prior approval from ATC	FAA's Aeronautical Data Delivery Service https://adds-faa.opendata.arcgis.com/datasets/special-use-airspace/explore
	Stadiums	MLB, NFL, NCAA D1 Football, NASCAR, IndyCar, and Champ Series Race	No flying from 1hr before to 1hr after scheduled event; Clearance at 3NM radius around selected stadiums, 3000 ft AGL	FAA's Aeronautical Data Delivery Service https://adds-faa.opendata.arcgis.com/datasets/stadiums/explore
Environmental	National Park Service	Lands owned by the NPS such as parks and historic sites	Cannot take off, land, or operate inside NPS boundaries; recommended (not mandatory) clearance is 2000 ft AGL	NPS's Data Portal https://public-nps.opendata.arcgis.com/datasets/nps-boundary-1/explore
	US Fish and Wildlife Service	National Wildlife Refuge System	Illegal to operate on refuge property without special permit; recommended (not mandatory) clearance at 2000 ft AGL	USFWS's ServCat https://ecos.fws.gov/ServCat/Reference/Profile/140888
Local Zoning	Prisons	Local and State Prisons; currently there are no legal restrictions, but flights over are strongly discouraged	Avoid if possible	Homeland Infrastructure Foundation-Level Data (HIFLD) https://hifld-geoplatform.opendata.arcgis.com/datasets/prison-boundaries/explore
	Security Zones	Area of land/water necessary to prevent damage or injury to any vessel or waterfront facility, to safeguard ports, harbors, territories, or waters of the U.S. or to secure the observance of the rights and obligations of the U.S.	No take-off or landing inside the zones. Avoid flying through zones, can trigger alerts to homeland security	HIFLD https://hifld-geoplatform.opendata.arcgis.com/datasets/security-zones/explore

Category	Restriction	Description	Requirements	Sources
Physical Obstacles	Point Obstacle	Locations and heights of vertical obstacles from the Airport Data and Information Portal (ADIP)	Keep 200 ft clearance to avoid collisions	Airport Data and Information Portal https://adip.faa.gov/agis/public/#/public Account creation required

With these restrictions in mind, an origin and destination were selected for each use case that fit the use case profile and were feasible for AAM craft. Route construction consisted of an iterative process:

1. Map a straight line between the origin and destination.
2. Identify large areas to avoid (controlled airspace, National Parks, prisons) or visual indicators to follow (the Ohio River) and adjust the straight-line path accordingly.
3. Use 3D information along the adjusted flight path to identify an ideal cruising altitude that does not conflict with the remaining obstacles (both areas and point objects).
4. Continue to adjust the flight path and altitude to account for obstacles near the origin and destination, as well as the desired slopes and other local constraints such as preferred approaches.

A 3D model of each use case was created and evaluated to inform the framework in Chapter 8 and is shown in Figure 12. To illustrate the process, two representative samples are shown in the following sections and lessons learned are summarized at the end of the chapter.

Faster and more direct travel for business.

Transport doctors and equipment between hospitals.

More efficient travel than ground transportation along major corridors.

Surface transportation is limited by bridges; Brent Spence bridge construction will cause more surface congestion.

Mason has a growing population with much of its workforce commuting 30-40 minutes to Dayton or Cincinnati.

Through ODOT's Space Act Agreement will help inform NASA's National Campaign to demonstrate regional cargo delivery at these airports.

Figure 12: Statewide Map of Potential Use Cases

6.1 Regional Air Mobility Use Case

The hypothetical Regional Air Mobility use case, shown in Figure 13, starts at the Mansfield airport (A) and travels to Burke Lakefront Airport in downtown Cleveland (C) along the coast of Lake Erie (see inset for detail). The straight-line path connecting the two airports would take an AAM aircraft through the center ring of the Class B airspace at Cleveland Hopkins International. To avoid crossing into this airspace the route bends to the east under the second ring (B) and flies between 1,300 MSL and 1,900 MSL to avoid entering the second ring of airspace.

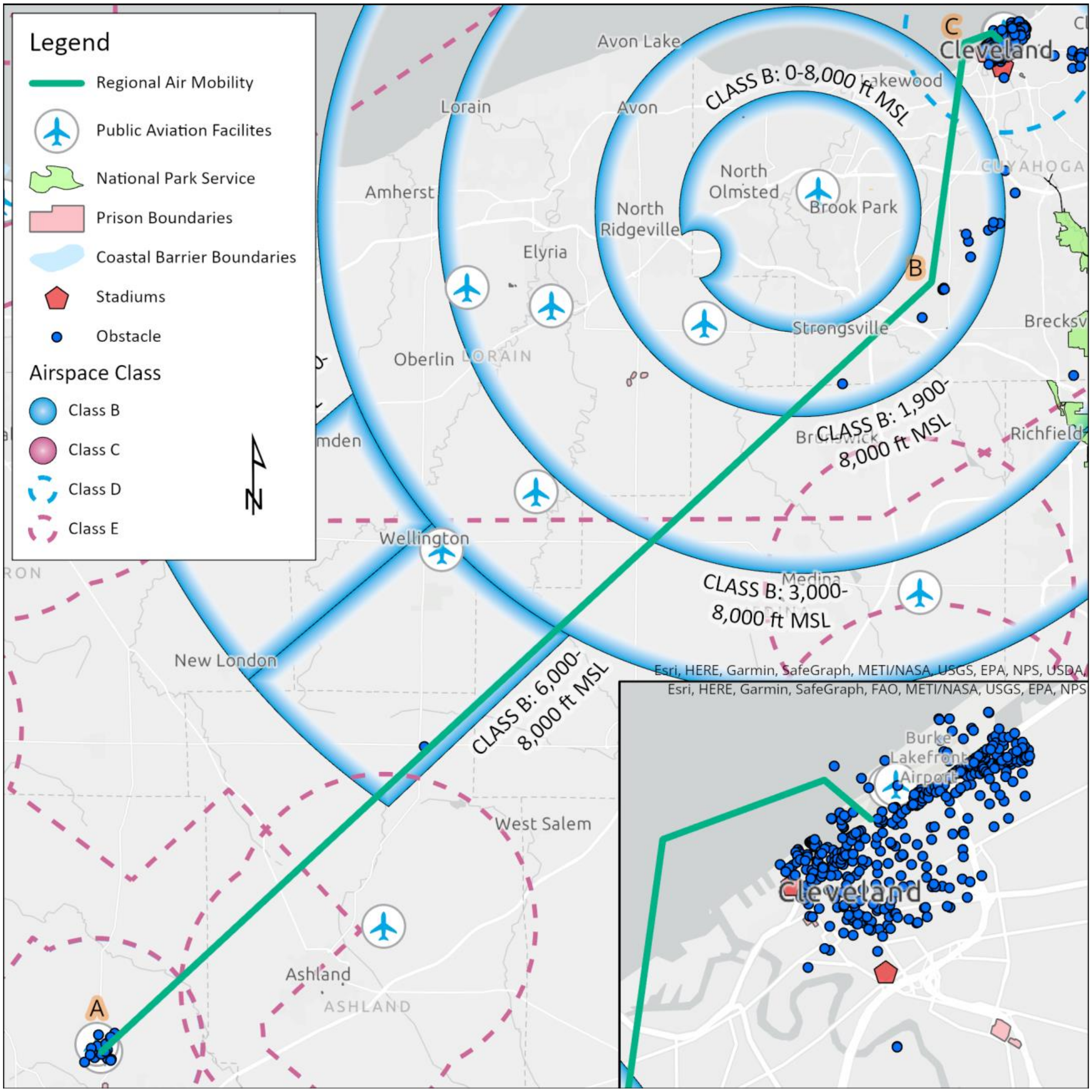


Figure 13: Regional Air Mobility Representative Use Case

6.2 Emergency Services and Medical Air Ambulance

The hypothetical Emergency Services use case, shown in Figure 14, starts at the helipad above Akron General's Emergency Room (A) and goes to the helipad at the Cleveland Clinic Main Campus (D). The route travels over the Cuyahoga Valley National Park (B), which requests all aircraft to fly over at a minimum of 2,000 ft AGL. The ground elevation in this area varies between 1000 to 1200 feet MSL, so flying 2,000 feet AGL will put aircraft very close to the Class B airspace (C). This may require the flight path to be bent to the east to eliminate flight over the national park where the Class B airspace floor is at 3,000 feet. A 3D profile view of this constraint can be seen in Figure 15.

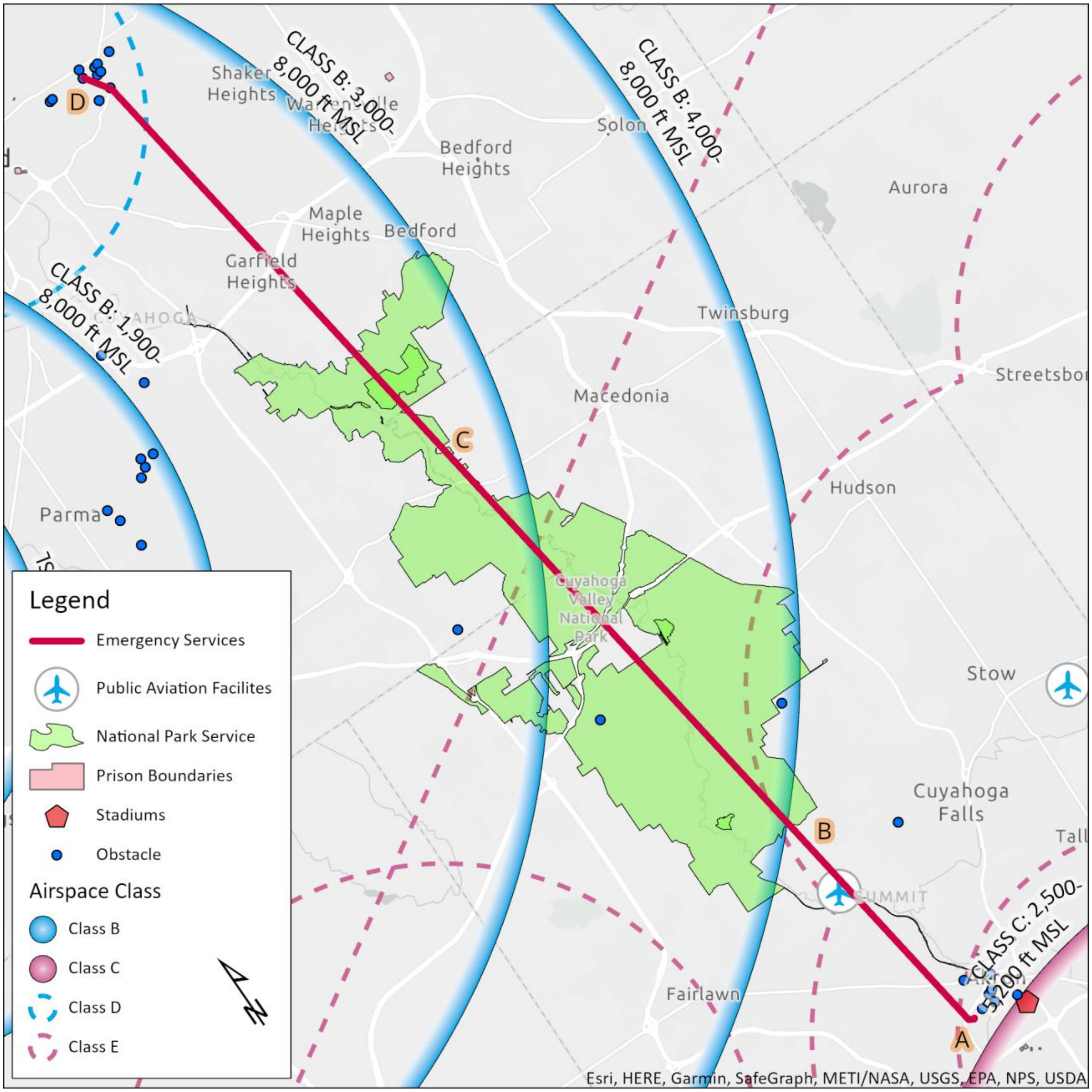


Figure 14: Emergency Services Use Case

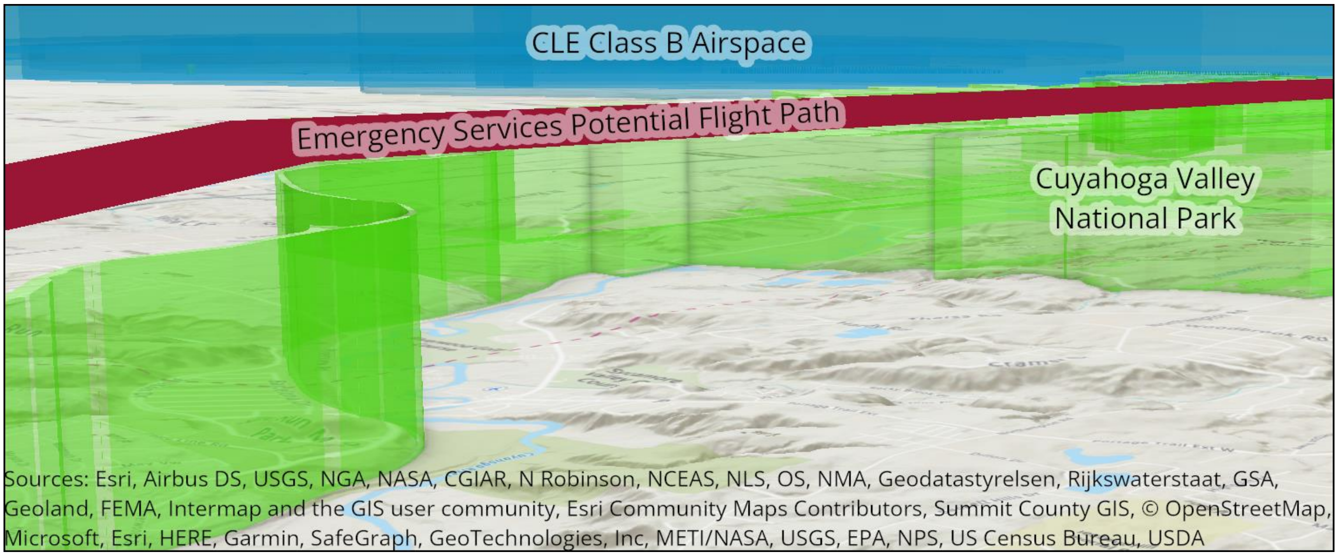


Figure 15: Flight Profile Over Cuyahoga Valley National Park

6.3 Lessons Learned

The following considerations were highlighted by the route planning process:

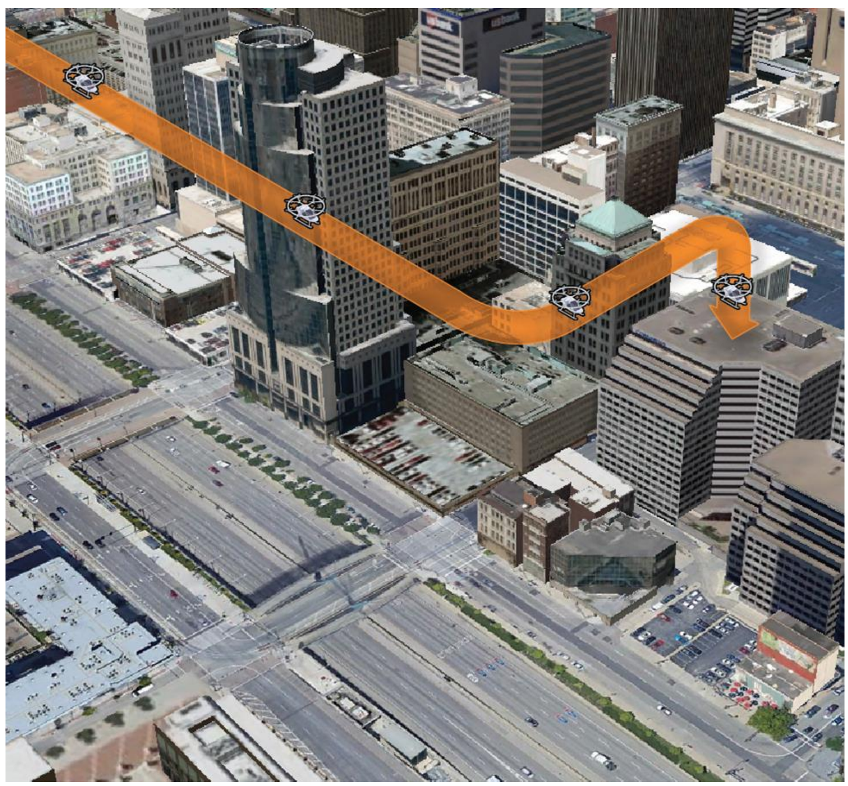


Figure 16: Landing Site on Rooftop

- New rules will need to be developed for autonomous aircraft operating in controlled and restricted airspace.
- Rules differ for piloted and remotely piloted flights, so operators and OEMs will need to account for these rules as they progress towards autonomy on that development path.
- Route planners will have to carefully balance directness (time and fuel savings) with flight paths (avoiding controlled or restricted airspace, using preferred low-impact paths).
- More research needs to be done on noise impacts of multiple craft to determine adverse impacts.
- FAA obstacle data is a useful starting point, but insufficient for navigation during fully automated flight.

- Getting NOTAMs (Notice to Air Missions) to fully automated and remotely piloted aircraft is not as straightforward as the existing process for piloted flights.
- Vertiport location can affect the route including airspace coordination, obstacle avoidance, and preferred approach direction. See Figure 16 for an illustration of a preferred approach into Cincinnati where a VTOL approaches the city along the river, then flies over I-71 and E 3rd St. to land on the roof of a building.
- Different vehicle classes are subject to different rules from airframe certification to allowable flight zones and will have different route planning processes. For example, the Cargo use case is uncrewed and will require adherence to new UTM rules.
- As pressure on airspace increases due to the increased volume of traffic, it will be necessary to establish corridors to avoid overwhelming air traffic controllers.

7. Recommendations for Establishing Vertiports

This chapter presents recommendations for establishing vertiports. The state, MPOs, counties, and municipalities can leverage these recommendations to inform land use planning, establish rulemaking for permitting vertiports, and establish criteria for operational policies in the urban, suburban, and rural contexts. The six use cases discussed throughout this framework largely fall into three categories: passenger transport, cargo transport, and medical transport (which could also include passenger, cargo, and organ transport). Each category has specialized and distinct requirements for ground and air support infrastructure. Through discussions with industry stakeholders (see Chapter 5), many important infrastructure criteria for siting and operating a vertiport were identified. The criteria below are skewed towards passenger transportation. Further criteria for cargo and medical uses are described later in this chapter.

7.1 Key Infrastructure Criteria

The discussions with industry stakeholders identified important considerations for the establishment of urban, suburban, and rural vertiports. This list is not intended to be all-encompassing but rather represents influential criteria with respect to land use planning and vertiport operations.

Land Use-Influencing Criteria:

1. Ownership: Speaks to which entity should be the owner of the vertiport infrastructure: public entity or private entity.
2. Access: Support and opposition to vertiports near residential areas are both high, indicating a high degree of polarization.[55] Access also speaks to accessibility for all passengers.
3. Zoning, Height, and Noise Restrictions: Should vertiports further restrict zoning in the vicinity of the vertiport?
4. Adjacent Airport/Vertiport: How close should vertiports be to adjacent vertiports or airports?
5. Staffed Management: Describes how both air traffic and vertiport ground traffic should be managed.
6. Scheduled and Unscheduled Service: Describes how accommodating both scheduled and unscheduled service can influence vertiport requirements.
7. International Processing: Addresses whether facilities should consider provisions for international passenger processing for those locales that are within 100 miles of Canada.
8. Public Safety: Addresses the need for first responders either on site or within a certain proximity of vertiports.
9. Facilities for Multiple Operators: Addresses whether vertiports should provide the ability to accommodate a wide range of operators while also providing branding opportunities for them.
10. Intermodal Connectivity: Addresses how vertiports should be connected to other modes of transportation: private vehicle parking, public transportation, TNCs, bikeshare, etc.
11. Land Use Planning: Considers the visual and aural impacts of vertiports on residential land uses.

Operational-Influencing Criteria:

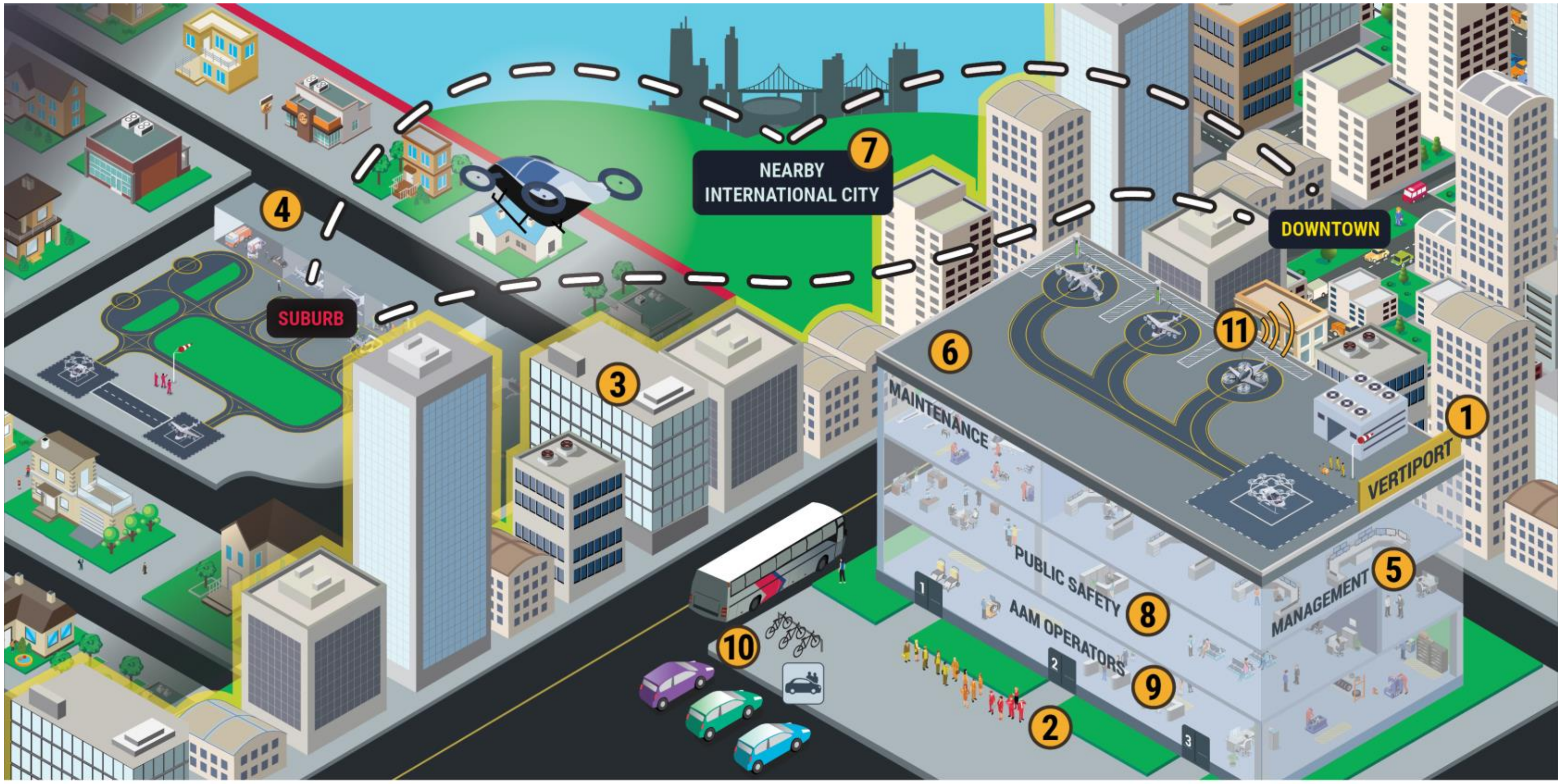
1. Fuel Types: Addresses what types of fuel should be accommodated at vertiports in the different contexts. Quieter electric motors may be permitted closer to residential land uses.
2. Vehicle Size: Addresses how the physical size of AAM aircraft can influence facility requirements and the operational environment.

3. RON Parking: Will Remain Overnight (RON) parking be provided at vertiports, or will they be required to fly off-site for staging and storage?
4. TLOF Quantity: Addresses finding a recommended ratio of Touchdown and Lift Off areas (TLOFs) to AAM aircraft parking positions at vertiports.
5. Diverse Fleet Accommodation: As the industry evolves, this criterion addresses the need to be forward thinking to accommodate a wide range of known and unknown vehicle types and configurations, which impact flight profile requirements.
6. GSE Support: Addresses whether vertiports should accommodate ground service equipment (GSE) support operations such as maintenance, refueling, security, and resetting craft for the next flight.
7. Weather Observing Instrumentation: Addresses the quality of weather reporting instrumentation that is recommended for each type of vertiport.
8. AAM Maintenance: Addresses recommendations for accommodating different types of maintenance activities at each type of vertiport.
9. Vertiport Traffic Management Infrastructure: Vertiports above a certain size will need staffed air traffic control or R-TWR technology.

On the following five pages, high-level recommendations for both the land use and operational-influencing criteria are depicted for:

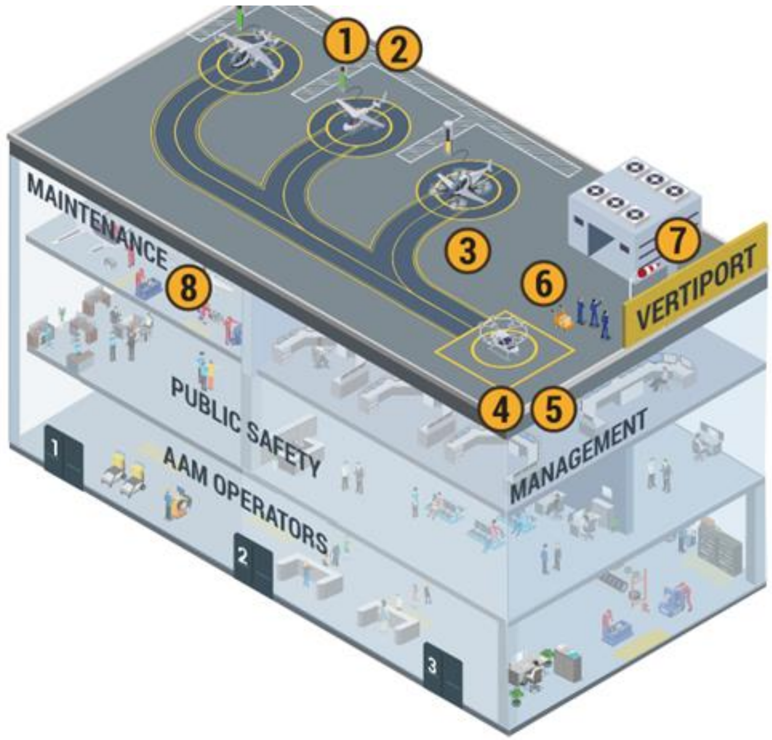
- Urban vertiports (Figure 17 and Figure 18),
- Suburban vertiports (Figure 19 and Figure 20), and
- Rural vertiports (Figure 21 and Figure 22)

Many of these topics and the corresponding recommendations have been discussed with industry stakeholders and generally align with many of their positions. The intention of these recommendations is to ensure that Authorities Having Jurisdiction (AHJs) across the state factor these into local policy making for permitting and approving vertiports in their jurisdiction. The recommendations can also inform policy making at the state level to help maintain consistency across jurisdictions to enable business decisions and simplify operational responses to regulation.



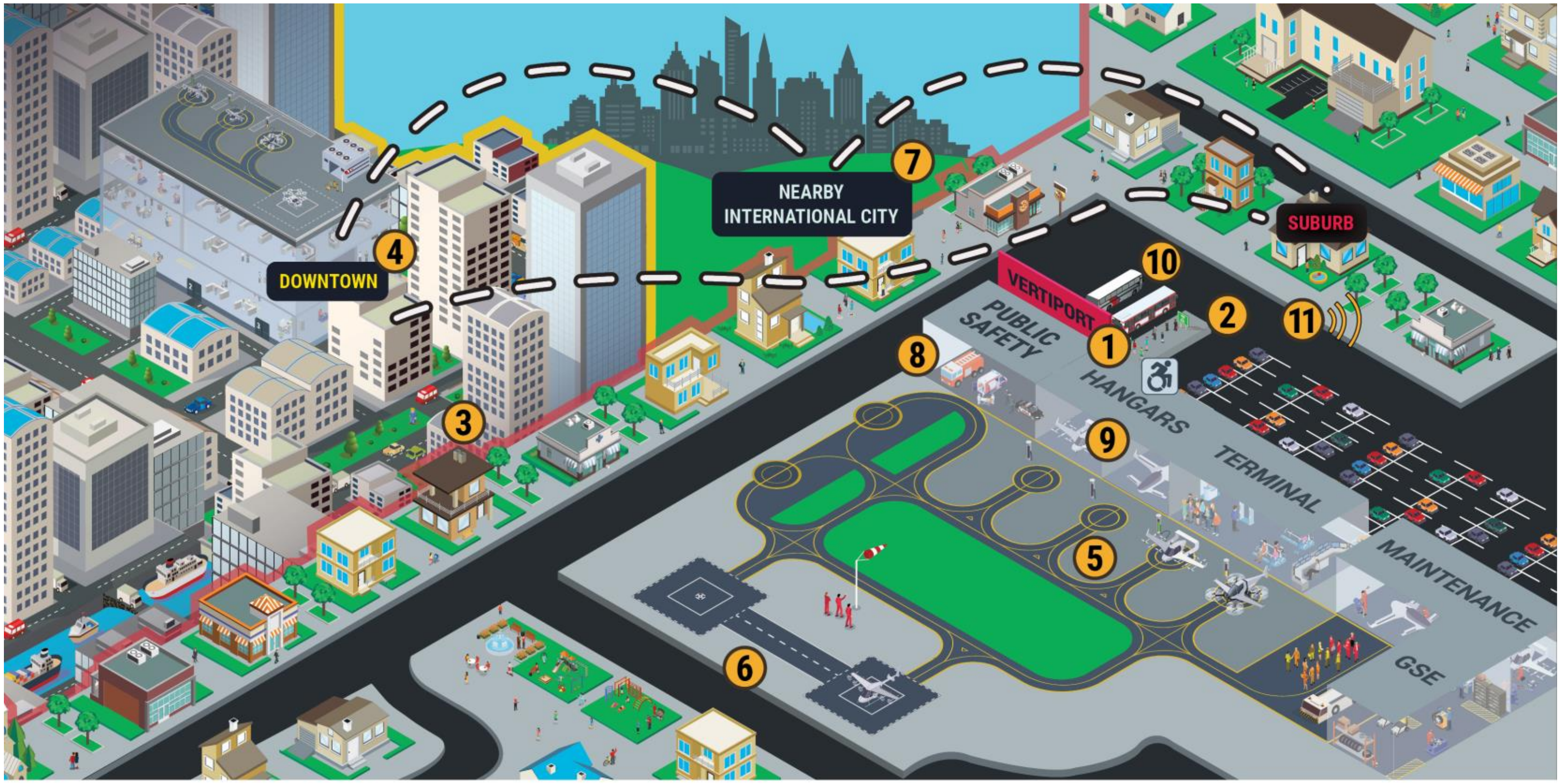
1. **Ownership:** Urban Vertiports may be under public or private ownership. However, subsequent recommendations apply regardless of ownership model.
2. **Access:** Irrespective of ownership, Urban Vertiports are expected to be accessible and available to all operators and passengers.
3. **Zoning Height Restrictions:** As vertiports are sited in the Urban context, zoning height restrictions should be enacted to protect airspace associated with vertiports.
4. **Adjacent Airport/Vertiport:** Planners need to provide recommendations for the proximity of adjacent Urban Vertiports to limit impacts to other development, congestion and ensuring capacity.
5. **Staffed Management:** AAM Traffic will be managed by commercial air navigation providers. Busy, Urban Vertiports will require the capability of having on-site staffing for passenger amenities, security, first responders and other services.
6. **Scheduled and Unscheduled Service:** Planning parameters for Urban Vertiports will need to account for both scheduled and unscheduled service, which greatly influences infrastructure requirements.
7. **International Processing:** Cities within range of the Canadian border may consider having international processing capabilities.
8. **Public Safety:** Urban Vertiports will require planning considerations for security, police, and fire/emergency medical response.
9. **Facilities for Multiple Operators:** While Urban Vertiports should be accessible to all providers, consider provisions for operators' brand identity/amenities.
10. **Intermodal Connectivity:** Urban Vertiports will need connection to public transit, TNCs, bike share,and other congestion-reducing transportation modes. Minimize private vehicle parking.
11. **Land Use Planning:** Location of Urban Vertiports will be influenced by considerations of noise and visual impacts to surrounding areas, especially residential zones. Compatible development around Vertiport sites should be considered in land use planning.

Figure 17: Urban Vertiport Operations Concept



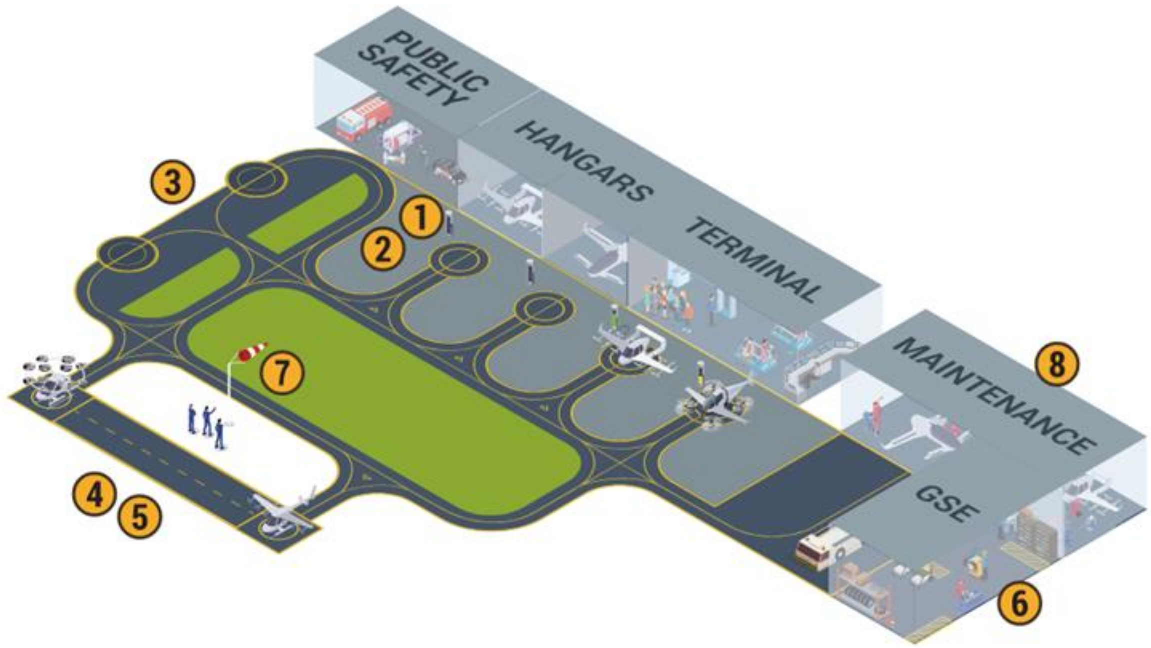
1. **VTOL Fuel Type:** Urban Vertiports will provide for electric charging stations. Other fuel types may be accommodated based on National Fire Protection Association (NFPA) requirements but will be individually evaluated based on user needs and site constraints.
2. **VTOL Physical Characteristics:** Urban Vertiports will set parameters on aircraft physical characteristics (e.g. maximum wingspan) that the facilities can accommodate.
3. **RON Parking:** Due to limited space in the urban context, Urban Vertiports will not accommodate remain overnight (RON) parking.
4. **Touchdown and Liftoff Area (TLOF):** The quantity and sizes of TLOFs at Urban Vertiports will depend on capacity analysis and the parameters set for allowable aircraft size. A generalized ratio of one TLOF to three parking positions should be considered for site layout.
5. **Diverse Fleet Accommodation:** While Urban Vertiports are designed for next generation VTOLS, consider accommodating helicopter operations.
6. **Ground Service Equipment (GSE) Support:** Urban Vertiports may require GSE equipment to accommodate the support of passenger operations.
7. **Weather Observing Instrument and Sensor:** Urban Vertiports will require provision for necessary weather observing instruments and sensors needed by the Vertiport Operational Control Center.
8. **AAM Maintenance:** Urban Vertiports will require provisions for light maintenance capabilities (e.g. minor part changes). Heavy maintenance will occur elsewhere.

Figure 18: Urban Vertiport Concept



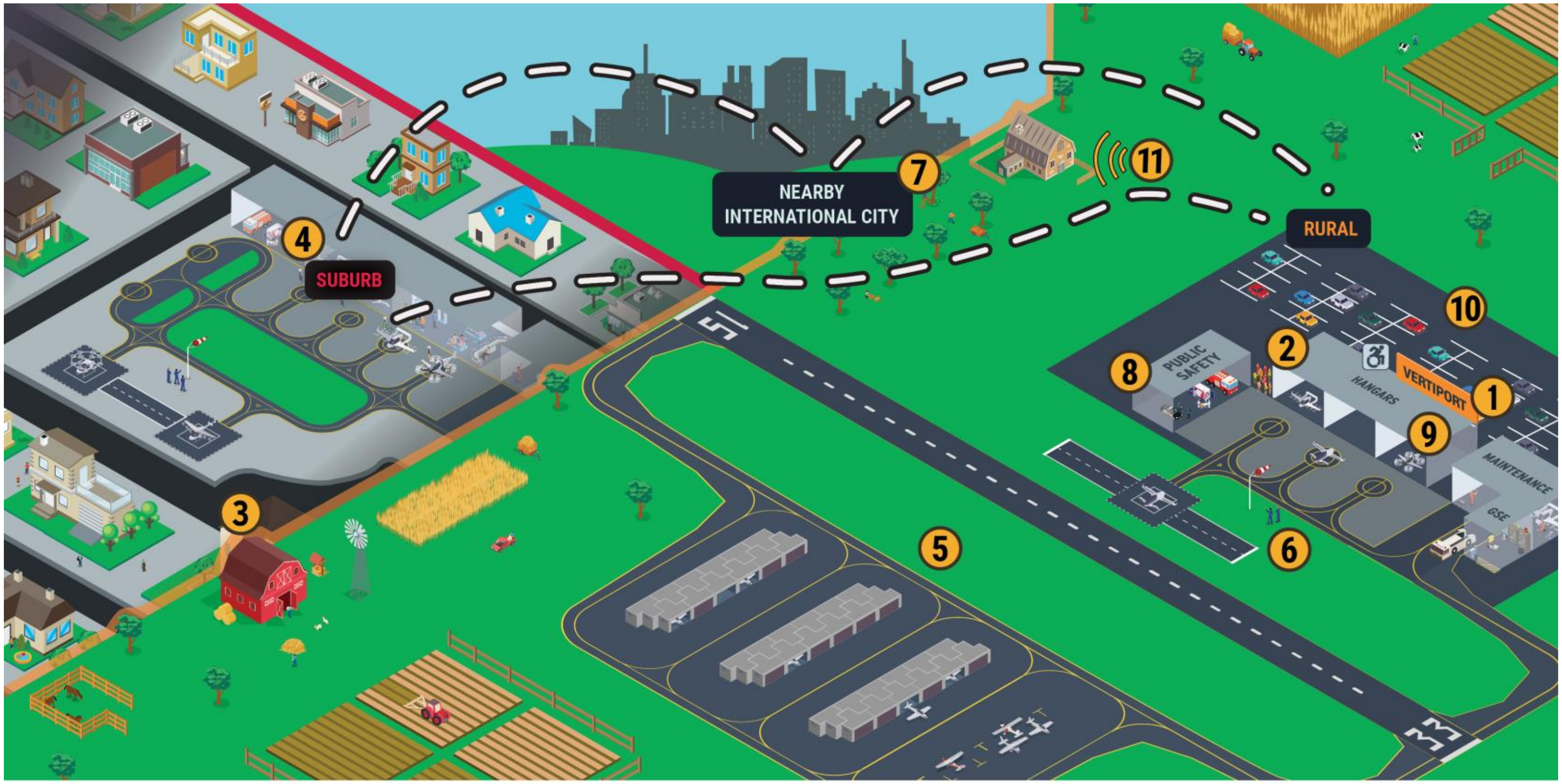
1. **Ownership:** Suburban Vertiports may be under public or private ownership. However, subsequent recommendations apply regardless of ownership model.
2. **Access:** Irrespective of ownership, Suburban Vertiports are expected be accessible and available to all operators and passengers.
3. **Zoning Height Restrictions:** As vertiports are sited in the suburban context, zoning height restrictions should be enacted to protect airspace associated with vertiports.
4. **Adjacent Airport/Vertiport:** Planners need to provide recommendations for the proximity of adjacent Suburban Vertiports to limit impacts to other development, congestion and ensuring capacity.
5. **Staffed Management:** AAM Traffic will be managed by commercial air navigation providers. Busy, Suburban Vertiports will require the capability of having on-site staffing for passenger amenities, security, first responders and other services.
6. **Scheduled and Unscheduled Service:** Planning parameters for Suburban Vertiports will need to account for both scheduled and unscheduled service, which greatly influences infrastructure requirements.
7. **International Processing:** Cities within range of the Canadian border may consider having international processing capabilities.
8. **Public Safety:** Suburban Vertiports will require planning considerations for security, police, and fire/emergency medical response.
9. **Facilities for Multiple Operators:** While Suburban Vertiports should be accessible to all providers, consider provisions for operators' brand identity/amenities.
10. **Intermodal Connectivity:** Suburban Vertiports will need connection to public transit and TNCs, as well as accommodate private vehicle parking.
11. **Land Use Planning:** Location of Suburban Vertiports will be influenced by considerations of noise and visual impacts to surrounding areas, especially residential zones. Compatible development around Vertiport sites should be considered in land use planning.

Figure 19: Suburban Vertiport Operations Concept



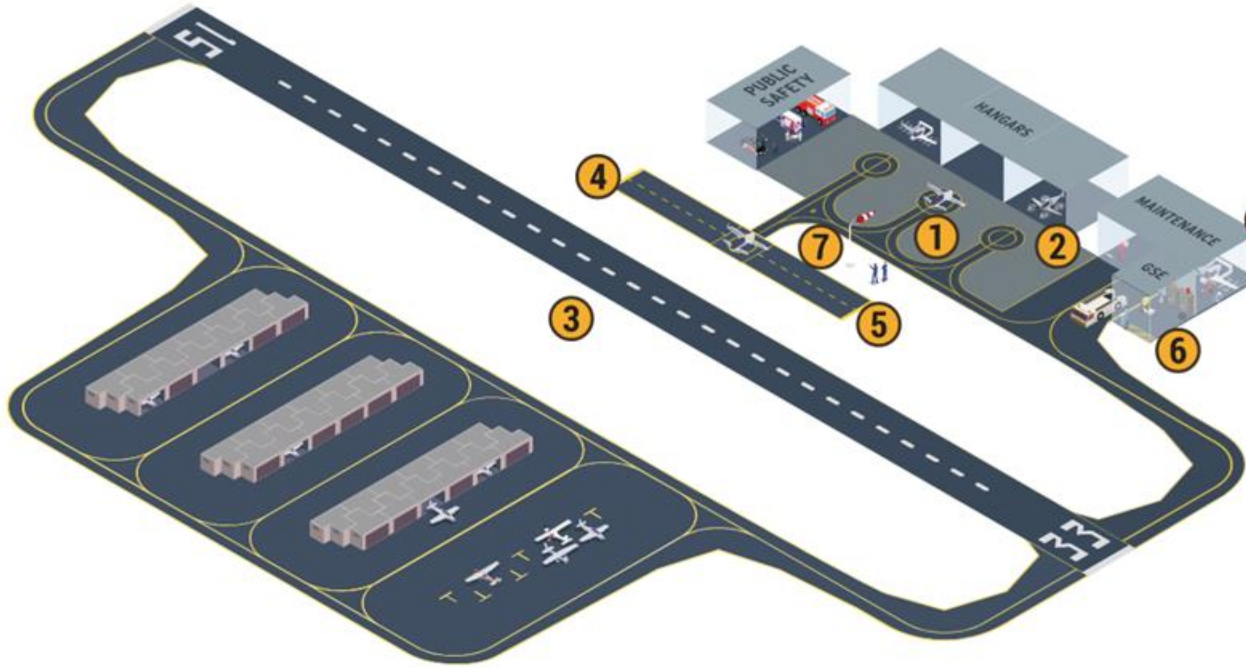
1. **VTOL Fuel Type:** Suburban Vertiports will require consideration for fueling capabilities for various types of power/energies.
2. **VTOL Physical Characteristics:** Suburban Vertiports will set parameters on aircraft's physical characteristics (e.g. maximum wingspan) that the facilities can accommodate.
3. **RON Parking:** Suburban Vertiport may require areas to accommodate remain overnight (RON) parking.
4. **Touchdown and Liftoff Area (TLOF):** The quantity and sizes of TLOFs at Suburban Vertiports will depend on capacity analysis and the parameters set for allowable aircraft size. A generalized ratio of one TLOF to three parking positions should be considered for site layout.
5. **Diverse Fleet Accommodation:** While Suburban Vertiports are designed for next generation VTOLS, consider accommodating helicopter and other next generation STOL (Short Takeoff and Landing) operations.
6. **Ground Service Equipment (GSE) Support:** Suburban Vertiports may require GSE equipment to accommodate the support of passenger operations and aircraft maintenance.
7. **Weather Observing Instrument and Sensor:** Suburban Vertiports will require provision for necessary weather observing instruments and sensors needed by the Vertiport Operational Control Center.
8. **AAM Maintenance:** Suburban Vertiports will require provisions for heavy maintenance capabilities (e.g. vehicles repair).

Figure 20: Suburban Vertiport Concept



1. **Ownership:** Rural Vertiports may be under public or private ownership. However, subsequent recommendations apply regardless of ownership model.
2. **Access:** Irrespective of ownership, Rural Vertiports are expected to be accessible and available to all operators and passengers.
3. **Zoning Height Restrictions:** As vertiports are sited in the rural context, zoning height restrictions should be enacted to protect airspace associated with vertiports.
4. **Adjacent Airport/Vertiport:** Planners need to provide recommendations for the proximity of adjacent Rural Vertiports to limit impacts to other development, congestion and ensuring capacity.
5. **Staffed Management:** AAM Traffic will be managed by commercial air navigation providers. Rural Vertiports will not require on-site staffed management.
6. **Scheduled and Unscheduled Service:** Planning parameters for Rural Vertiports will primarily account for unscheduled service.
7. **International Processing:** Rural Vertiports will not provide international processing capabilities.
8. **Public Safety:** Rural Vertiports will require planning considerations for security, police, and fire/emergency medical response.
9. **Facilities for Multiple Operators:** While Rural Vertiports should be accessible to all providers, consider provisions for operators' brand identity/amenities.
10. **Intermodal Connectivity:** Rural Vertiports will accommodate private vehicle parking. Connections to public transit and TNCs are dependent based on location.
11. **Land Use Planning:** Location of Rural Vertiports will be influenced by considerations of noise and visual impacts to surrounding areas, especially residential zones. Compatible development around Vertiport sites should be considered in land use planning.

Figure 21: Rural Vertiport Operations Concept



1. **VTOL Fuel Type:** Rural Vertiports will require consideration for fueling capabilities for various types of power/energies.
2. **VTOL Physical Characteristics:** Rural Vertiports will set parameters on aircraft's physical characteristics (e.g. maximum wingspan) that the facilities can accommodate.
3. **RON Parking:** Rural Vertiports may require options to accommodate remain overnight (RON) parking.
4. **Touchdown and Liftoff Area (TLOF):** The quantity and sizes of TLOFs at Rural Vertiports will depend on land dedicated to the site.
5. **Diverse Fleet Accommodation:** While Rural Vertiports are designed for next generation VTOLS, consider accommodating for helicopter, CTOL (Conventional Takeoff and Landing) and other generation STOL (Short Takeoff and Landing) operations.
6. **Ground Service Equipment (GSE) Support:** Rural Vertiports may require GSE equipment to accommodate the support of passenger operations.
7. **Weather Observing Instrument and Sensor:** Rural Vertiports will require provision for necessary weather observing instruments and sensors needed by the Vertiport Operational Control Center.
8. **AAM Maintenance:** Rural Vertiports will require provisions for light maintenance capabilities (e.g. minor part changes). Heavy maintenance will occur elsewhere.

Figure 22: Rural Vertiport Concept

7.2 Recommended Physical Geometry of Vertiports

Preliminary guidance for vertiports was released by the FAA in the form of an engineering brief in February 2022 that provides vertiport planning and design standards. A full advisory circular for vertiports is expected in 2024. Physical geometry for vertiports is described in FAA Draft Engineering Brief #105 and depicted in Figure 23 and Figure 24 and summarized in Table 14.

Table 14: Summary of Federal Guidance from FAA Draft Engineering Brief #105

Federal Guidance	Current Expectation
Space constraints	TLOF (touch down and lift off area): Based on the vehicle size and type. Controlling Dimension (CD) is defined as the longest distance between the two outermost opposite points on the aircraft. FATO (final approach and take off area): Width and length are twice the CD Safety buffer: ½ the CD.
Approach/departure surface (applies if you are in a metro area trying to land amidst tall buildings)	Single clear path in and out of the vertiport required. Requirement is 8:1 surface (e.g., to clear a 200' building 8' x 200' = 1,600' of horizontal buffer is required on one side). Preference is to be with the prevailing wind, so more than one path is desirable.

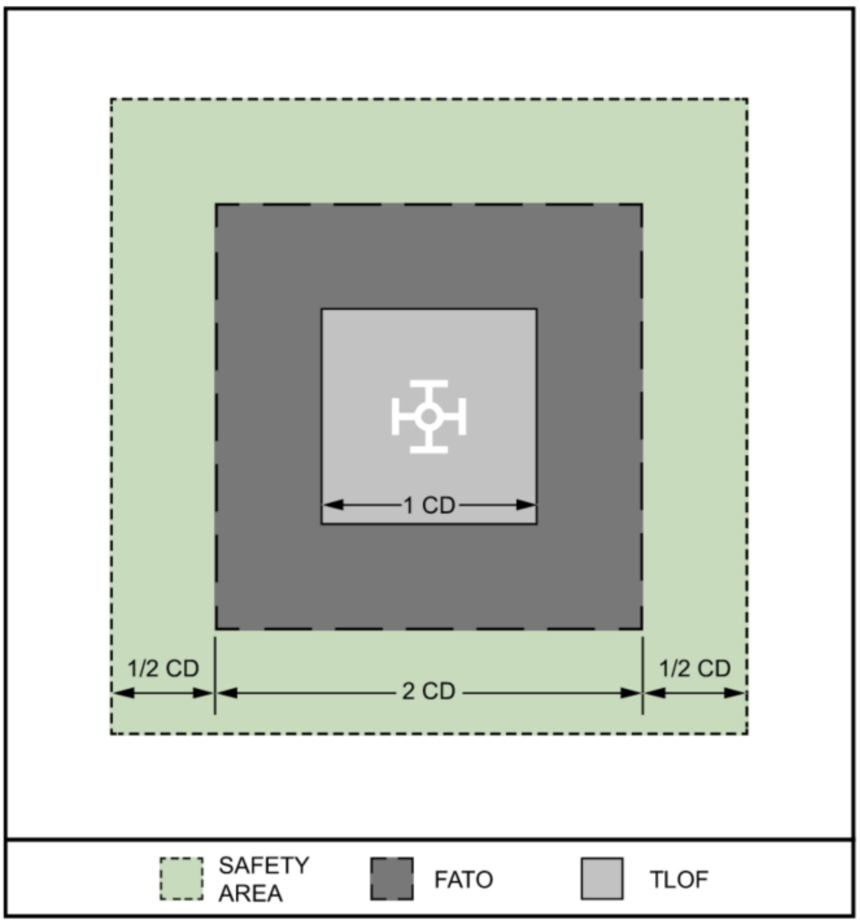


Figure 23: Relationship and Dimensions of Vertipad Components[56]

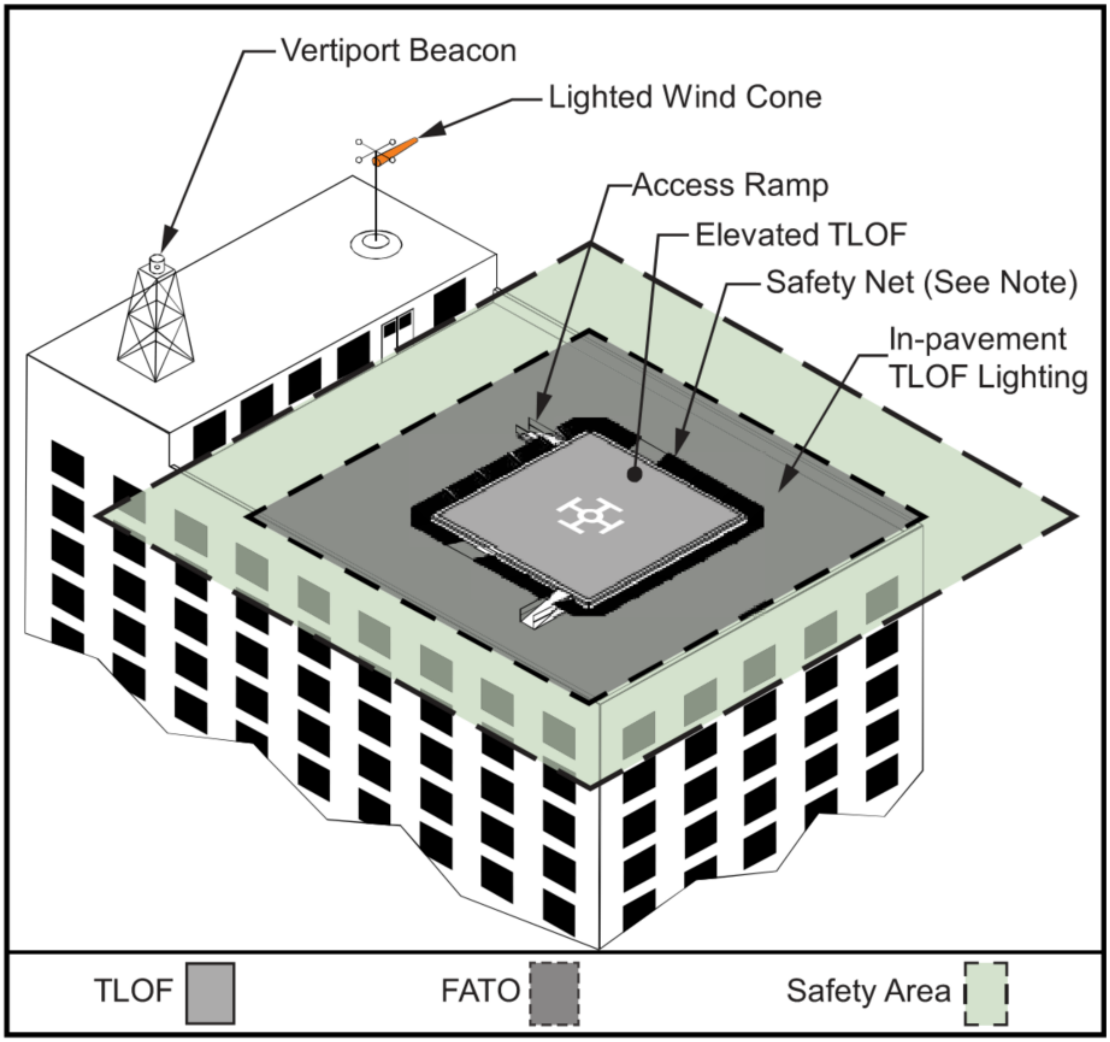


Figure 24: Elevated Vertiport Configuration[57]

7.3 Vertiport Infrastructure Needs of Cargo and Medical Use Cases

Cargo (delivery, E-Commerce, on-demand deliveries, etc.) and medical use cases have unique needs for infrastructure and zoning support. Descriptions of the subtleties of each of those use cases follow.

7.3.1 Cargo Use Cases

In the use cases evaluated in this framework, cargo includes home/business package delivery, E-commerce, logistics transportation, and general on-demand deliveries (i.e., food delivery), among others. This use case includes both crewed and uncrewed activities. Most cargo trips will originate on privately owned and exclusive use infrastructure (such as a company warehouse) and terminate at another privately operated destination. In some instances, such as a package delivery, AAM vehicles would make delivery stops at customer locations, with a return to base upon completion.

Compared to AAM passenger travel, AAM cargo movement will likely see uncrewed flights earlier and in greater percentages as the risk for loss is greater with passengers than with cargo. As such, it is important to understand that most of the passenger-driven requirements are not applicable to cargo use cases.

Cargo users are expected to operate out of privately owned and exclusive-use areas in facilities owned or leased by the operator. Sizes of vehicles may range from a small 3 ft by 3 ft delivery vehicle to a cargo drone with a 50-foot wingspan. In all cases, flexibility of facilities should be considered where feasible to maximize the future value of their construction. Vertiports permitted and approved for cargo uses should be held to the same minimum safety standards established for passenger transportation and have data integration with other types of AAM. Automated loading, unloading, and sorting infrastructure will be necessary for the success of this use case.

7.3.2 Medical Use Cases

The medical use case encompasses patient transportation/transfer, emergency medevac, time sensitive material transportation, and doctor/staff transportation, among others. Many of these functions will make use of existing heliports, helipads, or helistops that have been previously constructed at medical facilities for use by traditional helicopters. Standards for the geometric criteria of these facilities are currently identified in FAA's Advisory Circular 150/5390-2C. Many of the criteria and recommendations for passenger transportation are applicable for the medical segment, however, it is common that these facilities are much smaller than those described for cargo or general passenger travel use cases. In some situations, medical missions may make use of passenger vertiports to facilitate evacuation, patient/doctor/staff transportation, or to maintain, store, or stage vehicles. However, many hospitals already have helipads, and time is especially critical for this use case, so this is expected to be limited.

8. AAM Strategic Framework

Successfully standing up a new AAM-based transportation system will require collaboration across all levels of government, the aerospace industry, OEMs, academia, equipment providers, systems integrators, the utility sector, and the financial sector, among others. The strategic framework presented here covers:

- The future, as currently understood, for each of the six identified AAM Use Cases including what to expect and the level of support needed to move the industry forward.
- FAA and Federal policies and actions to watch, stay informed of, and influence. This includes grant funding opportunities, certification of aircraft, approval of BVLOS activities, coordination of air traffic, activation of public and private use vertiports, among many other actions.
- State actions that can be taken to enable and reduce barriers for AAM activities, and to create an attractive and supportive environment for AAM research, manufacturing, and workforce development.
- MPO and RTPO activities that can position regions and local partners for a successful AAM future. MPOs and RTPOs are experts in convening stakeholders around emerging topics of interest.
- County, City, and other local government considerations to position for AAM adoption and operations. Local governments can help develop regulations and ordinances to advance AAM.
- Industry considerations that must incorporate the business needs of OEMs, OEM suppliers, EV charging providers, utility companies, electrical and computer equipment installers, data providers, data connectivity needs for the supporting services, and the industry organizations that can bring these players together.
- Regulatory considerations since AAM is still in its infancy and it is critical that Ohio legislators and administrators engage in the evolving regulatory environment. Leadership in this space could help define federal regulations and attract businesses to the state that understand the value of well-organized and efficient government.
- Workforce training will be needed to create a talent pool of next-generation mechanics, manufacturing, supply chain, air traffic controllers, and electrical/software engineers to capture the 15,000 AAM-related jobs forecasted to be created by 2045.

8.1 Use Cases

This section addresses what to expect and what is needed for each use case to succeed.

Table 15: AAM Use Cases

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<tr>
<td rowspan="2">
On-Demand Air Taxi</td>
<td>What to Expect:
For on-demand air taxi AAM service, there may need to be multiple vertiports in a county or metropolitan area. Vertiports will initially be located in defined areas that will generally require first-last mile connectivity by other modes to get from travel origin to destination. They will vary in size depending on the type and quantity of aircraft and what infrastructure support is necessary.
Aircraft types will likely be VTOLs needing a high degree of versatility. eVTOL aircraft currently designed include models with wings and models without wings. Many of the models used for Air Taxi likely will have smaller capacity and will require more frequent turnaround times.
Siting vertiports that support a high degree of versatility (airspace, zoning, first-last mile, operator for business case) will be important.
Initially, infrastructure will be driven by private investment. Except for cargo and emergency services, it is anticipated that, as the industry becomes more established, public vertiports will emerge, particularly to address limited availability of takeoff and landing locations. Developers will need to work with utilities and localities as they build out battery charging infrastructure. They will also need to work with the OEM(s) on their unique infrastructure requirements.
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<td>What Support is Needed:
Many operators of uncrewed aircraft are planning for smaller, lower cost, “no touch” landing sites – often only needing proper zoning and technologies such as remote tower systems (rTWR).
A robust communications infrastructure with redundancy is critical for this use case to thrive and to spur economic development. Economic development staff partnerships with cellular providers, for example, is critically important for sUAS. Additionally, the FAA and FCC must collaborate on establishing dedicated frequencies for AAM communications. Redundant, high speed data communications and connectivity are needed for takeoff and landing locations.
To expedite the launch and scale of AAM passenger services, investments in infrastructure to support USSs, PSUs, UAS traffic management, radar for Detect and Avoid systems, communications systems for command and control, and in-time aviation management systems such as those that monitor weather systems and infrastructure for sensor/network health and integrity monitoring and mitigation should be considered by the public sector. Operators can share data they are collecting (e.g., weather data) with the public sector.
Public education is also critically important. Localities, business associations, and the AAM industry can collaborate to address community concerns such as audible/visual noise and equity while focusing on the benefits to consumers, passengers, and potentially the environment. Public education is also critical for building user confidence in the technology.
While some spare parts could be housed at the vertiport for emergency maintenance, full repair, and typical maintenance (Part 145 providers) should be conducted offsite. Proximity to parts suppliers for a robust ecosystem is something to be considered by local officials.
Workforce training programs will need to be set up or expanded to include a new combination of skills. Operators will need pilots and specially trained mechanics. New certifications will need to consider training across previously siloed activities. FAA certifications, for example, do not cover high voltage work.
As the industry changes, the FAA should look at certification for pilots and remote operators to remain globally competitive and meet the new demands of AAM. Reduction of piloting requirements through automation will need to be reflected in pilot certification to meet increased workforce demands.
Fire codes for eVTOL supported infrastructure should evolve because battery fires are different than typical facility fires. Facilities may be required to store multiple different types of fuels (electric power, hydrogen, traditional oil-based fuels) to accommodate a variable fleet mix.
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Regional Air Mobility	What to Expect: The support considerations for On-Demand Air Taxi also apply to Regional Air Mobility (RAM), however there are some additional nuances that must be considered. • The aircraft utilized for RAM will more than likely accommodate a greater number of passengers and utilize scheduled service rather than on-demand. • In addition to eVTOL aircraft, crewed and uncrewed eCTOL/eSTOL aircraft are emerging and will play a significant role in RAM. These aircraft may require more space for takeoff and landing.
	What Support is Needed: • Given that travel is occurring between cities, it will be critical for state and local entities to coordinate and share lessons learned. • Due to the number of aircraft types to be used for RAM, AAM operators may consider using current traditional runways at General Aviation facilities to maximize aerodynamic and power efficiencies. • Staff limitations at General Aviation facilities should be considered since their capacity to support AAM operation may be minimal.
Airport Shuttle	What to Expect: • Given what could be a dramatic rise in AAM, combined with the stringent security requirements at commercial service airports, there will need to be extensive collaboration between AAM industry stakeholders, airport management, and local governments to determine optimal siting of vertiports so as not to hamper safe airport operations. • Potential siting locations could vary from airside to landside to offsite, but consideration should be given to the proximity to passenger terminal facilities. • For onsite airport shuttle service, the vertiport location may serve multiple operators. In this case, the infrastructure will be shared and will need to serve multiple aircraft types.
	What Support is Needed: • With shuttle origination/end points at or near the airport, necessary security measures such as prescreening, TSA services, and baggage handling will need to be considered and coordinated. • Integration of supporting surface transportation will be important to prevent additional congestion on the airport grounds. • As with traditional airport operations, available first/last mile connectivity will be important for vertiports. • Airports and localities will need to consider options to own and develop the infrastructure, including the necessary support facilities for services such as battery charging and hydrogen refueling.
Emergency Services and Medical Air Ambulance	What to Expect: • Piloted AAM aircraft will greatly reduce aircraft, operating, and maintenance costs. Traditional helicopter fleets will be replaced with newer VTOL/eVTOL aircraft operating more efficiently and safely. This will allow expansions of medical air services across networks, improving response times. • Uncrewed services will likely first be provided for deliveries (medical supplies, samples, organs, etc.) followed by piloted aircraft to transport personnel and patients. Procedures and medical equipment required can vary between emergency service providers and currently must comply with Section 4766 of the Ohio Revised Code. • For trauma response, it is important to ensure safe transport and landing locations for emergency personnel and medical supplies. Co-location with emergency facilities and/or on-ground emergency transport services is essential. As AAM scales, response to aircraft accidents is also a possibility, particularly given the remote nature of many incidents and the improvements to detect-and-avoid technologies.

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<td>
Emergency Services and Medical Air Ambulance</td>
<td>What Support is Needed:

In the near-term local authorities and emergency service providers should collaborate in identifying areas of high incidence and/or in most need of service to develop potential routes and anticipated services. This could include roadways with the highest incidents, as well as remote areas with poor connectivity.
Hospitals/medical facilities will need to identify the most promising opportunities for AAM delivery of samples, equipment, tissue, organs, etc. and help identify the most advantageous origins/destinations.
All involved healthcare providers and suppliers of medical goods and services should identify bottlenecks/pain points relating to ground networks that can be addressed with AAM or that need to be resolved as part of the overall supply chain flow.
Air management authorities will need to prioritize air travel for emergency services and build standard operating procedures and data tracking to ensure success.
Healthcare and insurance providers will need to collaborate to both align with Centers for Medicare & Medicaid Services and provide mechanisms for billing of services and payment of healthcare providers. They should also identify cost savings through utilization of AAM that can be passed on to insurance providers.
Public acceptance and education are important, particularly for understanding the need and benefits, as well as anticipating the public witnessing of aircraft landing on/near roadways and other non-conventional landing sites.
It is critical that OEMs and healthcare providers collaborate to ensure aircraft are properly equipped and meet their needs.
For policy development, coordination will be required between hospitals/emergency services, public safety, and local/state regulatory authorities, especially for traffic accidents.
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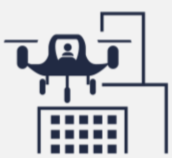
<td rowspan="2">
Corporate / Business Aviation</td>
<td>What to Expect:

This use case includes the potential for vertiports to be developed on private property such as corporate campuses. Developers will have more authority over the structure, design, and accessibility of these vertiports, but will need to ensure that the property's zoning allows for this type of service and that designs are permitted and inspected.
Businesses will need to work with operators to gain access to these services between corporate campuses and from campus to customer locations.
Corporate/business aviation will not have exclusive routes, but leverage prescribed routes and corridors established for other use cases.
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<td>What Support is Needed:

Businesses and operators may also need to collaborate with economic development organizations and/or local governments for approved flight paths from a public perception standpoint. This will be added traffic from what will be deployed initially by operators for AAM and will add to perception of audible and visual noise.
As the AAM industry matures, businesses may wish to consider private eVTOL aircraft and direct flights/access for company employees to airports from their campus, particularly from remote locations.
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Cargo and Freight Delivery</td>
<td>What to Expect:
To scale cargo delivery service, particularly uncrewed drone deliveries, it is important to look for ways to leverage existing infrastructure to avoid costly new investments. Key areas of collaboration are battery charging infrastructure and ground-based radar (at airports).
Carriers are currently using their existing ground facilities or those of their clients (e.g., hospitals and retail) to store their drones. As the industry grows, some carriers will want to site their own drone ports. Since business growth will result in job growth, there is an opportunity for carriers to collaborate with economic development organizations and municipalities on strategic drone port locations.
Shipment of goods can be made either by sUAS aircraft with delivery direct to clients for smaller packages or via larger AAM vehicles transitioning to first/last mile alternative ground-based delivery models. These modes will have significantly different infrastructure requirements.
This use case has the largest variation of vehicle types ranging from next generation CTOLs to STOLs and VTOLs under crewed and remotely piloted operation.
In the AAM future, drone piloting requirements will be reduced, and the certification process will need to be eased in line with operational automation. Similarly, maintenance, repair, and overhaul (MRO) will be streamlined due to electric motors and disposable/replacement parts requiring less stringent certification.
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<td>What Support is Needed:
Continued development of Command and Control (C2) links to ensure communications connectivity. This will require coverage for the area(s) of operation, reliability (at a latency required for C2), redundancy, and security to ensure continuity. Cellular networks will still play an important role in communications as they can be utilized for location reporting and as a back-up communication system.
To expedite the launch and scale of AAM cargo services, investments in PSUs, UAS traffic management, and weather systems should be considered by the public sector. Operators can share data they are collecting (e.g., weather data) with the public sector. The public sector can share elements of infrastructure data to improve safety. Data standards, as well as a clear line for what data is publicly and privately owned is necessary.
Accommodate the infrastructure demands from the wide variety of vehicle types. This will require investment and oversight of traditional airports and private and public use vertiports.
Heavy maintenance is anticipated to be outsourced, in which case, it will be important to grow that ecosystem through training and economic development.
While crewed AAM has the opportunity to operate under existing FAA rule sets, the FAA currently requires separate approvals/waivers for each deployment/test of uncrewed drone deliveries. Scalability will benefit from overall rules and guidelines established by the FAA.
Collaborating on a test area where the public can view, hear, and experience drones would be helpful for acceptance.
As in the air taxi and regional air mobility applications, to realize the full potential of AAM, the industry will need more pilots and mechanics. This presents an opportunity for collaboration, development of certifications and apprentice programs, and training (or re-training) through community colleges.
Local and state authorities can convene with industry to understand potential supply chain disruptions affecting AAM activities and to develop policies for backup systems/alternatives to minimize the delay of critical goods delivery.
Deliveries made by sUAS aircraft will need to satisfy the “point of delivery problem” (PDP) to ensure the package is delivered reliably and safely. Considerations include whether delivery deadlines can help address customers’ expectations and if continuity of operations can be provided with multiple providers operating simultaneously in a given environment.
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8.2 Federal

Federal funding is currently available for AAM infrastructure at FAA facilities through existing USDOT funding and financing programs, although many of these programs are oversubscribed.

As part of the bipartisan Infrastructure Investment and Jobs Act (IIJA) signed into law November 15, 2021, the federal government has greatly expanded their support for clean transportation. Given the importance of Ohio's aerospace and manufacturing sectors, federal policy is likely to provide relatively greater benefits to Ohio than other states.

As federal formula and discretionary grant programs are defined, Ohio can identify opportunities to build on current successes and help the industry mature.

Table 16 identifies potential federal policy actions that may be used to advance AAM in the next few years.

Table 16: Framework for Federal Support of Ohio's AAM Ecosystem

Type	Agency	Actions
Rulemaking	USDOT/FAA	Develop and maintain relationships with FAA to monitor and understand rulemaking related to AAM including: Aircraft (certification): • How vehicles operate remotely piloted and eventually remotely monitored aircraft beyond visual line of sight (BVLOS). • Autonomous parcel delivery and passenger vehicles. • Electric airframes and electric propulsion systems for all configurations. • Certification of VTOL and forward flight transition. • Vehicle operational spacing and offset standards based on evolution of IFR/VFR and eventual adoption of digital flight rules. Airspace (standards and rules): • Proactive airspace design. • Approach paths into and out of vertiports for (eVTOL and STOL) Infrastructure (certification of ground facilities): • Standards for vertiports that are responsive in a timely manner to meet industry expiations while maintaining safety. • Advisory circular (mandatory standards if an FAA airport or funded by FAA) on vertiports expected by 2024. • Standards for and integration of remote towers into the National Airspace System (NAS). • Set standards for communications within NAS so that FIMS and USS/PSU can interact with vehicles, operators, and infrastructure. • Sensors, including those for weather reporting and hazard identification.
Research	NASA	• Continue working with NASA to identify collaborative opportunities to advance technologies and demonstrations needed to inform policy and standards development. • Work jointly with NASA in maturing and developing concepts of operation that enable the implementation of the use cases of interest to Ohio and that incorporate environmental and community integration considerations.

Type	Agency	Actions
Research	USAF	• Continue to partner with USAF, AFRL, AFWERX and Agility Prime for use of military flight release (MFRs), supporting vehicle certification, and access to DOD bases and airspace. • Partner with DOD in joint demonstrations addressing dual use operations, especially in the areas of logistics support and cargo/freight delivery.
Infrastructure Support	FAA Airports Division	• Monitor Airport Improvement Program (AIP) funds as guidance on IIJA gains clarity. • Electrification is a clear driver for AAM and should be placed as a high priority. • High-speed and secure data networks for airports. • R-TWR technologies will allow for increased operations at underutilized or smaller airports to increase AAM operations. • Target opportunities for investments synergistic with AAM.
Research	DOE	• Capitalize on Ohio leadership in energy production to pursue opportunities to partner with DoE National Renewable Energy Laboratory (NERL) in advancing power and energy technologies, including batteries, hydrogen fuel cells, and other alternative energy sources.
Demonstrations	USDOT	• Sponsor studies for understanding local and regional passenger demand, cargo transportation needs and intermodal connectivity to inform the design of multi-modal transportation facilities • Sponsor studies for Investigating transportation patterns in and out of major airports to city centers, suburban and rural community to understand what infrastructure needs. • Expand the use of competitive grant funding for AAM vehicle and infrastructure demonstration programs, including technologies at early stages of commercialization. • Pursue localized and multistate projects.
Infrastructure Support	USDOT	• Pursue opportunities within the IIJA for funding for EV charging stations, including charging for medium to heavy-duty vehicle fleets that would support a multimodal transportation system. • Support allowing terminal and public fleet charging to be eligible.
Taxation	IRS	• Monitor taxation planning that may impact the implementation of AAM. Specifically, regulations related to commerce and transportation.

8.3 State

As discussed in Chapter 4.2, Ohio has been investing in UAS research and development for a decade and is actively collaborating with NASA, AFRL, FAA, and industry to position Ohio for the future of AAM.

Figure 25 lays out an infrastructure investment strategy starting with radar systems and air traffic operations support and adding in a remote tower system by 2029. Ohio intends to initiate this system to promote remote air traffic control or similar services for vertiports and general aviation airports to accelerate adoption.

On the aircraft side, the state will expand crewed licensing programs to uncrewed (in 2027) to help offset infrastructure costs and supporting services.

Investments are needed in each of these areas. The infrastructure deployments (both physical and digital) represent a combination of private led, public led, and public-private partnership investments. In 2021, the results of the Economic Impact Analysis of AAM for the state of Ohio, estimated a total OPEX and CAPEX of over $1.4B by 2045, with over $375 million for the first 10 years. In the development of this framework, the infrastructure investment needs were developed further. Although, in some cases the balance of investment is not yet well understood, the state-side anticipated magnitude of investment required to accomplish these infrastructure deployments is estimated at more than $60 million in the next ten years.

For example, engineering for radar systems in each urban area is estimated at $300,000. Once operational, the radar system is estimated at $10,000 per month per site to lease. Assuming three sites are needed per urban area for adequate coverage, the annual cost to lease radar and provide coverage in the Columbus area, for example, is estimated at $360,000. As coverage is added to Cincinnati, Cleveland, and other Ohio cities these costs will grow proportionally.

Likewise, air traffic operations would likely start with 8-hour coverage during the work week and gradually grow to include weekends and a second and third shift. This may be an area that the state initiates in the early stages, forming policies and procedures that may be further developed and administered by private industry.

Similar investments are currently being pursued by many states throughout the United States. The state funding is manifested in different modes in different states, varying from direct state appropriated funded to a collection of grants and other external funding. Those states with consolidated programs and appropriated funding for advancing AAM are progressing faster. The State of Ohio must pursue having specific appropriations and consolidated programs to ensure proper coordination and management of AAM implementation efforts.

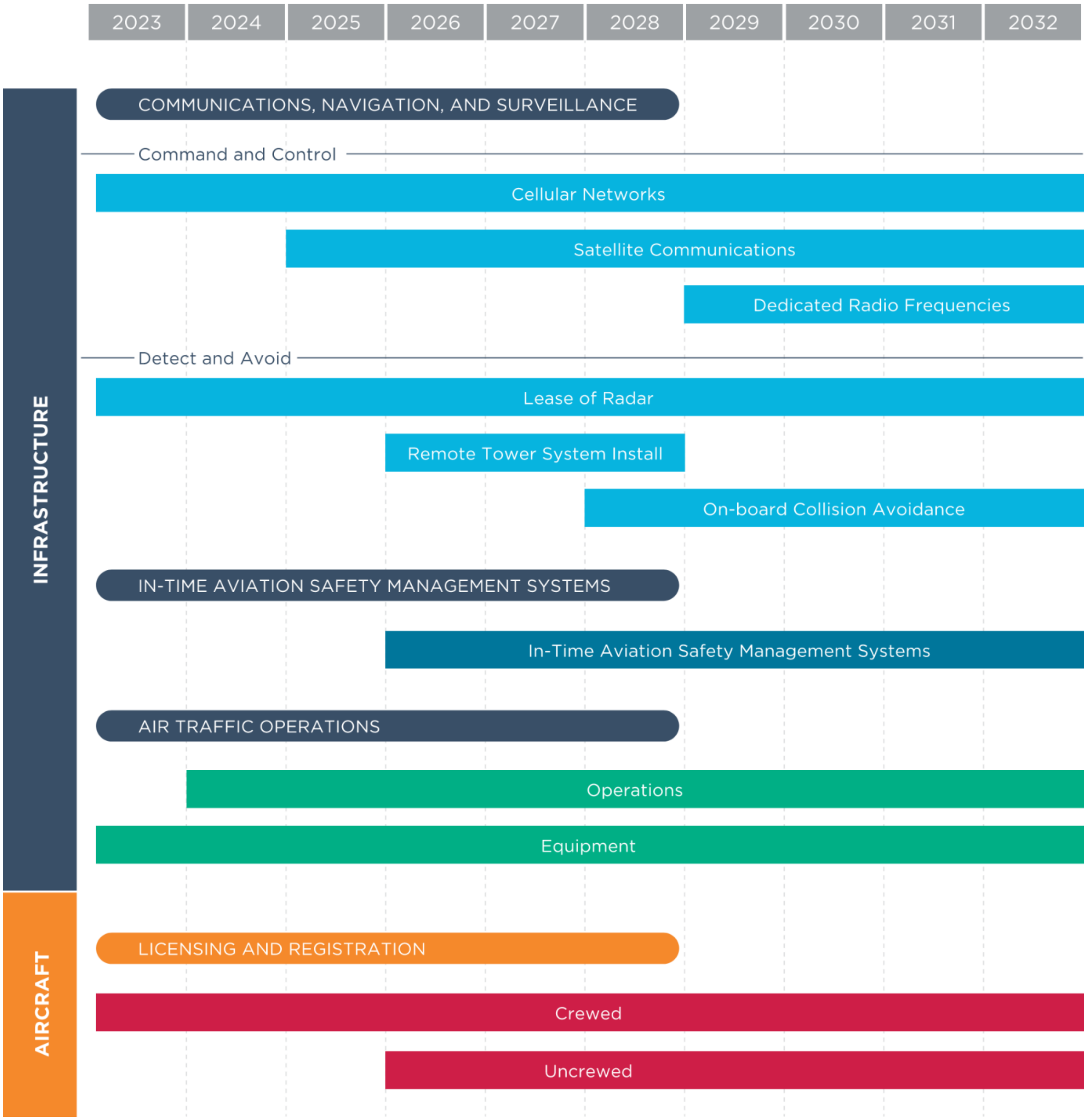

Figure 25: FlyOhio 10-Year AAM Deployment Plan

The State of Ohio has many tools and strategies at their disposal across multiple departments that can help position Ohio to attract more AAM-related business activity, research, testing, service deployment, and job creation. ODOT will have responsibility to champion this effort. Table 17 captures ways that ODOT, through DriveOhio and FlyOhio, can work with other state departments to advance AAM.

Table 17: Framework for ODOT Support of Ohio's AAM Ecosystem

Type	Recommended Future Action
Rulemaking and Policy	• Develop and maintain relationships with FAA to monitor, understand, and inform rulemaking related to AAM airspace, general aviation airspace, and infrastructure. • Establish a regular information exchange forum with FAA to understand certification progress (vehicle, operator, infrastructure) and share data and knowledge gained through Ohio sponsored activities. • Coordinate with other state agencies, partners, and stakeholders to develop statewide strategies and provide input to FAA and other federal agencies.
	Work with the state legislature, MPOs, and localities to complement FAA regulations and avoid patchwork laws that would make AAM flight paths harder to design and vertiports harder to place. Share sample locality ordinance language and apply guidance consistently across jurisdictions.
	Work with airport and airport zoning boards to educate and inform them on AAM to prepare and protect current and future AAM activities.
	Work with the Ohio Department of Public Safety (ODPS) to discuss the need to frame out regulations regarding safe operation, regulatory compliance, and enforcement as AAM evolves and airspace access becomes commonplace for individuals. Consider items such as an Ohio Air Patrol, as the Ohio State Patrol was created for the Interstate system.
	• Consider if any vertiports will be state owned and therefore become transportation facilities as defined in ORC 5501.01 (A).
Infrastructure and Equipment Investment	Collaborate with other state agencies and local jurisdictions for consistent supporting policies related to AAM in areas to such as: • Licensing/permitting processes for airports/vertiports • Height zoning around airports/vertiports • Fueling and charging safety (i.e., national, state, and local fire code coordination) • Insurance regulations (Ohio Department of Insurance)
	• Further develop AAM corridor and infrastructure plans to support infrastructure, policy, funding, and technology advancements. • Continue development of low-altitude airspace design led by the Ohio UAS Center (Skyvision, Ohio UTM, and Remote Towers) to attract AAM operators and advance definition of Ohio centric use cases. • Work with Ohio's MPOs/RTPOs to incorporate AAM into statewide transportation plans and require AAM sections in comprehensive transportation plans for counties and localities. • Encourage Airport Master Plans to consider impacts of AAM and how to leverage assets to promote the industry's growth. • Develop grant strategy to help in pursuit of funding that advances AAM priorities. Engage public and private partners to support the pursuit of federal grants. Collaborate with industry consortiums on identification and development of conceptual plans for ground infrastructure (equipment, communications, power) at priority vertiport locations.
	Work with Ohio Federal Research Network (OFRN) to identify ways to drive AAM innovation, commercialization through academic institutions, funding through research and development, and key partnerships that support this.
Public Outreach and Education	• Work with Ohio Department of Administrative Services (ODAS) to add and publicize UAS, EV charging, and later AAM models that are on the state's universal term contract list to Ohio's state and local governments.

Type	Recommended Future Action
Workforce and Economic Development	• Collaborate with the Ohio Aerospace and Aviation Technology Committee (OAATC) on the continued coordination of the aerospace and aviation sectors to ensure Ohio's legacy is maintained. • Continue regular interactions with the recently established Ohio AAM Steering Committee comprised of key AAM stakeholders. • Continue to conduct information gathering sessions with industry to stay on top of emerging trends for technologies, manufacturing, and existing/proposed policies, and get feedback on state progress. • Continue to provide latest trends on Ohio's UAS activities through the public website www.uas.ohio.gov. • Pursue additional opportunities for showcases and events that share the vision and progress of AAM in Ohio. ○ Develop educational materials that can be used by the state, MPOs/RTPOs, counties, municipalities, Ohio Aviation Association, and others to educate their partners, members, and the public.

	• Work with JobsOhio to:
	  ○ Promote Ohio's capacity and AAM supportive resources (AAM manufacturing ecosystem, flight test range, flight infrastructure, etc.) to attract OEMs, suppliers, and other support businesses to Ohio.
	  ○ Collaborate with industry to inform AAM adoption and use case opportunities to support job growth in and between the healthcare, logistics, and aerospace sectors.
	  ○ Identify allocations for incentives to encourage business development and job growth within Ohio. Ensure allocations cover urban, suburban, and rural business development.
	  ○ Identify state programs (financing, grants, incentives, etc.) to support AAM industry investment and job growth in Ohio.
	  ○ Identify opportunities to directly fund infrastructure projects related to AAM.
	  ○ Coordinate with DriveOhio on continued collaboration with Ohio's educational institutions to develop aerospace industry talent through ongoing vertiport innovation challenges and K-12 STEM activities focused on AAM infrastructure.
	Coordinate with DriveOhio on continue collaboration with Ohio's educational institutions (university/college programs and regional training centers) to develop curriculum to cultivate the next generation of aerospace engineers, laborers, and mechanics to support OEM manufacturing scale-up and to attract new AAM aircraft manufacturers.

	Continue to look for ways to support testing and operation of a breadth of AAM vehicles to grow the local knowledge base and position Ohio for future opportunities.

8.4 MPOs and RTPOs

Metropolitan planning organizations play a critical convening and education role and as a home rule state, Ohio's local governments lead critical land use and infrastructure decisions. Together, these institutions will shape how AAM functions. The following is a summary of items MPOs can begin to integrate into their planning processes, so they are well positioned when AAM scales.

Airports and Heliport Operators should consider the potential of increased operations at their locations. Existing aerodromes will be the early adopters for AAM activities prior to more elaborate vertiport construction. The reduction of cost for AAM aircraft will allow logistic companies to expand air operations to suburban and rural areas.

Table 18: Framework for MPO and RTPO Support of Ohio's AAM Ecosystem

Type	Recommended Future MPO Actions
Education	Educate elected officials and staff on AAM, its economic opportunities and required electrical grid support and policy/code adjustments.
	Provide opportunities for governmental staff to be educated on the goals and processes of the AAM market transition.
Climate Change	Provide data and processes to support regional GHG calculations that can be used to quantify impacts of AAM growth and/or mode shift.
Planning	Work with local communities in continuing to define the most impactful AAM use cases and missions for their respective areas, including local enablers and challenges of AAM.
	Airports and other locations that are suited for AAM landings and takeoffs should consider adopting zoning to protect the airspace that will be needed for AAM operations.
	Consult with and inform Airport Zoning Boards to ensure positive impacts on future uses.
Data	Consider how to incorporate AAM as an element in future travel demand modeling.
	Gather and maintain regional AAM data to facilitate planning and grant applications.

8.5 Counties, Cities, and Other Local Governments

Referring back to elements discussed in 2.3.3 Public Acceptance Considerations, it is expected that the FAA will take responsibility for items such as safety (including airspace management) and interoperability standards. Control of airspace and prohibitions will also ultimately be up to FAA. Local agencies will need to address privacy and property rights, land use compatibility, permissible sound levels, and visual noise. Zoning for vertiport facilities; multimodal planning; vertiport building safety codes; fire codes, and noise ordinances should all be considered (reference the considerations identified in Chapter 7).

In Ohio's system of governance, it is reasonable to expect different local preferences for AAM routes, provided capacity, and vertiport facilities. The vertiport operations concepts in Chapter 7 provide a starting point.

The following is a summary of items local agencies can begin to integrate into their planning processes, so they are well positioned when AAM scales.

Table 19: Framework for Local Agency Support of Ohio's AAM Ecosystem

Type	Recommended Future Local Agency Actions
City Ordinance or Regulation	Local governments can develop and adopt thoughtful zoning, multimodal planning, vertiport building safety and fire codes and noise ordinances.
Infrastructure	Support matchmaking of site hosts, OEM & battery charging equipment suppliers and dealers, utilities, permitting agencies, and funding opportunities within their jurisdiction.
Local Departments	Incorporate processes and procedures into their local government operations. Specific considerations include: • Law Department: liability, privacy & property rights, noise ordinance, security • Building Department: building codes, fire codes, enforcement of such, building permits

Type	Recommended Future Local Agency Actions
	• Planning Department: zoning codes, land use planning, entitlements, zoning changes and neighborhood buy-in • Fire Department: input on location, fire codes, incident management, recovery of costs from owners, enforcement of codes/inspections, ability to respond to emergencies • Police Department: enforcement, public relations, security • Economic Development Department: marketing/incentives, maximizing economic opportunities for adjacent land, redevelopment/reuse • Transportation Department: permit approval, traffic impacts/parking, multimodal planning, data/statistics, vehicle staging • Municipal/Local airport considerations: o Coordination with FAA and updated standards/training o Compliance with current FAA design standards and grant assurances o Required credentials for pilot/owner permitting o Requirements for vehicles/vehicle permitting and inspections o Space management (if at airport) – rent, contracts o Air traffic control (local or FAA/both) and space needs o Other office space needed and additional staff o Monitoring noise complaints, crash data, other data/statistics o Enforcement o Aircraft maintenance support o Formation and education of Airport Zoning Boards as AAM scales

8.6 Industry

Across the AAM industry from OEMs to their suppliers, from EV charging equipment vendors to utility companies and across industry organizations there are many ways to support AAM progress. A few of these include:

Table 20: AAM Industry Support Framework

Type	Future Industry Considerations
Industry Organization	Support matchmaking of site hosts, OEM and EV charging equipment vendors and dealers, utilities, permitting agencies, incentive programs, and funding opportunities.
	Monitor proposed state and local legislation to offer education on AAM and to try to mitigate potential future conflicts/issues.
Coordination	Formalize ongoing industry coordination and dialogue.
Contracting	Ensure contracts with vehicle and equipment vendors provide sufficient maintenance and support.
Financing	Consider innovative financing (bond of investor financing, longer leases) that enable positive return on investment for terms longer than the typical industry lease.
Demonstration	Undertake projects to put equipment into service, gain operating experience, gather data, and obtain results that can be validated and shared.
Operations	Evaluate the use of networked operations to manage demand as fleets scale.
Data	Gather and maintain regional AAM data to facilitate planning and grant applications.
Education	Educate elected officials and staff on AAM and impacts.

Type	Future Industry Considerations
Positive Exposure	Ensure vertiport and AAM roll outs generate enthusiasm by confirming new equipment works as intended and issues are resolved ahead of time.
Replication	Formalize sharing of lessons learned between states focused on AAM.
Renewable Energy & Storage	Leverage the value of renewable energy and battery storage technology, where appropriate, to lower charging costs and reduce electrical grid impacts in a demand-based utility rate structure.
Utility Items	• Collaborate to proactively plan for grid investments to support AAM transition. • Evaluate rate structures, including providing off-peak battery charging rates to commercial users. • Identify and promote sites with underutilized grid infrastructure as low-cost EV fleet expansion sites.

For stakeholders interested in evaluating the implementation of a vertiport, Figure 26 identifies many of the items to consider.

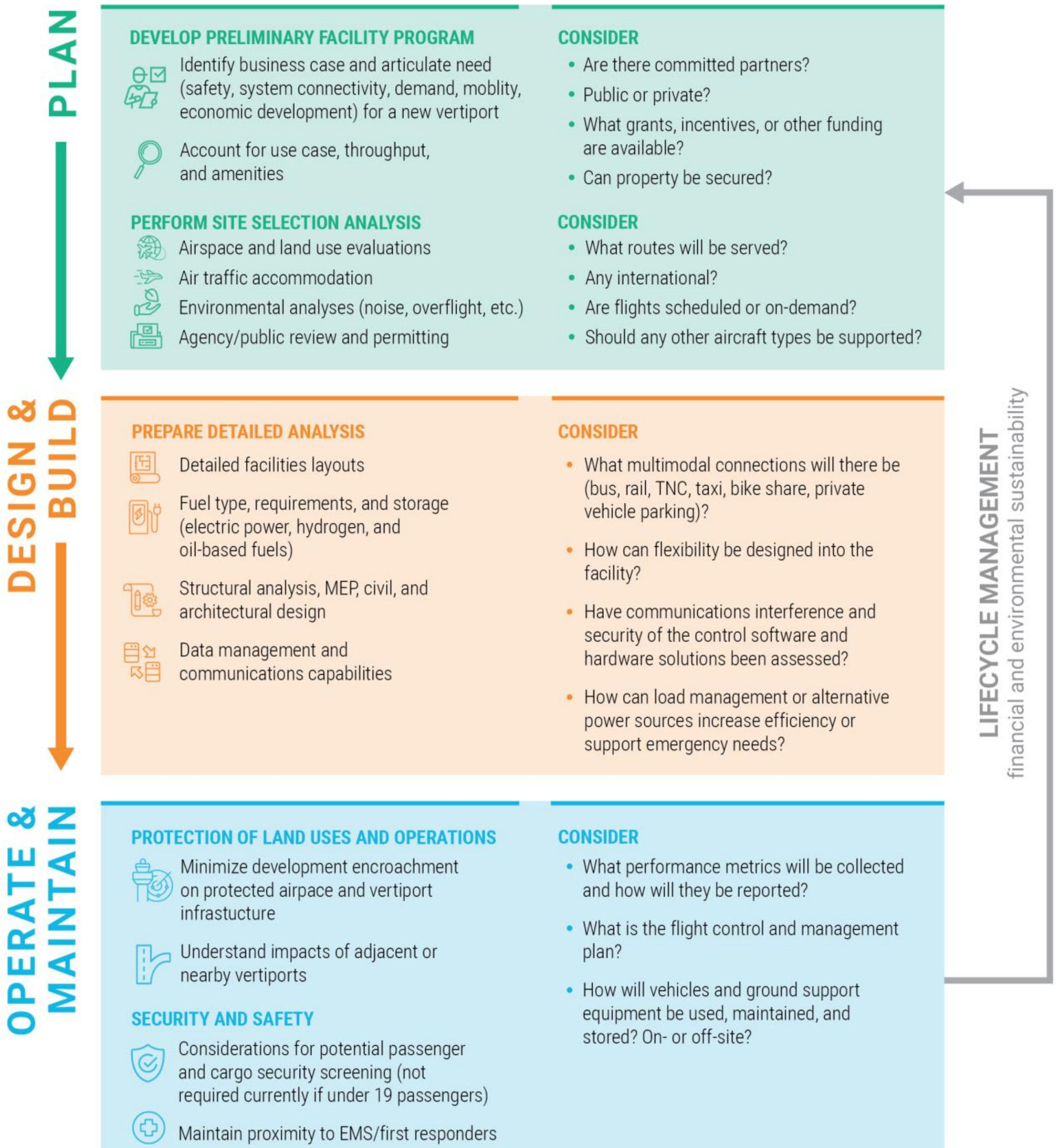

Figure 26: Vertiport Implementation Development Process

8.7 Regulatory Considerations

With AAM still in its infancy, it is important for Ohio to engage at the federal level to inform and make necessary accommodations to the evolving regulatory environment. At the state level this is just as important given the vast number of agencies with the ability to pass regulations that could impact the industry. In addition, preemptive legalization could have unintended consequences for future use cases.

8.7.1 Federal Regulations

There are several regulatory barriers that need to be addressed and resolved for the creation of a dense, effective AAM ecosystem. With the potentially negative impacts of disruptive technology, regulators are moving cautiously to introduce AAM aircraft into the airspace to ensure a high standard of safety is maintained as has been the precedent from aviation's history. Specific issues such as finding consensus on standards, protecting proprietary information, and regulating new technology such as electric aircraft and automated piloting functions must be tackled by regulators and industry alike. Certification of new technologies will also open the door for retrofitting traditional, gas, crewed aircraft.

8.7.2 Local Regulations

As discussed in Chapter 4, the FAA is the agency that regulates and controls navigable airspace while the states and local governments have authority over the creation and passage of laws and regulations that assist in the complementary areas of land use and zoning to uphold the intent of the FAA's regulations while taking into consideration the needs of citizens and future economic development. As of April 2022, the State of Ohio has three bills[c] pending that generally include updates to align the language of Ohio's laws with FAA regulation of UAVs and systems, vertiports and spaceports. The updates also introduce requirements around obtaining and using data collected by a UAV and to suggest ordinance topics for local governments as it relates to UAVs.

Ohio's local governments are not strangers to ordinances and regulations around drones and UAVs with some having laws dating back to 2015. Of the cities, villages, counties, and park districts that enacted a rule or ordinance, many include language derived from FAA regulations or that generally defer to the FAA, but some have overly broad language that may contradict FAA regulations, such as:

1. Prohibition of UAS operation in a manner that "harasses, disturbs, intimidates, annoys or threatens persons or wildlife"[58]
2. Prohibition of UAVs flying below 400 feet
3. Prohibition of UAVs flying within 400 (or 1,000) feet of schools, city buildings, utilities, emergency scenes
4. Prohibition of launch or operation of a UAS weighing more than 4.4 pounds

Note that most of these laws and regulations are aimed at UAVs. Currently they do not affect crewed aircraft with passengers. That is expected to change rapidly however as several OEMs are already flight-testing passenger aircraft that they hope can be operated by remote pilots, if not fully autonomous, as soon as the aircraft are certified and enter service. Advances are also being made towards uncrewed cargo and package delivery, and these services may need to be reconsidered by localities that want to take advantage of the new technologies. The Ohio UAS Center is available as a resource to assist in any jurisdiction that is considering implementing local policies or regulations. The UAS Center can help the jurisdiction understand the state of AAM in Ohio, share the vision for AAM in the future, and share how any proposed policies or regulations would impact Ohio.

As AAM's role in the transportation ecosystem continues to develop, it will be important for local governments to understand the effects their regulations will have on the success of these economic development opportunities. The FAA is expected to continue control over the airspace and any local

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[c] 134th General Assembly of Ohio – House Bills 485, 486 and 490

regulations going against the existing FAA regulations could lead to AAM developers viewing Ohio as unwelcoming for investment. Also, the need and content of regulations may shift over time as AAM moves from autonomous cargo packages to crewed passenger flights and ultimately to remotely piloted or autonomous passenger flights. Therefore, local governments crafting AAM legislation could find success in broad, comprehensive legislation that takes into consideration all the technology discussed in this document, i.e., piloted, remote piloted and autonomous vehicle types from sUAS to UAVs. The OAATC is supporting this by working with the OSU John Glenn College of Public Affairs to establish a policy framework that will be used to inform and advise local decision makers.

Another opportunity for local governments to prepare regulations for AAM development is to review long-range planning and zoning for land use and possible vertiport location siting. While much of the travel itself will be governed by the FAA, there will be opportunities for local governments to support both cargo and passenger AAM flights operations on the ground. Incorporating compatible land use recommendations into a community's long-range plans and adopting height zoning around existing or potential vertiport locations will foster development of AAM and its benefits for local communities while at the same time promoting harmony with the communities' social and environmental goals. An airport zoning board is a good starting point to consider how AAM and existing airport infrastructure will work together.[59]

8.8 Workforce Considerations

The AAM market is projected to be in the tens of billions of dollars by 2045. The 2021 AAM economic impact report for the State of Ohio forecasted a growth of more than 15,000 jobs by 2045 related to AAM in the state. To fully capitalize on that opportunity, additional workforce training will be needed. Job growth in existing sectors is expected to include package delivery and personal mobility services. New jobs will be created around manufacturing, data analysis, supply chain, and new services tied to AAM such as UAS traffic management systems, remote pilots, and new skills for mechanics. Ohio has several advantages that will allow it to capitalize on these opportunities, including world-class educational institutions, strong connections to existing automotive manufacturing (including Connected and Automated Vehicle research and testing), and a rich airline history that fosters continuous growth.

There will be significant overlap between a successful EV transition and a successful eVTOL transition. Building out battery, hydrogen and electronics production capability will support both industries. Skilled manufacturing for zero-emission vehicles may also carry over to advanced air frames. And the supply chains that feed EV and hydrogen manufacturing will also easily adapt to next-generation airframe manufacturing. The university and community college systems in Ohio are ready to train workers on these skills, as well as train the software engineers that will be needed to manage the large amount of data required to operate these sophisticated aircraft. Existing programs to train passenger car, freight, and aviation mechanics on high-voltage skills and safety will need to be modified to include AAM vehicles.

As the industry moves from transporting goods to people, passenger-carrying services could move highly skilled workers longer distances, unlocking additional benefits as the influence of skilled workers increases. Supply chain resiliency will need to be addressed as more critical goods and services are moved via AAM.

9. Moving Forward

Global trends towards electrification and automation are converging to allow the burgeoning AAM industry to benefit from the related technology advancements and economies of scale. Most new aircraft being developed are being developed with high levels of automation. Electrification or hybrid thrust will be a key driver for an eventual uncrewed aircraft technology to evolve.

The speed of this transition will vary by use case and vehicle type.

In all cases, designing infrastructure and regulations to facilitate growth will require close government and industry collaboration in the form of additional research, policy discussions and decisions, and development and streamlining of permitting processes.

Leveraging its history of aerospace leadership and manufacturing prowess, Ohio can steer the AAM transition. Ohio is already in a strong position to collaborate across all levels of government and stakeholder industries to reap the related workforce and economic opportunities for generations to come.

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