NORTH DAKOTA UNMANNED AUTONOMOUS SYSTEMS COUNCIL

UAS Legislative Study and Advanced Air Mobility

Presentation by Matt Dunlevy
24 Jun 24

The North Dakota Unmanned Autonomous Systems Council's mission is to promote and advocate for the UAS industry in North Dakota while providing ongoing opportunities for networking, sharing, and community outreach.

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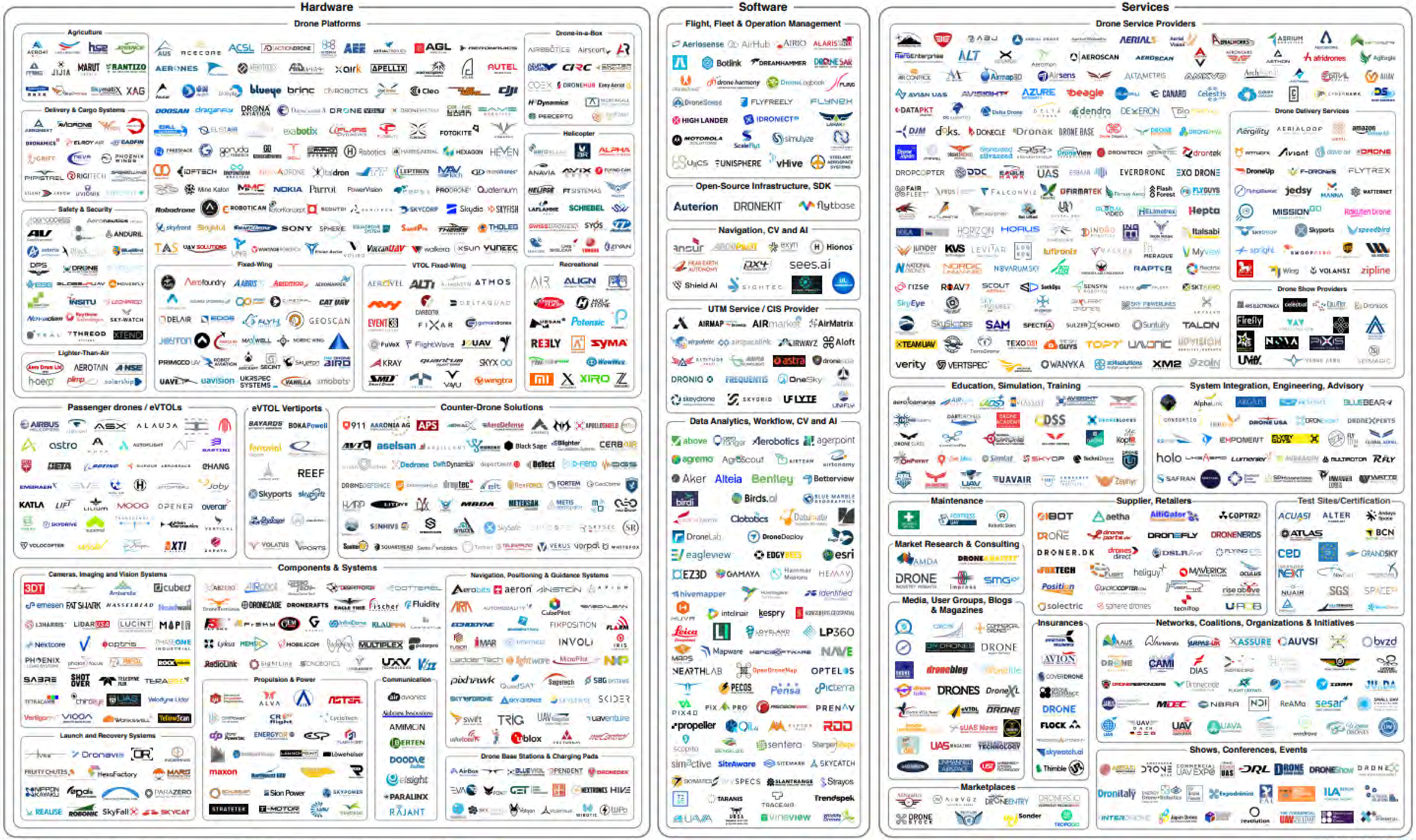
DRONE INDUSTRY INSIGHTS

The Drone Market Environment 2022



DRONE INDUSTRY INSIGHTS

ND Ecosystem

UNMANNED AIRCRAFT SYSTEMS
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SEMPER VIGILANTES

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UAS TEST SITE

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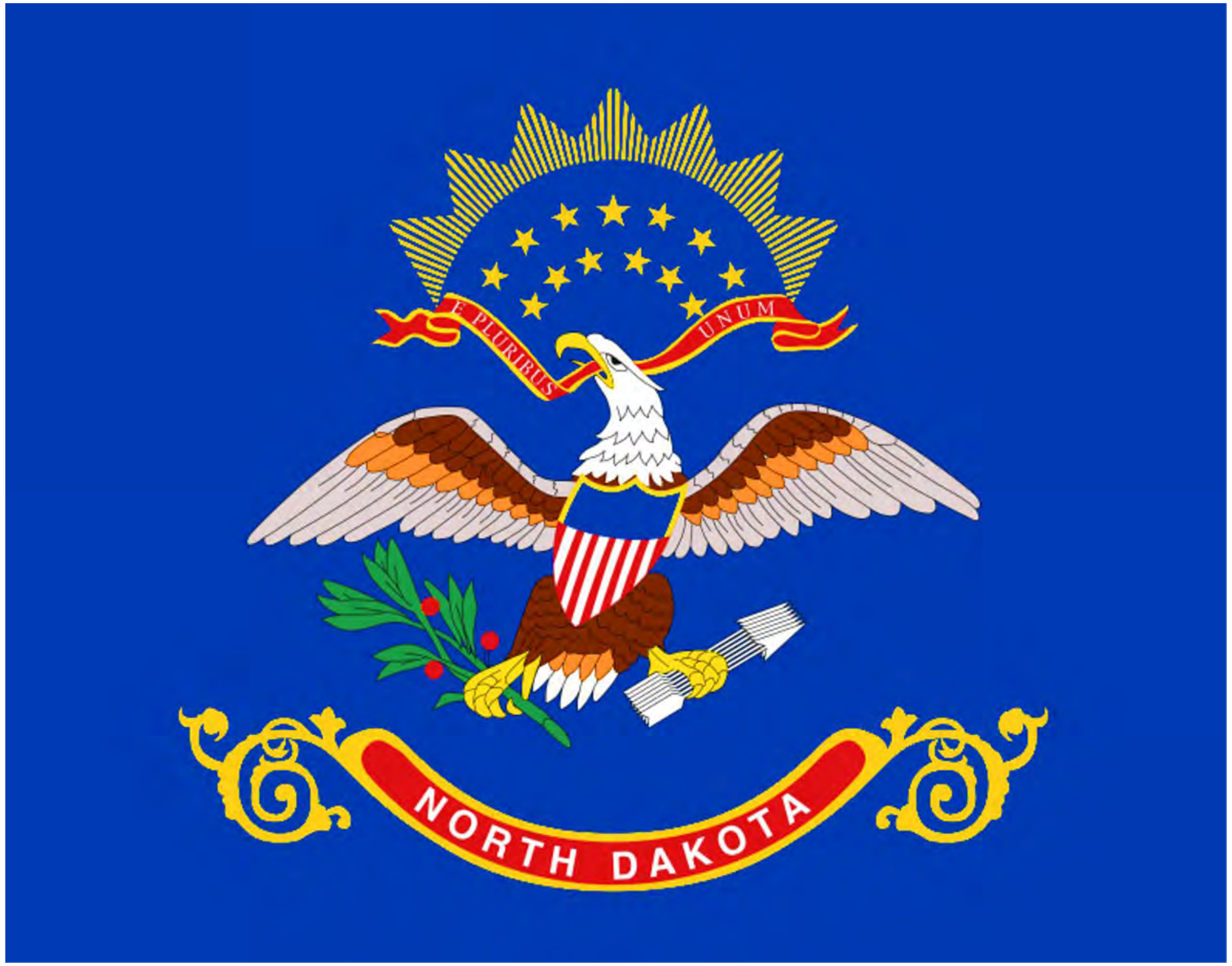
BEYOND

THALES

The Legislative Side

- HB1519: Brainchild of the Council
- State Focus, Autonomy Focus
- Workforce and Economic Stimulation
- Invest and Calculate ROI



HB 1519

SECTION 3. LEGISLATIVE MANAGEMENT STUDY - UNCREWED AUTONOMOUS SYSTEMS.

During the 2023-24 interim, the legislative management shall consider studying the **utilization of existing** autonomous systems **capabilities and infrastructure** to provide solutions to workforce and safety needs in the state.

The study must include an analysis of utilizing autonomous technology for:

1. Infrastructure inspection
2. Rural emergency services needs
3. Agriculture advancement
4. Energy industry application
5. *Other opportunities for collaboration*

…through the utilization of autonomous system technology. The legislative management shall report its findings and recommendations, together with any legislation required to implement the recommendations, to the sixty-ninth legislative assembly.

Other Opportunities for Collaboration:

1. Rural emergency services: eVTOL, AAM
2. UAS Engineering Research
3. Road monitoring for safety purposes
4. Education funding for CTE and 2-year schools
5. UAS workforce marketing, branding, and messaging
6. Operational support
7. Expansion of the UAS in agriculture grant with the Department of Agriculture
8. Advanced waiver development: Pilot ratio, heavier aircraft, higher altitudes, hazardous liquids
9. UAS component manufacturing: batteries, ground control stations, command software, etc.
10. Buyback programs, tax incentives, official guidance
11. Trade group associations
12. Qualitative and quantitative study of public and private UAS investment in North Dakota
13. AAM strategy

Advanced Air Mobility (AAM)

U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: Type Certification—Powered-lift

Date: DRAFT
Initiated By: AIR-600

AC No: 21.17-4

1 **PURPOSE.**

1.1 This advisory circular (AC) provides guidance for the type, production, and airworthiness certification of powered-lift. This AC also designates the criteria in appendix A as an acceptable means, but not the only means, of showing compliance with title 14 of the Code of Federal Regulations (14 CFR) 21.17(b) for Federal Aviation Administration (FAA) type certification of certain powered-lift.

NORTH DAKOTA
UNMANNED AUTONOMOUS
SYSTEMS COUNCIL

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Infrastructure to Support Advanced Autonomous Aircraft Technologies in Ohio

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Prepared for:

The Ohio Department of Transportation,
Office of Statewide Planning & Research

Project ID Number: 111453
June 2021
Final Report

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Ohio Department of Transportation **1980 West Broad Street** **Columbus, Ohio 43223**		**Final Report** 14. Sponsoring Agency Code
15. Supplementary Notes		
The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Ohio Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.		
16. Abstract		
The State of Ohio faces both opportunities and challenges with regards to future transportation systems. Advanced Air Mobility is a concept of air transportation that moves people and cargo between places not conveniently served by surface transportation or underserved by aviation. Driven by the economic and societal promise of AAM, the Ohio Department of Transportation (ODOT) commissioned this Economic Impact Analysis for Advanced Autonomous Aircraft Technologies in Ohio. This report forecasts the industrial and economic benefits of AAM systems and services through the year 2045.		
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The Crown team acknowledges and is thankful for the input of the many people directly involved and consulted during the performance of this effort. Special gratitude for guidance on this project goes to the Technical Advisory Committee members, including Fred Judson, Rich Fox, Jordan Collins of the Ohio UAS Center, and Tim Sweeney from JobsOhio

About Crown Consulting Inc.

Crown Consulting, Inc. is shaping the future of air transportation with concept development, design, and deployment of systems and aircraft. Crown brings more than three decades of experience working with aviation innovators and is a leader for innovation in advanced air mobility and intermodal transportation, air traffic management, and advanced aerospace systems that enable profitable commercial services, cost-effective government services, and communities of the future. Crown provided overall management of this project. Crown brought expertise in regulatory input, technical challenges, and potential implementation barriers of advanced air mobility (AAM), including the development of the use cases developed herein for small-unmanned air systems and AAM.

About NEXA Capital Partners, LLC

NEXA Capital Partners, LLC, is a specialist investment bank providing corporate and strategic financial advisory services, market intelligence, and capital investment to the aerospace, transportation, logistics and geomatics sectors. For this project, NEXA Subsidiary UAM Geomatics, Inc. provided geospatial mapping and analysis of all relevant geographic features for the State of Ohio. NEXA subsidiary NEXA Advisors provided business case studies for the urban air mobility and advanced air mobility use cases developed herein. NEXA Advisors also performed in-depth economic impact analysis of job creation opportunities for the State of Ohio.

About the University of Cincinnati

The University of Cincinnati's (UC) Department of Aerospace Engineering and Engineering Mechanics is intimately involved with the advancement of small unmanned aircraft systems and AAM technologies in the USA The department is leading various efforts for UAS and artificial intelligence for the state. For this project, UC provided Ohio UAS technology insights and subject matter expertise for characterizing the aerospace supply chain for the state. UC supported the outreach to key national and state stakeholders and conducted an assessment of the potential impact of noise for AAM operation.

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Executive Summary

The State of Ohio faces both opportunities and challenges regarding future transportation systems. In Ohio, surface traffic operations have grown to cost taxpayers over $12 billion annually. The future transportation needs and expectations of Ohio citizens include a heightened emphasis on sustainability, affordability, and efficiency. Technological innovations and new business models offer enormous potential for innovative approaches to passenger and cargo mobility. Advanced air mobility (AAM) is a concept of air transportation that moves people and cargo between places not conveniently served by surface transportation or underserved by aviation, bringing urban and regional mobility into the third dimension.

Driven by the economic and societal promise of AAM, the Ohio Department of Transportation (ODOT) commissioned this economic impact analysis for advanced autonomous aircraft technologies in Ohio. The overall goal of this project was to forecast the economic benefits of advanced autonomous aircraft systems and services through the year 2045. There are many challenges associated with developing and applying a forecasting method that accounts for significant uncertainties—uncertainties in services, markets, technology maturity levels, and operating constraints. To obtain meaningful, policy-relevant benefit estimates, ODOT needs forecasts built on realistic assumptions on the nature of AAM products and services, their impacts on Ohio's own supply chain, and the constraints of the regulatory environment in which they operate.

The team followed a multi-step plan designed to deliver benefit estimates that account for technology and regulatory realities, emphasizing interaction among team experts in economics, AAM, and small Unmanned Aircraft Systems (sUAS) programs.

The first stage of the project was to gather industry perspectives on AAM and sUAS modes, technology readiness, and gaps in industry research by conducting a series of interviews and surveys with the most relevant and key stakeholders.

The second stage of the investigation phase required critical infrastructure to be identified, categorized, and mapped using ArcGIS, a geospatial mapping and analysis tool. Over 35 different data layers important to the implementation of AAM were researched, compiled, and loaded into the ArcGIS software to be mapped onto the State of Ohio.

The information obtained through the interviews, coupled with the analytical ArGIS data, was used to develop the potentially most impactful use cases and were fed into the AAM Business Case Model to determine the region's ability to adopt and sustain AAM operations. ArcGIS infrastructure data was paired with over 100 other inputs to produce operating expenses (OpEx) and capital expenditures (CapEx) figures for ground infrastructure, development of infrastructure for Providers of Services for Unmanned Air Vehicles (PSU), total electric vertical takeoff and landing (eVTOL) aircraft expenditures, and operator revenues for passenger, cargo, and emergency medical use cases. Concurrently the sUAS cases were analyzed to forecast and qualify the efficiency, safety, productivity and societal benefits of its services.

Outputs from the AAM Business Case Model were then used as inputs to the AAM Economic Impact Model, calculating the total impact of AAM on the Ohio economy at three levels: the direct level, the indirect level, and the induced level, providing job growth forecasts and GDP estimates, in addition to tax revenues at the state and local levels.

The study produced important findings intended to guide the State of Ohio and its policy deliberations. These findings are supported by in-depth analytics guided by the experience of the senior team members working in the global AAM field.

The State of Ohio is well positioned to grow and sustain profitable AAM operations in urban, suburban, and rural areas over the 25-year forecast period.

- Commercial business activities among all pillars (revenues from operators and aircraft manufacturing, and capital and operational expenditures from providers of services for UAMA (PSU) and ground infrastructure) are expected to approach $13 billion between 2021 and 2045 for six use cases of involving emergency services, passenger services and cargo movement.
- About 66% of the forecasted $13 billion of value-added impact is considered direct and indirect; the remaining 34% from induced impacts
- More than 15,000 direct, indirect, and induced permanent, high-paying, full-time jobs are forecasted. Since the direct and indirect effects of AAM account for roughly two-thirds of the impact, we see that job types, or occupations needed, are closely aligned with the industries tied to AAM.
- More than $2.5 billion in federal, state and local tax revenues is expected over the 25 years of the analysis. Local and state governments revenues account for $464 million and $542 million, respectively, while the federal revenues account for about $1.5 billion. The local level represents totals for townships, cities, and counties for the entire state.
- The overall state-wide infrastructure revenue to investment (R/I) ratio is in the range of 2.2, suggesting that private capital sources will be attracted to make infrastructure investment.

The economic activity due to needed investment for ground and PSU infrastructure is estimated at more than $1.4 billion over the 25-year forecast period.

- Investments in multiports will be needed in the future. Ohio’s efforts with NASA Ames in vertiport planning are critical to better identify the most impactful locations of vertiports in urban environments within Ohio’s largest cities. This work will inform future investments for new vertiports. However, immediate and near-term infrastructure investment will be concentrated in remediating existing heliports, adding airport multiport installations, and establishing logistic corridors PSU systems.
- Current Ohio efforts such as SkyVision, Ohio UTM and Remote Tower provide a strong foundation for investment to low-altitude air traffic management and PSUs systems. These efforts must be physically expanded to other areas, including investments in the PSU systems along the interstate corridors.

In addition, application of sUAS operations, although relative to AAM not bringing significant increase in direct job creation and economic benefit, will provide significant benefits by making more efficient use of resources (i.e., improving productivity), enabling the fidelity of data, increasing social benefits such as workplace safety, and decreasing the environmental impact of other operations. Use of sUAS will also significantly enhance the mission of execution of ODOT and other government entities by improving infrastructure inspection, and workforce operating efficiency and productivity.

The team provides actionable recommendations in four categories:

- Strategy, policy, and legislative framework
- Studies, demonstrations, pilot programs, and local AAM planning initiatives
- National AAM leadership activities
- AAM supply chain, manufacturing and service opportunities for Ohio

Introduction

Driven by the economic and societal promise of advanced air mobility (AAM), the Ohio Unmanned Aircraft Systems Center (UAS Center) operating as part of the DriveOhio initiative of the Ohio Department of Transportation (ODOT) commissioned this economic impact analysis for advanced autonomous aircraft technologies in Ohio. The report, produced by Crown Consulting, Inc. (Crown) in partnership with NEXA Capital Partners, LLC (NEXA) and the University of Cincinnati (UC), forecasts the industrial and economic benefits of AAM systems and services through the year 2045 to inform ODOT's policy decisions.

The Transportation Challenge

The State of Ohio faces both opportunities and challenges with its future transportation systems. Surface congestion is high increasing safety challenges and costing residents and the State time, frustration, and money. Ohio is the seventh most populous state in the country and one of the most centrally located. As such, it has one of the largest highway networks. According to a report by TRIPNET.org[2], the annual statewide cost of congestion of the five major metropolitan areas in Ohio alone is more than $4.6 billion (see Table 1).

Table 1: TRIPNET.org Vehicle Operations, Safety, and Congestion Costs (in $Million) for Selected Ohio Cities

	Vehicle Operations	Safety	Congestion	Total
Cincinnati	$574	$391	$1,057	$2,022
Cleveland-Akron	$873	$306	$1,001	$2,180
Columbus	$557	$352	$997	$1,906
Dayton	$649	$460	$631	$1,740
Toledo	$468	$525	$983	$1,976

Ohio citizens expect increased safety, sustainability, affordability, and efficiency with regards to their transportation needs. At the same time, technological innovations and new business models offer enormous potential for new approaches to passenger and cargo mobility. Bringing urban and regional mobility into the third dimension—the airspace—may support cities to enlarge their smart mobility solutions portfolio by offering multimodal and integrated commuting solutions that are faster, more sustainable, safer, reliable, less stressful, and affordable.

The Potential of AAM

What Is AAM?

AAM is a concept of air transportation that moves people and cargo between places not conveniently served by surface transportation, or underserved by aviation—local, regional, intraregional, urban—using revolutionary new aircraft that are now becoming possible. The vision of AAM relies mostly on eVTOL (electric vertical takeoff and landing) aircraft carrying passenger or cargo, and small unmanned aircraft systems (sUAS). The aircraft are envisioned to be powered by hybrid electric systems, batteries, or, at some point, hydrogen fuel cells.

[2] Modernizing Ohio's Transportation System: Progress and Challenges in Providing Safe, Efficient and Well-Maintained Roads, Highways and Bridges (2018)

AAM is an emerging technology landscape with the potential for robust positive socio-economic impact. It is also a key element in our nation's emerging transportation system as it promises to be more environmentally friendly, more efficient, and more accessible to our entire population (urban and rural). Advances in technologies for high-density energy sources providing electric power enable aircraft to operate more simply, more reliably and more efficiently. Advances in automation enable more robust and high volume operations with reduce pilot requirements. These technological advances combined with advances in materials and reduction in aircraft maintenance, reliability and operation complexity brings more cost efficiency for many short-range aviation missions.

AAM's potential first became evident when sUAS arrived on the market to provide new efficient and safer ways to inspect and monitor infrastructure and agriculture, lead search and rescue efforts, respond to natural disasters and emergencies, and recently to deliver medical tests and products, as well as foods and other goods. In Winston-Salem North Carolina, UPS is already using sUAS to deliver a time-critical pharmaceutical product in minutes across a sprawling hospital campus, vastly speeding up delivery of important medicines. Zipline is racing personal protective equipment to healthcare workers and patients in Charlotte in response to COVID-19, and UPS is delivering blood test samples in minutes across another hospital campus in Raleigh, shaving more than an hour off previous delivery times.

Recent industrial innovations have produced dozens of electric and hybrid-electric powered small aircraft capable of providing services to the public, from medical transport to large cargo movement to air taxi services. These new aircraft provide services that will enhance our lives with on-demand mobility and open the door more widely to affordable access to health care services, especially for rural areas of the country.

Companies are planning to transport critical medical tests and equipment, organ transplants, and even health care professionals to patients and emergency scenes and return accident victims to the hospital quickly, safely, and efficiently. Large package delivery operators such as UPS, FedEx, and Amazon are planning new methods of delivery to and from sort facilities and distribution centers while avoiding surface traffic congestion that often slows down last-mile delivery by hours. Small and regional air service operators are considering newer, more efficient, and faster ways to provide their services, not just between major airports but to outlying rural communities, and at least one large ride-hailing service is developing platform services to enable air taxi services from downtown urban centers to airports and other transportation hubs. Recently Beta Technologies announced a deal with UPS to deliver over 150 aircraft for regional delivery (Figure 1).[3]

Figure 1: Beta Technologies UPS eVTOL

[3] https://evtol.com/news/beta-technologies-ups-deal-150-evtol-aircraft/

This AAM vision will have broad financial implications. According to a recent report for NASA by Booz Allen Hamilton on the potential impact of Urban Air Mobility,[4] "Airport Shuttle and Air Taxi markets are viable markets with a total available market value of $500B at the market entry price points in the best-case unconstrained scenario." A concurrent study for NASA by Crown and McKinsey[5] concluded that AAM is "likely to be a commercially viable market with both parcel delivery and air metro operations by 2030," projecting more than 500 million last-mile parcel deliveries and more than 740 million passenger trips. In addition, analysis performed by companies such as Morgan Stanley[6] and NEXA Advisors/UAM Geomatics[7] forecast a $1.9 trillion market opportunity by 2045.

Issues/Barriers of AAM

As with any great technological leap forward, especially one that will impact the lives of so many people, AAM must overcome numerous barriers before it can be implemented in a community, including:

- Interoperability standards, needed to facilitate and reduce time to market for aircraft manufacturers, fleet operators, and infrastructure and facilities managers, while at the same time imposing extremely high levels of safety for passengers and the communities of operation.
- Adequate capital and venture investment, required for development and commercialization of aircraft, control systems, and operational models. While venture, corporate, or institutional funders are closely watching, investment can only be forthcoming if supported by local business cases with reasonable cash-on-cash returns flowing within sensible timelines.
- Infrastructure investment are necessary to fund systems for urban air mobility traffic management (UTM), and systems for Providers of Services for Unmanned Air Mobility (PSU) that integrate sUAS and AAM eVTOLs into the existing airspace and vertiports (new landing and takeoff facilities) to facilitate cost-efficient and convenient passenger access.
- Sufficient market demand, including commercial, industrial, and consumer customers, where value delivered may significantly exceed cost.
- Public acceptance of these new systems and services, driven by positive perceptions of safety, mobility value, cost effectiveness, and affordability.
- Privacy, environmental impacts such as noise, and in some cases, property rights, which will weigh in this dimension, often at the local level.

During this study, we put special emphasis on the potential impact of noise to the evolution of AAM operations. It is believed that if AAM systems create unacceptable noise pollution in their operational communities, the potential economic benefits could be severely limited. The vision for AAM operations would realize hundreds or thousands of daily operations in populated urban, suburban, and rural environments. These aircraft would take off from vertiports in densely populated urban environments and fly over neighborhoods and communities at altitudes much lower than current commercial aircraft. The noise signature of these aircraft will be unlike any

[4] "Urban Air Mobility Market Study" (https://ntrs.nasa.gov/citations/20190000519)
[5] "Urban Air Mobility Market Study" (https://www.nasa.gov/sites/default/files/atoms/files/uam-market-study-executive-summary-v2.pdf)
[6] https://irei.com/news/morgan-stanley-flying-care-preparing-takeoff/
[7] *Urban Air Mobility: Economics and Global Markets 2020-2040.* www.nexa-uam.com

existing aircraft or helicopter, and the human response to these noise signatures is still unknown, but early research indicates that annoyance levels are still not well understood and may be in some cases higher due to the specific frequencies and tonal nature of the acoustic signatures. Appendix C: Noise and AAM presents in depth our findings and recommendations for the needed next steps to continue to gain understanding of this critical issue.

Ohio and AAM

Ohio is keenly aware that a state that invests now in transforming itself into a center for AAM and sUAS technology adoption will reap first-mover benefits—top talent and wide-ranging investment opportunities—as well as significant benefits for its taxpayers including reduced congestion, increased technology industries and jobs, robust economic activity, and a larger tax base. ODOT intends to apply AAM for the safe, efficient, and equitable transportation of goods and people throughout the state. AAM is a strategic growth area for Ohio's aerospace sector and enterprises within the state have made significant contributions to the research, development, and integration of AAM.

Ohio's vision builds on the state's long legacy in aerospace, embedded in the national consciousness as the birthplace of aviation and the birthplace of the first men to orbit the earth and walk on the moon. The Air Force Research Laboratory (AFRL) at Wright Patterson Air Force Base and NASA's John H. Glenn Research Center (NASA Glenn) are major aerospace research hubs. AFRL's AFWERX program spearheads innovation in AAM through the Air Force Agility Prime program. In addition to these federal laboratories, the state's more than 550 aerospace companies and the numerous vibrant university-based research facilities, offer a rich ecosystem of aviation-related talent. Ohio is the nation's largest aerospace industry supplier, with a workforce of more than 38,000 in the aviation and aerospace private industry. In addition, private and non-profit organizations, such as JobsOhio and the Ohio Federal Research Network (OFRN), support a statewide integrated approach to advancing technology and economic development.

The rapid evolution of the AAM and UAS sectors now brings dozens of new opportunities and initiatives in a to-be-defined industry and workspace to Ohio. As a tool to enable new modes of commerce and trade, Ohio intends to tap the full economic and efficiency benefits of optimally designed and operated lower altitude airspace. In the near future, Ohio will face many decisions, including:

- Prioritizing and phasing projects.
- Encouraging development where technology and implementation gaps exist.
- Investing in technology and infrastructure with viability, scalability and sustainability in mind.
- Deciding what investments have the most impact on critical AAM and UAS supply chains served by Ohio manufactures and suppliers.

To obtain meaningful, policy-relevant benefit estimates, ODOT needs forecasts built on realistic assumptions on the nature of AAM products and services, their impacts on Ohio's own supply chain, and the constraints of the regulatory environment in which they operate. Appendix D highlights several of the state's ongoing AAM and sUAS programs and initiatives.

Study Goals and Objectives

Studying how AAM will integrate into and enhance Ohio's transportation infrastructure is an important goal for ODOT to maintain its lead in aviation and to prepare for this exciting new future of transportation by air.

The goal of this study was to complete an AAM economic impact report for managed air corridors for the State of Ohio connecting Ohio's major urban centers. The team had five objectives:

Objective 1: Forecast economic effects and benefits of AAM for Ohio based on expert opinions.

Objective 2: Guide Ohio in attracting and sustaining AAM operators and businesses.

Objective 3: Predict Critical AAM and sUAS Supply Chains Embedded in Ohio.

Objective 4: Model viable AAM and sUAS use cases.

Objective 5: Understand the industry's perspectives on the evolution of AAM.

The approach undertaken in this effort was designed to consider these questions:

- What is the business and commercial opportunity for AAM and sUAS, and what does it look like from the standpoint of infrastructure costs and manufacturing?
- Does existing infrastructure in Ohio, including airports, heliports, logistics corridors, air traffic management systems, and others, provide a starting point?
- Can AAM and sUAS operators expect to become profitable, and can this profit be sustained over a 25-year period?
- Will these same operators be able to fund and eventually support new infrastructure?
- Will passenger and cargo services built on eVTOL aircraft become affordable and add value such as GDP growth and new jobs to Ohio's economy?
- What kinds of jobs will need to be filled, and will Ohio's system of schools and universities be capable of training them?
- What are the supply chains that will play an essential role in realizing AAM for Ohio, and are they already present in the state?
- Are there going to be meaningful economic and catalytic benefits for urban and rural areas of Ohio?
- What will be required by the taxpayers of the State of Ohio to kickstart and support this new economic sector?

To answer these and other questions, the team developed a multi-track approach to deliver appropriate findings with perspectives and to quantify results whenever possible.

Methodology

Overview of the Approach

As shown in Figure 2, the team followed a multi-step plan designed to deliver benefit estimates that account for technology and regulatory realities, emphasizing interaction among team experts in economics, AAM, and Ohio's UAS programs.

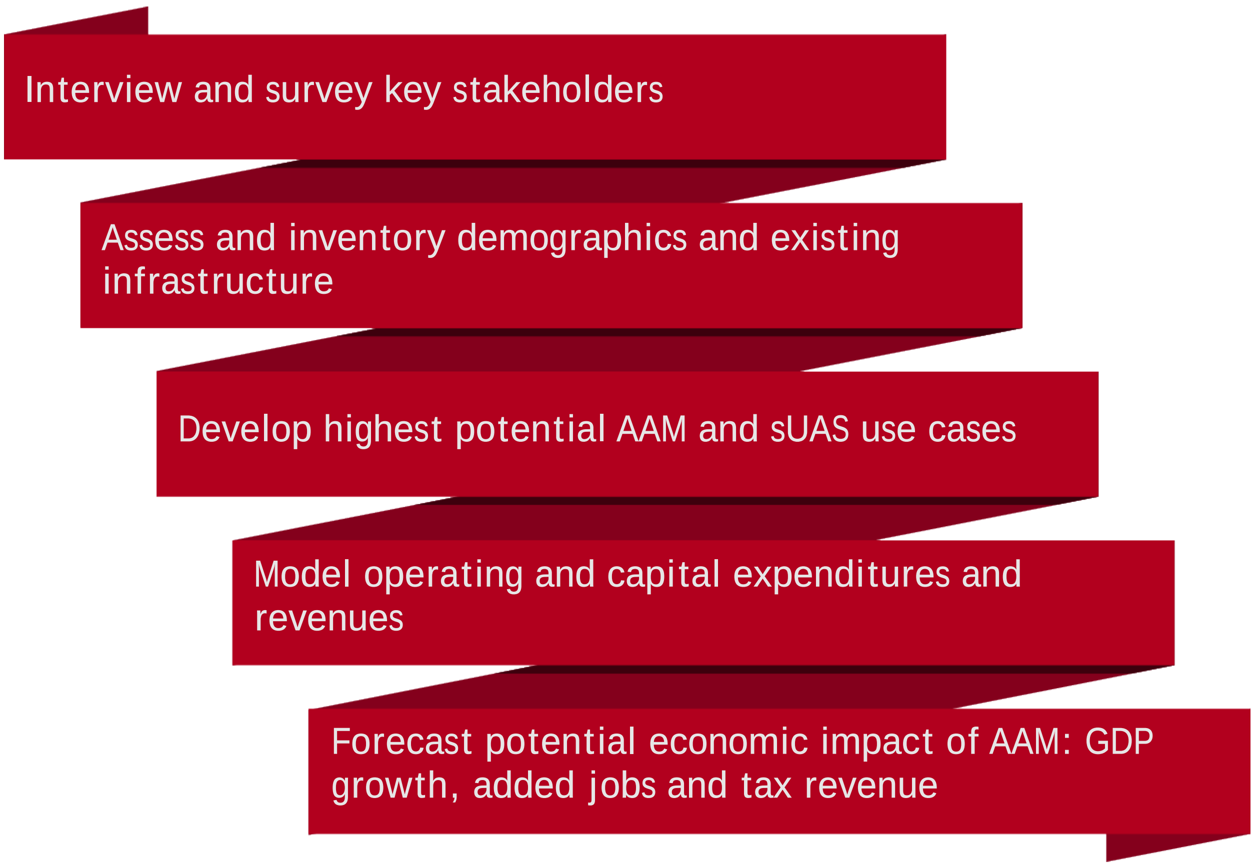

Figure 2: Study Methodology

After ensuring mutual understanding with ODOT on goals and objectives, the team proceeded to bring industry perspectives on AAM and sUAS modes, technology readiness, and gaps in industry research by conducting a series of interviews and surveys with the most relevant stakeholders. Concurrent with the interviews, team members began assessing and inventorying existing transportation infrastructure available throughout the State of Ohio using ArcGIS. This geospatial mapping and physical inventorying tool provided unique capabilities for applying location-based analytics. The team documented over 35 layers of information that will become indispensable when designing and operating new airborne systems within the State of Ohio.

The information obtained through the interviews, coupled with the analytical ArcGIS data, was used to develop the potentially most impactful use cases and were fed into the AAM Business Case Model to determine a region's ability to adopt and sustain AAM operations. ArcGIS infrastructure data was paired with over 100 other inputs, such as PSU systems costs, aircraft supply constraints, and passenger demand curves, producing operating expenses (OpEx), and capital expenditures (CapEx) figures for both PSU and ground infrastructure development, total eVTOL aircraft expenditures, and operator revenues for passenger, cargo, and emergency medical use cases, defined later.

Outputs from the Business Case Model were then used as inputs to the Economic Impact Analysis Model, using the economic assessment tool IMPLAN.[8] IMPLAN calculates the total impact of AAM on the Ohio economy at three levels: the direct level, the indirect level, and the induced level. These calculated impacts provide job growth forecasts and GDP estimates, in addition to tax revenues at the federal, state, and local levels.

Interviews with Key Stakeholders

The first stage of the investigation phase included collecting insight, through interviews or survey questions, from key stakeholders, including industry, government, and academia. AAM and sUAS have the potential to impact a large part of the economic landscape, and interview plans were designed to engage a diverse input to the process. The targeted stakeholders included those with current or potential presence in Ohio.

Based on earlier experience, the importance of in-person interviews was given priority. However, due to time and resource constraints, the team also identified the key stakeholders who could provide the most value during a one-hour interview, with other stakeholders receiving a survey to complete. This resulted in a wealth of information, which helped validate the use-case scenarios and provided reference when reviewing the demand-and-benefit forecasts produced by the team.

The team reached out to 54 potential interviewees, with 29 responding. Although it was not expected that all those contacted would respond, the 50% response rate could be attributed to a variety of factors, including the time of year and challenges faced during the COVID pandemic. Also, some industry partners were unwilling to share their market focus and looked to protect their strategic plans. Nonetheless, the team was able to engage the key stakeholders identified in Table 2.

The survey questions were used during the one-hour interviews conducted virtually, which proved beneficial, allowing more flexibility for the interviewee and a greater interview team participation. The format of the interview included an overview of the project, ODOT's AAM focus, including the broader vision, and an overview of Ohio's initiatives such as SkyVision and the US-33 UTM Research Project. The questionnaire helped guide the conversation, allowing the interviewer to pivot to dynamically respond to the interviewee's answers. In some cases, the interview team had worked with the partner over the years and had an established relationship. In other cases, this was the first time the interviewee was being briefed on AAM work in Ohio, and the initial discussion led to follow-up conversations on how to collaborate with the ODOT team on future opportunities. An added benefit of the stakeholder engagement was the greater national visibility with leading AAM stakeholders.

For those unable to be interviewed by the team, the questionnaires were sent via email to be completed within a specified timeline. This allowed the team to engage a broader group of key stakeholders outside of the interviews.

[8] https://www.implan.com

Table 2: Interview Participants by Categories

Operators	Manu--facturers	UTM/PSU	Airports	Cities	Federal Agencies	Academia	Economic Development
FedEx	Matternet	AirMap	Ohio Airports Association	Columbus	NASA Glenn Research Center	University of Cincinnati	Ohio's 33 Smart Mobility Corridor – Councils of Government
UPS Flight Forward	Moog	ANRA Technologies	Cincinnati/ N.Kentucky International Airport (CVG)			The Ohio State University	JobsOhio
Uber Elevate	Alaka'i	Kitty Hawk	Cincinnati Municipal Lunken Airport (LUK)			Georgia Tech	
Wing	Kelkona		John Glenn Columbus International Airport (CMH)				
Ohio Dept. of Public Safety			Rickenbacker International Airport (LCK)				
City of Columbus Division of Police			Bolton Field (TZR)				
Ohio Department of Transportation			Cleveland Hopkins International Airport (CLE)				
			Akron-Canton Airport (CAK)				
			Lorain County Regional Airport (LPR)				

The team also recognized that engaging key industry stakeholders and asking questions about their future plans would require a level of confidentially, since the team often engaged multiple partners competing against each other in the AAM space. The team drafted a confidentially release form that offered three levels of visibly in the public report. This provided a path for industry to contribute to the study, while not revealing their strategic growth plans publicly.

ArcGIS Methodology (Mapping of Existing Infrastructure)

Concurrent with the interviews, team members began assessing and inventorying existing transportation infrastructure available throughout the State of Ohio using ArcGIS. This geospatial mapping and physical inventorying tool provides unique capabilities for applying location-based analytics. Contextual tools are also able to visualize and analyze geospatial data via maps, datasets, algorithms, and reports. The team documented more than 35 layers of information that will become indispensable when designing and operating new airborne systems within the State of Ohio. These layers, shown in Table 3, were researched, compiled, and loaded into the ArcGIS software to be mapped onto the State of Ohio.

Table 3: Documented Data Layers Loaded into the ArcGIS Software

35+ Data Layers	
Demographic Information Overlay	Colleges and Universities
General Aviation Airports	Water and Shipping Ports
Commercial Airports	Military Bases and Airports
Roadways	Agriculture Zoning
Highways	Laboratories
Waterways	Fire Stations
Political Boundaries	Police Stations
Hospitals	Noise Measurement TIMS
Cargo Rail Stations	Towers/Antennae
Ports	Helipad Confirmation
Part 135 Operator Fleets and Lists	Passenger Rail Stations
Airport O/D, A/D, Fleet, FBO Data	Power Grid
Logistics Centers	Air-Based Cargo Hubs @ Airports
Manufacturing Plants	Major Shopping Centers
Headquarters of Fortune 1000 corporations	Major Music Venues
Major Local Employers	Government Facilities—Federal, Local
Major Sports Venues	MSA Demo Layer
Ohio Bridge Database	

With those layers, the ArcGIS analysis tools provide insight on critical infrastructure within given parameters. For example, we can determine how many helipads are within a city's metropolitan statistical area (MSA) or how many manufacturing and logistics centers are within five miles of Interstate 71. The tool provides myriad analysis options that offer the most accurate inputs for the business case model.

Business Case Model Methodology

AAM Passenger and Emergency Services Methodology

In addition to the geo-coded datasets, the Business Case Model analysis makes use of more than 100 additional sources of information necessary to perform demand and costing analysis, and to aid in estimating capital and operating costs for AAM ground facilities and UTM traffic management facilities, as described in Table 4.

Table 4: Sources of Economic Information

Ancillary Data Useful for Cost and Demand Modeling	UAM Ground Facility Cost Inputs	PSU Facility Cost Inputs	Other Demand Inputs
Population	Urban Planning Study Costs	UATM One Time Facilities Planning	Drivers of Cost of UTM
Population Density	Site Selection Study Costs	Finalization of InterOperability Standards	Passenger Traffic (Pass Per Day)
GDP in million purchasing power parity (PPP)	Environmental Study Costs	Site/Network Selection Studies	Average Vertiport/Heliport Nodes
Median Per Capita Income	Airspace Flight Approach Study	Systems Specifications	Flight Operations (Flights per Day)
Electricity Cost	Concession Agreements	Power Grid Studies	Other TBD
Jet Fuel Cost	Secure Project Financing	NOC Architecture/Interface with ANSP	
Average Taxi Cost Per Mile	Purchase Land/Lease Equivalent	Cyber Security Architecture	eVTOL Avionics – Incremental Capability Costs
Public Transport Cost	Acreage and Cost/Acre (varies by city)	Physical Security Architecture	GPS/DGPS/GNSS
Vehicle Ownership Cost	Construction Permitting Costs	Network Operations Center	Inertial/MEMS
Cost of Living	Architectural and Engineering Costs	Facilities (Offices) Rental Costs	Beacon Navigation System
Average Monthly Net Salary	Site Preparation	SQFT	Data Comm (Enhanced 5G)
2018 Business Arrivals & Departures	Site Construction	Cost/Sq Ft	Voice Comm
Cities in Motion Index Human Capital	Foundation or Building Modification	Annual Rent	Weather Information System (ADS-B In)
Distances from City Center to Largest Airport	Platform(s)	Geographic and Dynamic Geofencing Tools	LIDAR
City Total Area (Sq Mi)	Egress, Elevators, and Walkways	Furnishings	Kalman Filter Modules
Fortune G1000 Companies	Passenger Shelters or Larger Facilities	Big Data Analytics HW/SW	Advanced Display Screens for Passengers
Fortune G1000 Market Size	Parking	Automation Systems and Stations	
Fortune G1000 Employees	Lighting - General	Flight Decision Support Tools	Helicopter Fleet Operators (Part 135)
Airport Passenger Origins & Departures	Lighting - Landing Pad/Taxiways	Flight Plan and Flight Operations Database	Operator Type
Part 135 (or equivalent) Operators	Landing and CNS Systems	SCADA for Systems and Networks	Operator Name
Company Profile	IT and Security Systems	Computers and Equipment	Operator Fleets
Company Contact Info	Furnishings	Power Grid and Backup Systems	Aircraft Manufacturer
Personnel Profile with Contact Information	Power Grid Upgrades	Field Networks	Aircraft Model

Ancillary Data Useful for Cost and Demand Modeling	UAM Ground Facility Cost Inputs	PSU Facility Cost Inputs	Other Demand Inputs
Commercial Aviation Aircraft Fleet	Inspections	Network Design and Site Selection Studies	Aircraft Variant
Manufacturer	FAA Permitting and Certification	Weather Information Systems - Areal	Aircraft Full Name
Model Variant	Refueling Capability and Systems	Micro Weather Detection Sensors	Related Engine Model
In Service or Stored	Recharging Capability and Systems	Beacon Navigation Nodes	Aircraft InService
On Order	Fire Suppression Systems	Resilient Communications Nodes	Aircraft Stored
Grand Total	Airspace Approach Templates	High Density Radar	Aircraft OnOrder
Leased In	Aeronautical Chart Preparation	Annual UATM Operations Costs	Aircraft Average Age
Leased Out	Total CAPEX	Headcount	Owner Info
Average Age	Annual Operating Costs	Director/Managers	Name
Engine Type/Variant	Labor - Operations	ATC Specialists	Phone
	Labor - Facility Maintenance	Data Analytics Specialists	Fax
	IT and Security	Maintenance and IT Technicians	Email
	Power and Utility Services	Field Support Personnel	Website
	Other	Administrative Personnel	Year Founded
	Total OPEX	Other Professional Personnel	Business Types
	UATM Cost Inputs	Total Headcount	Total Employed
		Annual Salary ($'000)	Military Supplier
		Director/Managers	Small Business
		ATC Specialists	Disadvantaged Business
		Data Analytics Specialists	Helicopter Related
		Maintenance and IT Technicians	Space Related
		Field Support Personnel	FAA Repair Station
		Administrative Personnel	ISO9000
		Other Personnel	Sales Dollars
		Labor - Operations	Sales Euros
		ANSP Servicing Fees	Sales Pounds
		Annual Rent	Sales Yen
		Facility Overheads	Cage Codes
		Geofencing Services	
		Legal and Accounting	
		Telecom, IT, and Security	
		Power	
		Other	

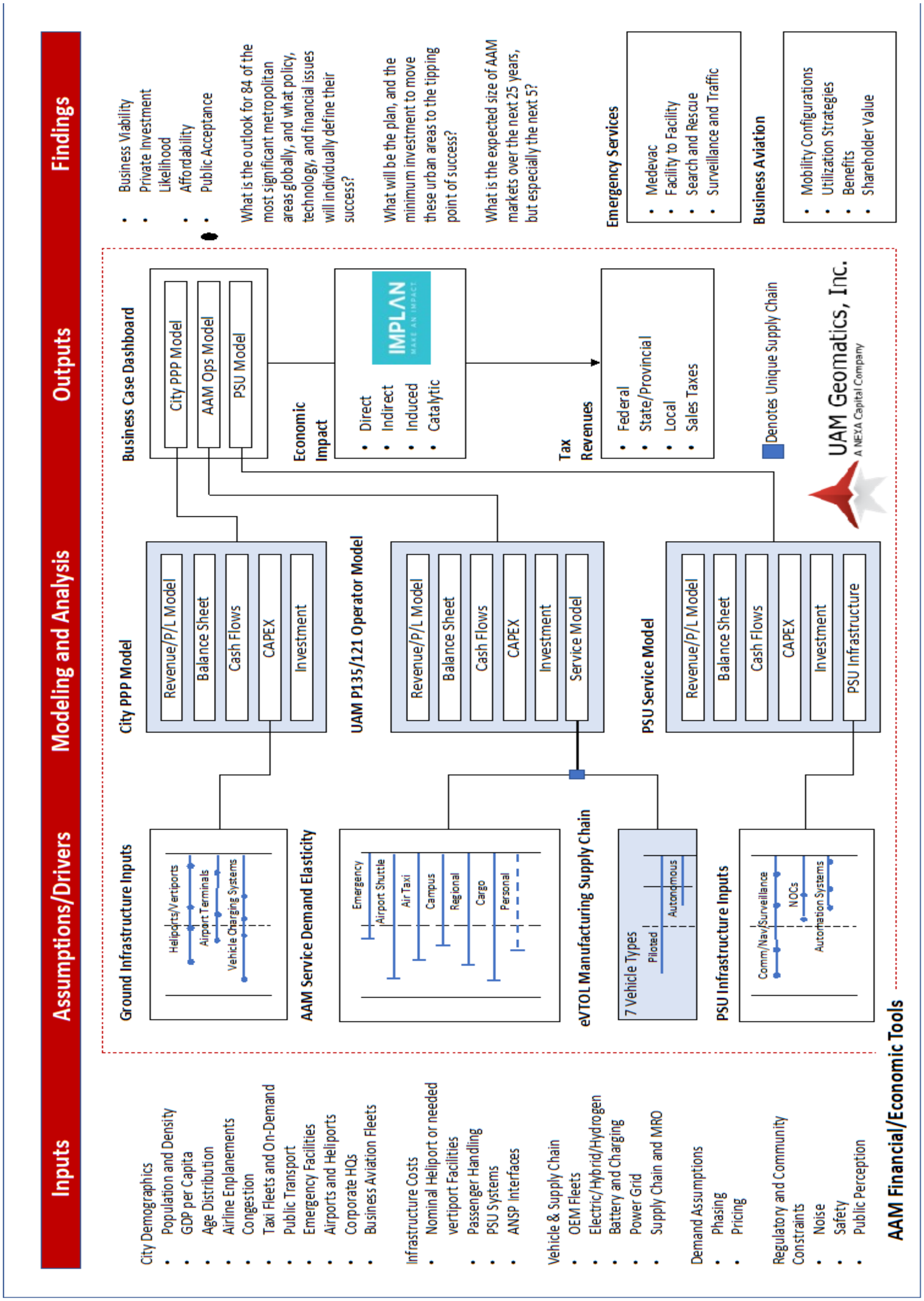

Figure 3: Study Analytical Framework

Team members bring experience forecasting the emerging trends and global market opportunities in AAM aircraft, systems, services, and infrastructure to explore new concepts in AAM products and services, and develop future revenue and market forecasts. The toolset also uses econometric forecasting to determine the size, composition, and probity of the market impacts by country and urban area. The analytical framework for the study is presented in Figure 3.

Key to this analysis tool is the three business case models in the center of the diagram. The tool accepts assumptions used for input drivers of each model:

- Aircraft Operators: Airport shuttle, on-demand air taxi, regional transport, corporate campus to destination, medical/emergency services, and cargo.
- Public/Private/Partnership model for AAM ground infrastructure.
- Public/Private/Partnership model for PSU infrastructure.

By modelling these three classes of stakeholders, we were able to ensure profitability on all fronts. The costs of these three entities are all accounted for when calculating ticket price. This allows for reasonable return horizons on the infrastructure, as well as profitability in the case of the operators. We posited the following investment thesis: for a city market, or in the case of Ohio, a region, to reach sustainable AAM revenue activities, operators and infrastructure investors must achieve profitability break-even success or, as a better outcome, a profitable bottom line.

Passenger demand is one of the most important inputs for the model, and for this forecast, the study team carefully developed supply and demand assumptions based upon a dynamic range of elastic and inelastic ticket prices.

There are, however, some fundamental questions that cannot be answered through financial and economic analysis. For example:

- Will Ohioans embrace these new services, finding sufficient value from improved AAM, thereby offsetting ticket prices?
- Will an extensive network operation involving dozens of aircraft flying above residential areas, generating noise and visibly daunting, find acceptance?

Key Assumptions and Findings on AAM Ground Infrastructure

In our report's 25-year forecasts, the team used the following macro assumptions while estimating the cost and schedule for AAM ground infrastructure:

- A large percentage of existing public, private, and unregistered heliports are first remediated to provide a baseline to support early eVTOL services before expansive new construction is undertaken.
- Certain numbers of heliports and vertiports are built or retrofitted to provide hybrid aircraft refueling, electric charging or fuel cell charging on a city-by-city basis. The estimated costs of such charging facilities or services are rolled into the ground infrastructure costs.
- All airports within a given city's economic catch basin, whether commercial air transport or general aviation/business aviation, will receive investment in vertiport facilities and AAM traffic management services to permit safe passenger handling and eVTOL traffic volume.

Regional Analysis

To understand the dynamic needs of Ohio on a statewide basis, the methodology needed to be adapted. To accomplish this goal, the traditional MSA areas used as inputs in the models were expanded to include the state in its entirety. The counties that had not been captured by the traditional MSA breakdown were the more rural counties in the state. They were then grouped with one of the existing MSA groups. This was informed by the economic development regions from JobsOhio. These new composited statistical areas (or CSA) were formed based on economic interdependencies between the rural counties and their paired metropolitan area. Figure 4 shows the grouping.

Figure 4: Map of Selected Regions by County

Importance of Business Case Tool for Infrastructure Financing

AAM ground infrastructure to support eVTOL operations will become a key prerequisite and enabler to sector success. As with other forms of transportation, AAM has specific infrastructure needs, which will also drive economic development and business investment. Research has shown that this is even more significant in global economies where economic opportunities have been increasingly related to the mobility of people, goods, and information. This is related to the quantity and quality of transport infrastructure in urban areas and the level of development needed. High-density transport infrastructure and highly connected networks are commonly associated with increased levels of economic growth, market development, and GDP output. AAM will have the most economic impact in the second decade of our forecasts.

While heliports and vertiports could have multiple landing zones with elaborate passenger handling features, most do not. The basic elements of a heliport are clear approach and departure paths, a clear area for ground maneuvers, final approach and takeoff area (FATO), touchdown and liftoff area (TLOF), safety area, and a wind cone. Figure 5 shows a typical heliport layout. This minimal facility may be adequate as a private-use-prior-permission-required (PPR) heliport and may even suffice as the initial phase in the development of a public use heliport capable of serving the emerging AAM segment of the helicopter and eVTOL community. The planning and organization required to properly design and construct new facilities is not trivial, involving the physical, technical, and public interest matters in the planning and establishment of a vertiport. For example, one of key differentiators of eVTOL ports is the flexibility provided by allowing for taxing, in addition to the vertical takeoff. For our work in Ohio, AAM infrastructure costs have been estimated for a viable ecosystem to be able to sustain itself on a city-by-city basis, using data collected from many industry experts. We estimate, for each of metropolitan areas, the entire life-cycle costs for sustainable operations. Beginning with the estimate that a single heliport platform can be remediated from an existing state to one focusing on passenger convenience at a cost of under $1 million, other cost elements include passenger facilities, lighting systems, airspace planning, and certification costs, all of which are included in our analysis.

Figure 5: Notional heliport

PSU infrastructure-related costs, including automation platforms capable of urban eVTOL air traffic management, as well as resilient wireless communications systems, augmentation of GPS through navigation beacons, and weather-related sensors, form an additive infrastructure category treated separately. AAM can provide a wide swath of benefits covering consumers and businesses, and supply chains dependent upon logistics. We identified the requirements and costs for densely placed heliports and vertiports in urban areas, as well as those suburban, exurban areas, and airports that will benefit from improved linkages within and between nodes. Importantly, airport elements will be identified at commercial, business, and general aviation airports, and at seaports and rail merge points. Ohio will also see a need to build out PSU infrastructure along its five main logistics corridors. These routes will see a high demand for time-sensitive cargo to be flown to many destinations between cities.

Cargo and Freight Delivery Methodology

In addition to the business case analysis for traditional AAM passenger use cases, a statewide heavy cargo and freight delivery eVTOL market analysis is presented. To determine the revenue potential of Ohio's eVTOL cargo market, we obtained existing air freight and trucking data from the Bureau of Transportation Statistic's Freight Analysis Framework 4 tool. The FAF4 tool provides both historical and projected freight movement data for the United States, categorized by commodity.

Both air freight and truck freight projections were used as inputs for the eVTOL cargo market model. These initial inputs were distilled to the eVTOL cargo market potential by three different filters, based on our stated assumptions: eVTOLs will transport cargo that is: 1) time Sensitive, 2) within payload capacity, and 3) high value.

First, the inputs were sorted by commodity codes and filtered by only time-sensitive commodities. Of the initial Standard Classification of Transported Good (SCTG) codes, the commodity categories relevant to eVTOL operations were Precision Instruments, Electronics, Machinery, Pharmaceuticals, and Perishables.

Next, the subcomponents of each of the five commodity categories stated above were assigned to a weight class. Commodities that were over 1,000 lbs. or under 50 lbs. were not considered. Each weight class corresponded to a market share percentage for each SCTG Code subcomponent. These percentages based on weight class were applied to Ohio's freight projections to further sort for the eVTOL cargo market potential.

Finally, subcomponents were filtered by value classes. We assumed that eVTOL cargo operations would cater to high value, given the cost of eVTOL use compared to traditional freight modes. SCTG Code subcomponents were assigned a value class and a corresponding market share percentage that was applied to the inputs.

After sorting by time-sensitive and high-value goods between 50-1,000 lbs., we arrived at the eVTOL cargo market potential. To understand what share of this total market potential cargo eVTOL operators could capture, we applied five different exogenous factor constraints over the 25-year period to reach a conservative estimate of the annual eVTOL cargo market share. This market share was then distributed among five Ohio logistics corridors based on current and projected freight flow percentages along those routes. The five logistic corridors were defined around four interstate highways (I-70, I-71, I-75 and I-80) and the U.S. Highway 33. Figure 6 is an ArcGIS representation of the five Ohio corridors, showing the many distribution centers across the state.

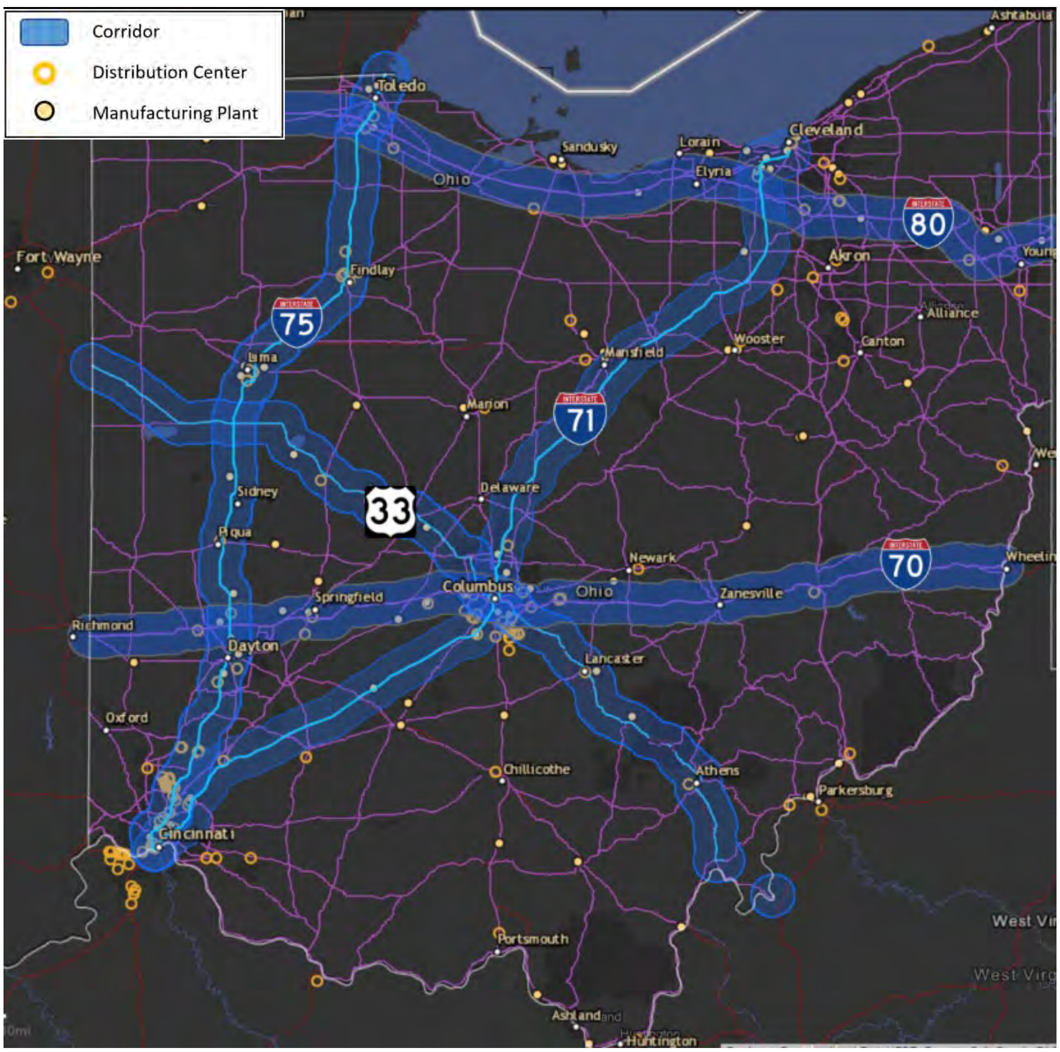

Figure 6: Ohio Logistics Corridors

Economic Impact Tool Methodology (Implan Methodology)

To undertake a 25-year economic impact assessment of AAM for the State of Ohio, the team used the IMPLAN input/output modeling tool in combination with a previously developed 84-city business case analysis model featuring six Ohio cities: Akron, Cincinnati, Cleveland, Columbus, Dayton, and Toledo. The combination depicts the most accurate possible impact assessment of the benefits AAM will deliver to Ohio. These results will help mobilize Ohio's resources to act on the AAM opportunity and seize a first-mover advantage in a $1.9 trillion market meant to improve safety, mobility, and economic growth.

In economics, an input/output model is a quantitative methodology that represents the inter-dependencies between different branches of a national economy or of regional economies. The IMPLAN input/output model depicts inter-industry relationships, showing how output from one industrial sector may become an input to another industrial sector. In the inter-industry matrix, column entries typically represent inputs to an industrial sector, while row entries represent outputs from a given sector. This format shows how dependent each sector is on every other sector, both as a customer of outputs from other sectors and as a supplier of inputs. This inter-industry relationship is expressed in the form of industry coefficients, or multipliers, that depict the rate of change of output among a set of interdependent industries, from a one unit increase in output by one industry.

IMPLAN's defines Output Multiplier as describing the total output generated as a result of one dollar of output in the target Industry. Thus, if an output multiplier is 2.25, that means that for every dollar of production in this Industry, $2.25 of activity is generated in the local economy—the original dollar and an additional $1.25.

Econometric and input-output models contain assumptions; after all, if every variable were known, we would have a list of facts and not a forecast. The most important assumption derived from our business forecast for Ohio includes the insertion of an "inflection point"—the introduction of highly automated flight systems requiring less human intervention. For example, an emerging view of AAM over the next 25 years is that cockpit automation will be necessary to improve the integrity and thus the safety of this new market sector. Automation should eliminate pilot error, enforce sense-and-avoid rules, and safely separate all aircraft, including eVTOLs and sUAS. Automation will reduce the cost of operations, as well as the demand for human operators. The cost structure of the entire industry will be dramatically impacted in synchronization with the expansion of aircraft and airspace capacity. The economic impact assessment in this report accounts for the inflection point, as will be reflected in the economic charts examined later. This is done through the input phase, whereby the model factors in automation and its impact on the overall AAM business case.

IMPLAN's input-output model also comes with certain assumptions and limitations. The first is the constant returns to scale: the same quantity of inputs is necessary to produce the additional unit of output. So, if outputs increase 10%, so too will the inputs. Second, it assumes no supply constraints: there are no restrictions to materials or labor, which may otherwise affect production capacities and prices. Third, the input structure is fixed: it will always require the same number and type of inputs to produce a certain output. Fourth, industries use the same technology to produce each of its products. Fifth, industry by-product coefficients are constant. This means that "an industry will always produce the same mix of commodities regardless of the level of production. In other words, an industry will not increase the output of one product without proportionately increasing the output of all its other products."[9] Finally, it is important to note that IMPLAN as a modelling tool only reports impacts using the latest data year available, which is 2019. Data fed into IMPLAN works off 2019 regional figures (e.g., 2019's total output for Ohio is applied at every phase, despite expected growth year-over-year), and does not forecast economic indicators beyond it.

Understanding IMPLAN Impacts

Economic impact analyses (EIAs) assess the impact of an "exogenous shock"—new economic activity that stimulates growth—exploring its impact on a number of indicators such as GDP, job creation, and tax revenues. Some of these indicators will be further evaluated at three levels of analysis: direct, indirect, and induced effect. Direct effects calculate the economic value that a business or industry generates by its own means through direct hiring of its own employees, revenue generation from sales, and the portion of its business activity that contributes to regional output. Direct effects include the initial change in expenditures by consumers and producers—the exogenous shock—producing the first round of economic activity in the form of new output, jobs, and revenues. Indirect effects gauge the economic impact that results from demand created by the direct impact. Products and services are bought to support this new activity (i.e., supply chain companies). Finally, there is the induced effect, which measures the economic impact on the broader economy resulting from demand created by employees of the new activity (direct component) and its supporting businesses (indirect component). IMPLAN defines the induced impact as follows: "the values stemming from household spending of Labor Income, after removal of taxes, savings, and commuter income. The induced effects are generated by the spending of the employees within the business' supply chain."[10]

In this instance, the direct effect of a $12.9 billion AAM multi-industry exogenous shock (direct impact) to the State of Ohio over 25 years will produce a number of direct AAM jobs, revenues, and expenditures that will further produce inter-industry demand (indirect impact). Additionally, the induced impact will capture unrelated excess economic activity (e.g., consumer spending in the general economy from increased income provided by AAM). Based on the EIA numbers, we go one step further in identifying AAM's catalytic effects for the state. Growth in AAM will improve labor market efficiencies and suburban/rural access, accelerate STEM education and funding, and boost investment in alternative energy for the AAM sector. These effects are discussed later as an extension to the EIA.

[9] https://blog.implan.com/implan-io-analysis-assumptions#:~:text=It%20assumes%20that%20an%20industry,of%20each%20of%20the%20products.

[10] https://blog.implan.com/understanding-implan-effects

Analysis Results

AAM Passenger and Cargo Carrying Use Cases

Working collaboratively with ODOT, the team finalized a series of use cases that presented the most potential for positive economic impact. For this, the team capitalized on our understanding of technology readiness, as well as the phasing of operations, and brought the input from interviewed stakeholders.

We explored various use cases for people movement, covering on-demand air taxi, air metro, medical evacuations (Medevac), organ delivery, corporate campus and business aviation, regional passenger transport, and personal aircraft. Cargo delivery considered last-mile, short-haul, medium, and long-haul, including medical services, freight transfer from airports to distribution hubs, neighborhood food delivery, and urban-to-rural delivery. Our ongoing analyses of these use cases provided insights into their feasibility and timing. Table 5 summarizes the final definitions of the key people and cargo movement use cases used during this economic impact analysis.

Table 5: AAM Use Case Definitions

Use Case	High-Level Definition
On-Demand Air Taxi	Defined as transportation in a city and the city's metro region, has the potential to radically improve urban mobility. This mode of operation will alleviate the substantial time lost in daily commutes or getting from one location to another.
Regional Air Mobility	Regularly scheduled or on-demand transportation between cities, over 50–75-mile distances. Numerous studies find that going by air using AAM for short inter-regional trips (city center to city center, or city center to rural proximity) rather than inter-city, makes time-saving sense.
Airport Shuttle	Scheduled or on-demand transportation between major and regional airport and city center or suburbs 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 and Medical Air Ambulance	Robust medical services transportation system, including emergency medical evacuations, hospital-to-hospital patient and equipment transportation, organ delivery, and search-and-rescue operations.
Corporate/Business 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 and Freight Delivery	Transportation of heavy cargo and freight from or between airports, distribution centers, and manufacturers and to end consumers. Logistics corridors and distribution operators providing freight and cargo to regional industries can provide value by prioritizing high value materials with rapid delivery using eVTOLs.

sUAS Use Cases

sUAS, as defined by the Federal Aviation Administration (FAA) under Part 107, are autonomous aircraft weighing less than 55 pounds, including payload. Their small size enables them to fly within constricted areas, and Part 107 restricts operations to less than 400 feet without a waiver. When fitted with sensors, sUAS provide enhanced capabilities for inspections, monitoring, surveillance and mapping. Some package delivery sUAS can be used for delivery methods for smaller payloads, including medical supplies.

The assessment of the potential for each use case is informed not only by the team's own experience with sUAS and interviews conducted for this project, but also on a national and global scale based on an industry-leading forecast by the Teal Group. While sUAS span a variety of applications, they share an important similarity that differs markedly from the passenger AAM use cases: relative to AAM they are not expected to generate a large number of new jobs nor to provide large additional revenue streams for the State of Ohio. In fact, even though sUAS are likely to provide potential cost savings in some use cases, that is rarely the primary driver for businesses and government to adopt sUAS technology. Rather, all the non-passenger sUAS use cases will provide significant benefits by making more efficient use of resources. Appendix C: Discussion of sUAS Operations is dedicated to an in-depth analysis of the potential market of sUAS in Ohio. Table 6 summarizes the use cases studied under this effort with acknowledgement that there are many other direct and indirect utilization of sUAS.

Table 6: sUAS Use Case Definitions

Use Case	High-Level Definition
Infrastructure Inspection – Bridges, Tunnels, Highways	Regularly scheduled visual inspection for cracks, corrosion, other deterioration. Bridge and some tunnel inspections currently performed by snooper bucket trucks, mostly involving lane closures. sUAS will supplement existing methods.
Infrastructure Inspection - Airport	Visual inspection of runway conditions, wildlife incursion control, lightning strikes damage, building inspection, and security perimeter monitoring
Infrastructure Inspection – Powerlines, Towers, Pipelines	Regularly scheduled and ad hoc visual inspection of assets. Allows up close inspection of towers for structural faults and pipeline inspections including leak monitoring
Law Enforcement and Public Safety	Applications, including accident investigation, event and crowd monitoring, prison and other secure facility protection, search and rescue, and fire prevention
Agriculture and Livestock	For agriculture, includes monitoring crop health, seeding, and spraying. For livestock management, includes herd location, health monitoring, and pasture monitoring
Package Delivery	Smaller packages and cargo or freight. Includes delivery of various items within facilities and to consumers, including last-mile e-commerce and restaurant
Medical Non-Passenger Transport	Includes services such as organ and device transport, isotope delivery, vaccine delivery, blood transport, and lab specimen transport

Supply Chains

It will take four supply chains to build a commercially viable AAM ecosystem. Supply chains have an end-product producer or Original Equipment Manufacturer shown as the Tier 0. Below the OEM are tiers of producers of systems, components and parts – show here in red and blue - that flow up through the supply chain to provide that finished product. Figure 7 summarizes these four critical supply chains, with further elaboration in the sub-sections below.

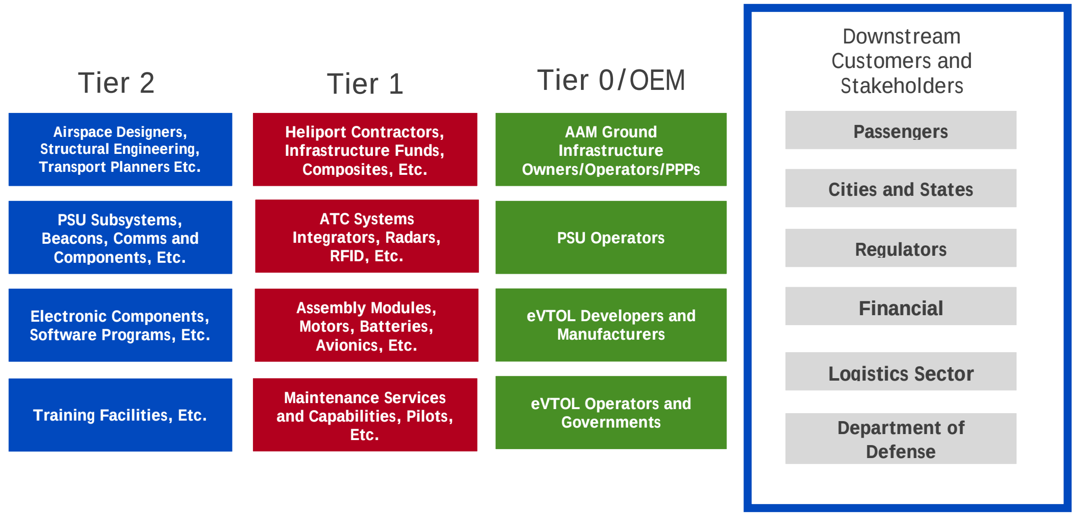

Figure 7: Four AAM Supply Chains

Supply Chain 1 – AAM Ground Infrastructure: Building Vertiports and Multiports

AAM ground infrastructure is needed to provide landing facilities. The world is well populated with heliports; however, fewer than half are in locations convenient for AAM applications. Ground infrastructure will require expansion into network configurations, with each node or vertiport carefully located and built to ensure passenger convenience and value. It will be easiest to create vertiports by remodeling existing heliports. This existing infrastructure can be updated for eVTOL aircraft by adding battery recharging stations and fuel stations for hybrid aircraft, as well as perimeter security, shelters, and other amenities. The region's power grid becomes an essential factor in determining vertiport locations.

Globally, many cities have heliports that are rarely or no longer used. It is likely that some of the unused or underutilized heliports, particularly those near hospitals, may be renovated to receive the new aircraft.

However, at some point in the future, eVTOL aircraft will land and take off from multiports. These large, specially designed transportation hubs will be able to service several aircraft at once and may offer passenger amenities such as food, restrooms, and shopping.

Integrating an eVTOL aviation network with the existing system of public transportation modes requires detailed planning and analysis. While the technology is available to upgrade heliports to vertiports and establishing multiports, there are still no agreed-upon standards. These regulations may be dependent on the types of aircraft selected, their footprint and weight, and their electric or hydrogen charging requirements.

While certain aspects of vertiports remain to be determined, it is safe to say that the development of infrastructure to support an eVTOL network has significant cost advantages over heavy-infrastructure approaches such as roads, light rail lines, bridges, and tunnels.

Supply Chain 2 – PSU: Managing the Air Traffic Flow

An air traffic management system ensures the safe and efficient movement of aircraft. Airplanes and helicopters are guided through the airspace by air traffic controllers. sUAS and eVTOL passenger and cargo aircraft must also be safely and efficiently managed. It is likely that the first passenger use cases will rely on the FAA's existing system of air traffic controllers: those eVTOL aircraft replacing and/or complementing existing aircraft operations.

It is unlikely, however, that the many new uses and new routes of eVTOLs—both passenger aircraft and sUAS—will rely on the traditional system of air traffic controllers for traffic management when volumes become challenging. The addition of hundreds more aircraft movements a day in Ohio alone will put too great a strain on the system. AAM will need its own air traffic management system working in conjunction with the current system. There are various concepts of how the airspace could be managed.

AAM must, within a few years, become economically viable to investors, as well as pay recurring costs such as equipment maintenance and upgrades, and employee salaries, and maintain public safety and convenience.

Supply Chain 3 - eVTOL Aircraft Manufacturers

Several eVTOL prototypes around the world are either in advanced stages of development or operational trials. Designs vary widely in terms of numbers of passengers, number of rotors, and operational capabilities. Even those developers furthest along have not released all details about their aircraft, but the expectation is that they will be lighter, quieter, and more flexible than helicopters. Emergency service eVTOLs, for instance, will be able to land safely in a smaller area, a great benefit when emergency rescue personnel need to reach a critically injured person on a congested road.

Several of these eVTOL aircraft currently in development are also designed to be piloted, at least initially. The next two decades will see increasing use of automation and autonomy performing many functions traditionally performed by humans. Increased automation offers the opportunity to reduce workload and enhance safety for critical aviation functions.

Supply Chain 4 - Operators of eVTOLs and sUAS

Current operators of helicopters are today's vanguard for eVTOL services. Helicopter companies have excellent longstanding safety records, trained pilots, weather dispatching expertise, and systems, quality, and safety programs. They are also familiar with the regulations, terrain, and locations of the heliports and airports in the region. However, there are many new potential players that will represent enormous opportunities.

sUAS operators can be independent individuals, small companies, and large players such as Amazon, FedEx, and DHL. Their missions are diversified and range from healthcare (isotope delivery, vaccine delivery, COVID test kits, blood transport) to package delivery, agricultural purposes, bridge inspection, and other useful applications.

ArcGIS Analysis Outputs

The statewide infrastructure mapping effort provided the inputs for the AAM Business Case Model. Ohio is already well positioned for the implementation of AAM, as there are more than 270 helipads and 500 runways within the state.

Cargo eVTOL operations will benefit from the 112 manufacturing centers and 138 logistics centers across the state, allowing eVTOL operations to swiftly integrate into existing freight transportation modes. With more than 1,100 fire departments and 171 hospitals, Ohio will have a high demand for eVTOL medical use cases, such as medevacs and patient transfers.

All the 35+ layers included in the ArcGIS data sets helped to determine a specific city's ability to adopt and implement AAM. These metrics were used as inputs in the Business Case Model to calculate a city's demand for eVTOL services over the 25-year period.

Figure 8 provides a graphic representation of the many layers of ArcGIS data information available during our analysis.

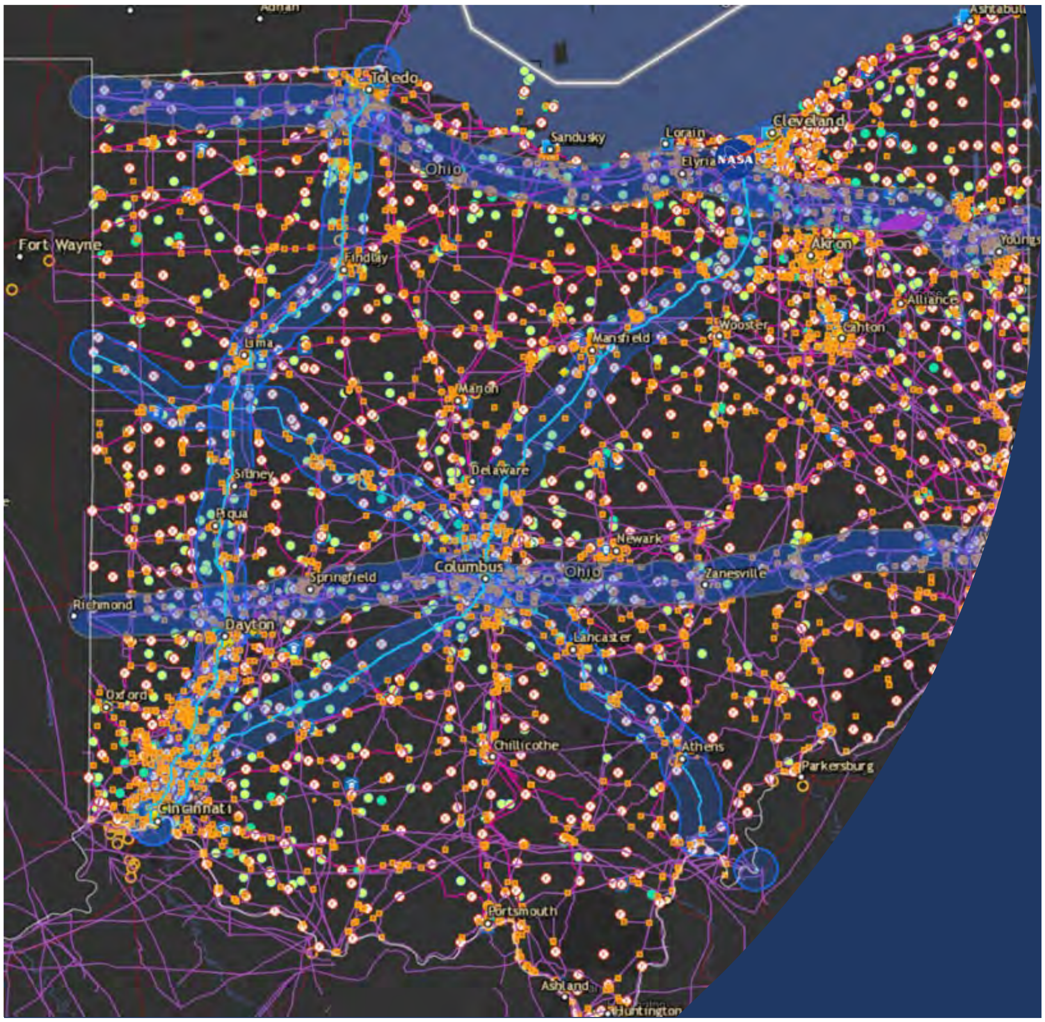

Figure 8: Layers of ArcGIS Data Available During Analysis

The state was analyzed within six regions, or CSA, based on the major cities and five logistic corridors. Figure 9 shows the ArcGIS visualization of the six CSAs showing the layers of hospitals, blood banks, fire departments and universities, among others. Previously, in Figure 6, the logistic corridors were shown.

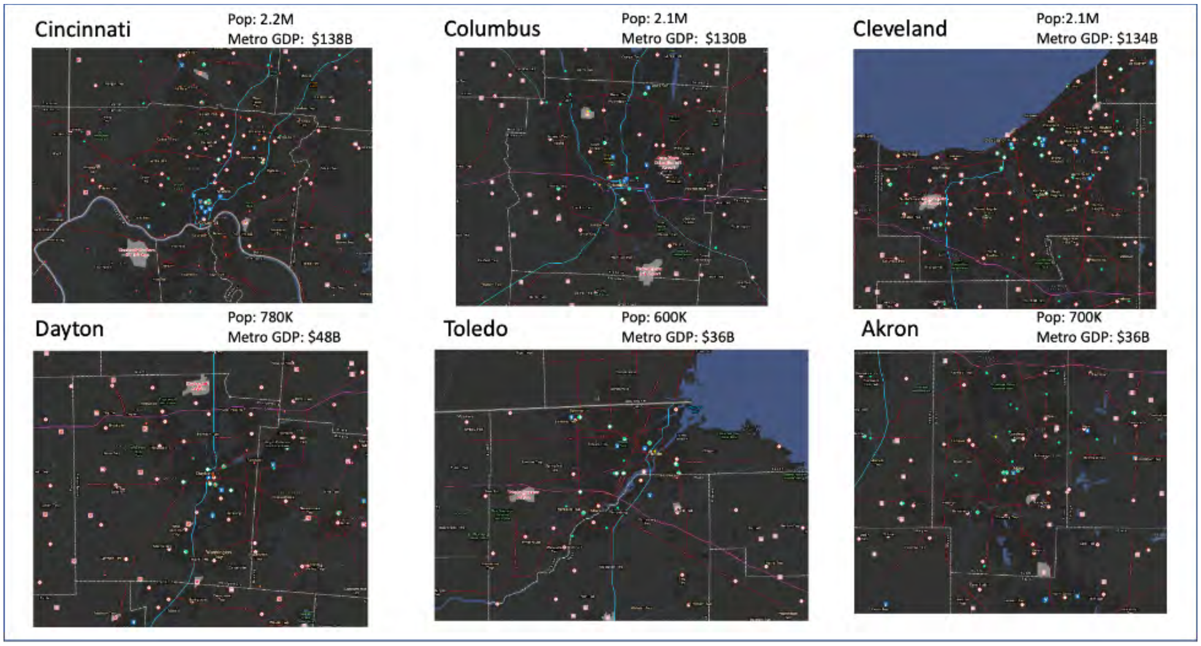

Figure 9: ArcGIS Visualization of Six Combined Statistical Areas (CSA)

Business Case Tool Output

Use Case Outputs for Six Major Cities

Table 7 shows the extensive analysis provided by the financial and economic tools used in the AAM Business Case Tool. The results are comprehensive including all the CSAs for all the use cases defined in Table 5 and the logistic corridors defined in Figure 6. The results are presented in five-year increments, referred also as the phases 1 to 5, for a total of 25-year revenue and capital investment estimates for Ohio. These financial estimates fall into three categories:

- CAPEX: Those capital expenditures funds used to acquire, upgrade, and maintain physical assets such as property, plants, buildings, and specialized facilities, technology, or equipment.
- OPEX: Costs that a business incurs through normal business operations. Operating expenses include rent, equipment, inventory costs, marketing, payroll, insurance, step costs, and funds allocated for research and development.
- Aircraft: Fleet acquisition and maintenance costs to acquire and operate sufficient eVTOL aircraft to sustain the use cases identified.

As ground infrastructure is built over the 25-year period, CAPEX costs decline and OPEX costs increase to run and maintain the new pieces of AAM infrastructure. PSU expenses are primarily focused in the earlier phases, with additional costs incurred in the later years to expand networks for larger operations.

Table 7: Economic Activity by Operators, PSU, Ground infrastructure, and Aircraft

	Year	2020-2024	2025-2029	2030-2034	2035-2040	2041-2045	SUM	Pillar Totals
Ground Infra-structure	OPEX	$30,378,227	$78,781,611	$142,434,815	$213,474,139	$272,555,871	$737,624,663	$1,060,532,154
	CAPEX	$80,365,680	$74,474,160	$118,745,280	$15,065,280	$34,255,080	$322,905,480	
PSU	OPEX	$4,897,999	$7,299,488	$33,766,518	$106,097,559	$109,654,734	$261,716,297	$464,669,827
	CAPEX	$23,614,110	$69,155,607	$35,421,164	$40,481,331	$34,281,319	$202,953,530	
AAM Operators	Passenger Revenues	$52,371,092	$350,161,775	$623,322,304	$1,363,453,265	$2,220,513,798	$4,609,822,234	$9,177,228,119
	Emergency Services Revenues	$52,510,693	$271,881,831	$500,063,439	$750,816,715	$879,786,522	$2,455,059,199	
	Cargo Revenues	$75,998,775	$197,417,439	$348,616,702	$670,269,311	$820,044,458	$2,112,346,685	
Vehicles	Vehicle Purchases	$85,800,000	$356,920,000	$436,828,750	$707,691,125	$694,598,839	$2,281,838,714	$2,281,838,714
Ohio Grand Total		$405,936,575	$1,406,091,910	$2,239,198,973	$3,867,348,725	$5,065,690,620	$12,984,266,803	$12,984,268,814

Due to the regulatory hurdles of AAM passenger operations, using eVTOLS for emergency services and medical air ambulance operations will be one of the first use cases to begin generating revenue. While annual passenger counts are low, emergency services "ticket" costs, or cost per use, are very high, producing high revenues in the early years. Cargo operations are also likely to occur before passenger use cases such as on-demand air taxis as a service of cargo using eVTOLs will improve just-in-time deliveries for manufacturers, including timely on-demand delivery, reducing warehouse costs and keeping inventory low.

Passenger revenues in Table 7 include the total for the four passenger use cases: on-demand air taxi, business aviation, airport shuttle, and regional air mobility. Figure 10 further represents the total 25-year revenues of passenger and emergency services by CSA.

Regulatory hurdles present challenges for operators in the early phases, but once those are overcome and aircraft supply can meet demand, passenger AAM revenues take off.

These statewide figures prove AAM to be a profitable business over the 25-year period, which is crucial to the development of initial infrastructure that could be funded by government initiatives, private sector investments or a combination though public private partnership models. It is concluded that with a profitable long-term business model, investors can safely provide funding for AAM development knowing they will receive their returns in the future.

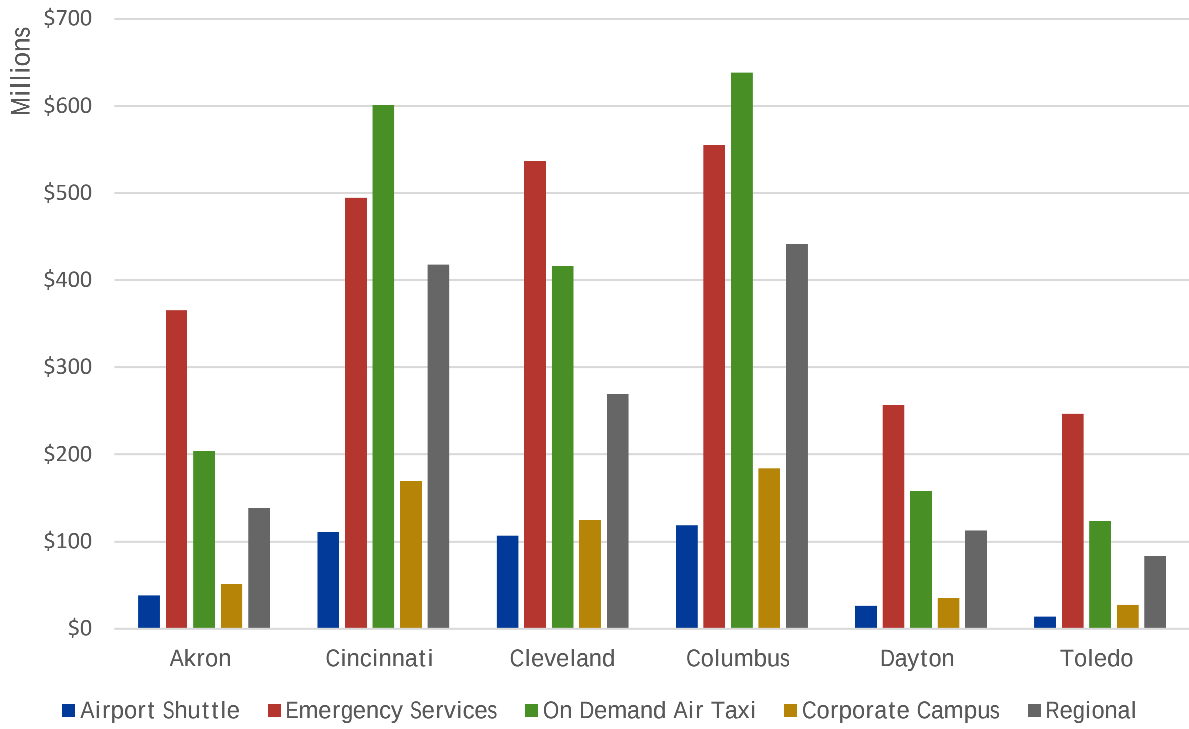

Figure 10: Ohio CSA Revenue by Market Type

The state will continue to see passenger demand grow as infrastructure is built to accommodate the increased demand. Figure 11 shows annual passenger traffic growth by CSA over the 25-year period. It is estimated that by the year 2045, the AAM demand will be over 7.2 million passenger per year.

Table 8 provides details on each CSA's ability to adopt AAM and the associated costs (excluding cargo revenues).

Due to their similar cost and demographic characteristics, Cincinnati, Cleveland, and Columbus all have similar volume of yearly passengers. Components such as population, cost of living, cost of construction, and GDP affect the Business Case Tool's outputs, and these three cities have very similar inputs. Accordingly, their CAPEX and OPEX numbers for both ground infrastructure and PSU are closely related, accommodating a similar demand curve in each city and the included counties in the CSA. Smaller CSAs such as Akron, Dayton, and Toledo forecast fewer annual passengers and operator revenues, but they are still financially viable options for operators and investors to pursue.

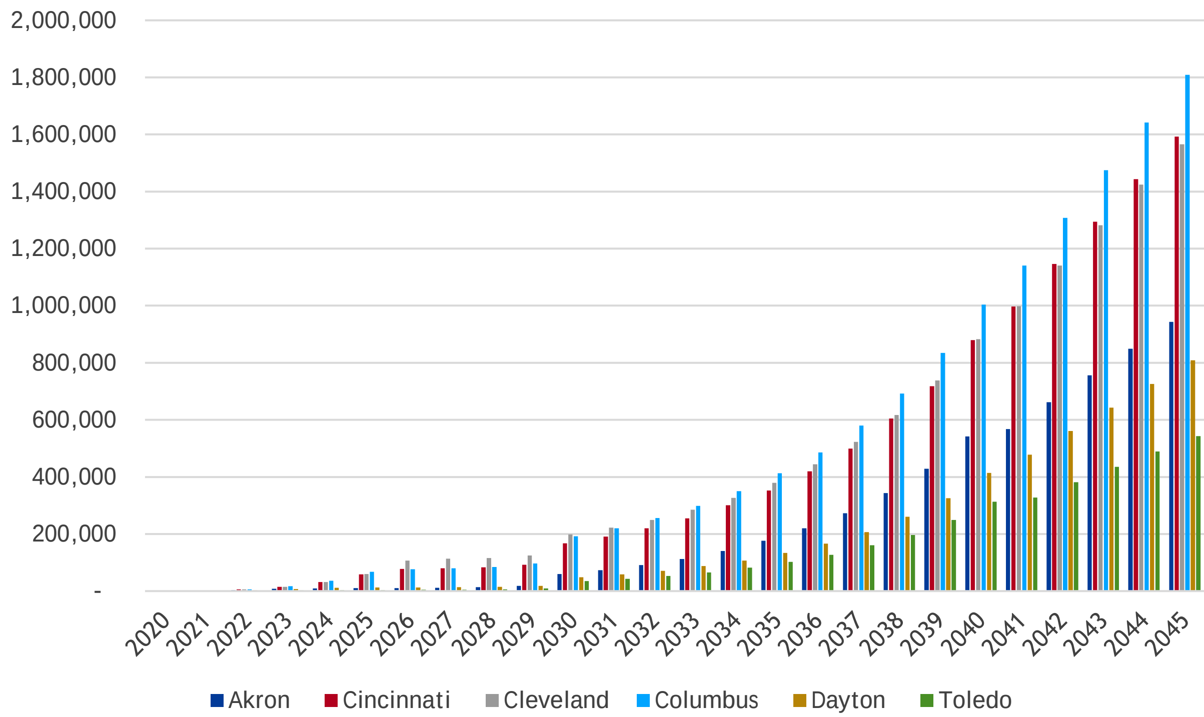

Figure 11: Estimated Passenger Traffic by Year by CSA

Table 8: Market Value and Forecasted Demand by City (excluding cargo)

City	Projected Verti-ports	Total Yearly Passengers (2040)	Total Passenger Operator Revenues	Total Ground Infra CAPEX	Total Ground Infra OPEX	PSU CAPEX	PSU OPEX	Total PSU Costs	Total Passenger Vehicle Costs
Akron	14	943,597	$799,099,084	$59,746,800	$135,540,656	$29,270,861	$33,609,690	$62,880,550	$254,828,084
Cincinnati	16	1,592,298	$1,770,277,399	$64,711,680	$148,228,363	$42,427,070	$53,798,495	$96,225,565	$306,772,056
Cleveland	16	1,565,761	$1,481,763,386	$64,711,680	$148,228,363	$40,987,909	$52,298,167	$93,286,077	$306,772,056
Columbus	22	1,809,336	$1,932,905,244	$70,759,080	$159,988,020	$48,534,143	$60,191,314	$108,725,457	$375,132,111
Dayton	9	808,225	$591,180,802	$55,932,840	$128,872,598	$23,041,994	$32,701,945	$55,743,938	$206,782,308
Toledo	4	1,171,842	$489,655,519	$7,043,400	$16,766,664	$18,691,553	$29,116,687	$47,808,240	$218,253,750
Total	**81**	**7,891,059**	**$7,064,881,434**	**$322,905,480**	**$737,624,663**	**$202,953,530**	**$261,716,297**	**$ 464,669,827**	**$1,668,540,366**

Each city and the surrounding CSA will also have its own vertiport buildout timeline, breaking out the required infrastructure in each phase of AAM operations over the period. In the earlier phases the majority of the investment will concentrate in remediating current helipad and heliport to accommodate eVTOL operations. As the adoption of AAM continues new vertipads both with and without co-located services will be needed as well as integration of eVTOL capabilities to existing airports. Figure 12 shows the total number of vertiports by type of investment and by phases. Figure 13 shows the total number of vertiports needed by phases for each of the CSA.

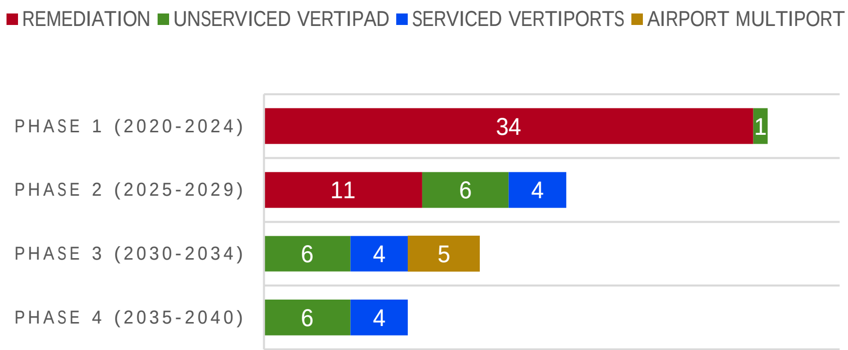

Figure 12: Number of Vertiports by Type

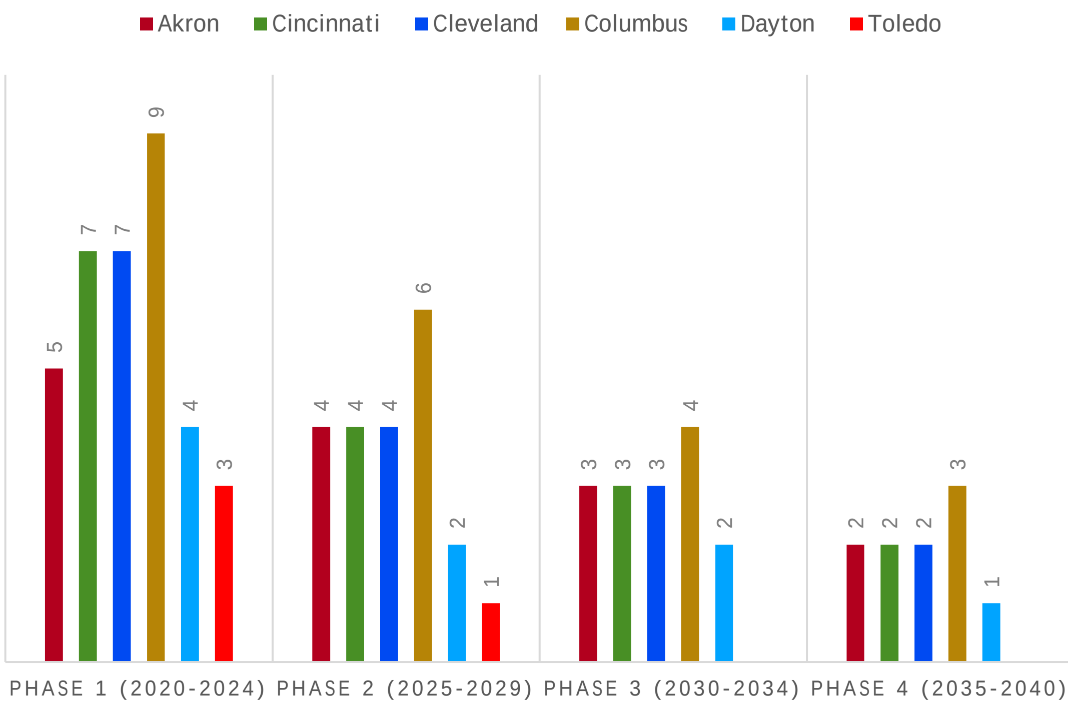

Figure 13: Vertiports by CSA and Phase

Cargo Along Corridors

The analysis shows that the total eVTOL cargo market share over the 25-year period would move more than 1.2 million tons of commodities valued at more than $5.5 billion. Revenues over the 25-year period total more than $2.1 billion, growing from $76 million in Phase 1 to $820 million in Phase 5.

Our analysis shows that a majority of eVTOL cargo flows will follow the I-71 corridor, as this corridor connects Ohio's three largest cities: Cincinnati, Cleveland, and Columbus. In Phase 5, the I-71 corridor will see more than $325 million in revenue during that five-year period. Over the entire 25-year period, I-80 increases its share of the eVTOL cargo market. Connecting Cleveland to Toledo and eventually Chicago, we anticipate increased interstate freight operations as cargo eVTOL technology advances, allowing for more revenue along the I-80 corridor in the later phases. Figure 14 shows estimated cargo revenues by corridor.

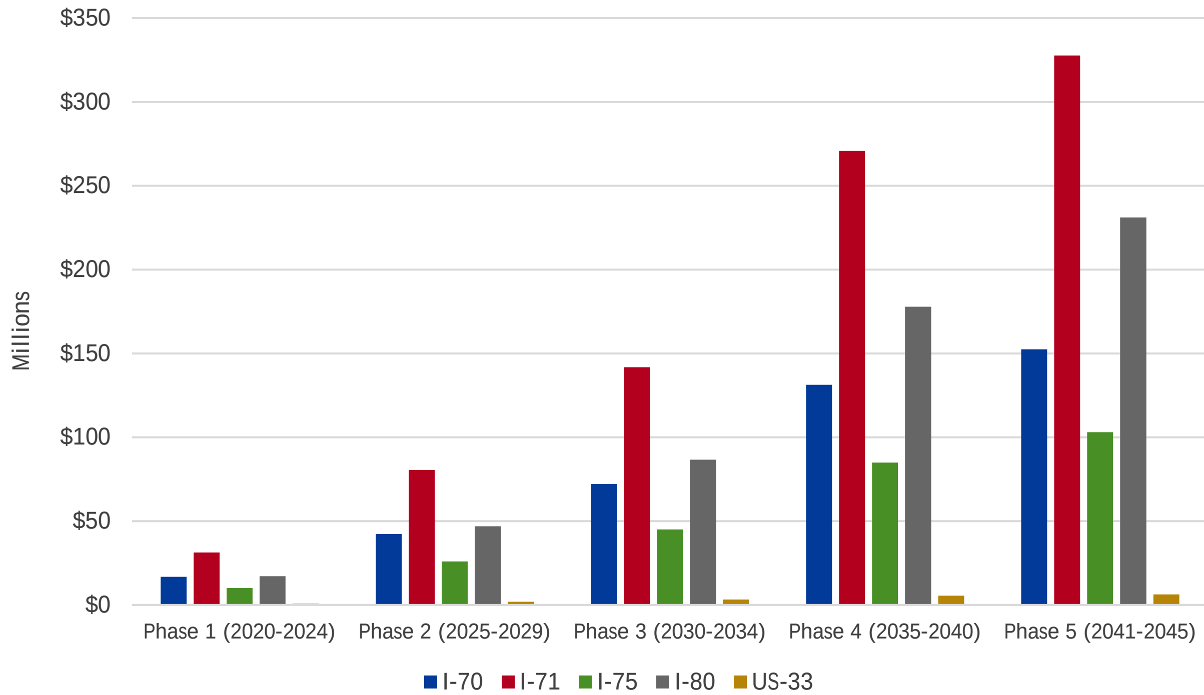

Figure 14: Cargo Revenues by Corridor

Economic Impact Analysis

IMPLAN and Results

The IMPLAN input/output model was the model of choice in studying AAM for Ohio. IMPLAN is a recognized modeling tool used to study impacts on all sectors and at all levels of an economy. Some relevant examples include a 2014 technical report on the impact of airports on Ohio's economy[11] and a 2019 study on the economic impact of NASA's Glenn Research Center, published by Cleveland State University.[12] IMPLAN was also used last year to assess the national and state economic impact of NASA's Moon to Mars Program.[13]

As mentioned before, in this study, the team analyzed the business case for CSA around six cities across the state, with each city comprising their MSA and proxy counties. Together, the six CSA capture every county in the state, allowing distribution of the outputs for the state as whole. As a result, the IMPLAN industry multipliers used in this scenario are state averages, with total impact represented at the state level.

[11] CDM Smith, "OHIO AIRPORTS ECONOMIC IMPACT STUDY," October 2014
[12] Iryna V. Lendel, Ph.D., Jinhee yun, Courtney Whitman, CSU Maxine Goodman Levine College of Urban Affairs, "The NASA Glenn Research Center: An Economic Impact Study Fiscal Year 2019," June 2020
[13] ASRC Federal Analytical Services, "National Aeronautics and Space Administration & Moon to Mars Program," August 2020

In combining the business case totals, the team produced consolidated operational expenses (OPEX), capital expenses (CAPEX), and revenues along the four supply chains discussed previously, with OPEX and CAPEX for ground infrastructure, PSU, and aircraft, in addition to revenue for the operators. These totals, or economic outputs, have been forecasted for each phase of AAM's development in Ohio until 2045. The flow of the analysis is represented in Figure 15.

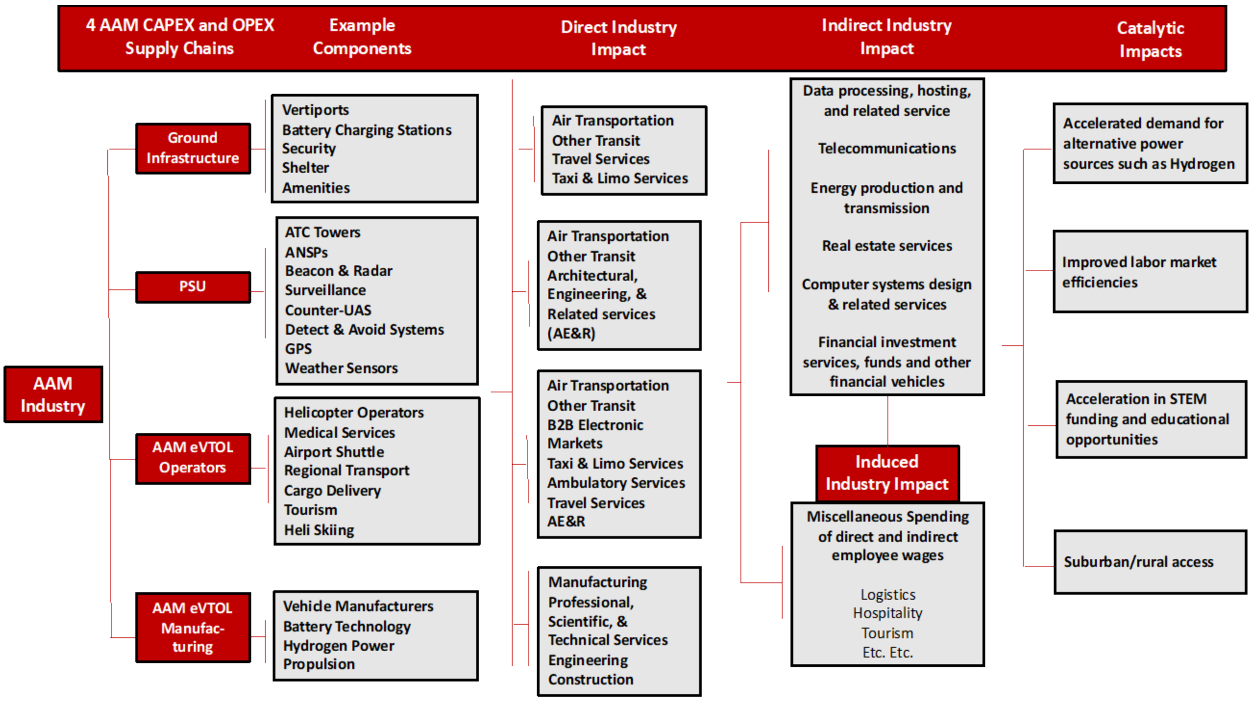

Figure 15: Economic Impact Analysis Flow Diagram

The OPEX and revenue outputs were then apportioned to seven inter-linked industries defined by the National American Industry Classification System (NAICS), a "standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy."[14] These industries were analyzed for best fit as it pertains to the infrastructure and businesses necessary to support and maintain AAM operations. These are:

1) air transportation,

2) other transit and ground passenger transportation and scenic and sightseeing transportation and "support activities for transportation,"

3) taxi and limousine services,

4) architectural, engineering, and related services,

5) travel arrangement and reservation services,

6) miscellaneous ambulatory services, and

[14] https://www.census.gov/naics/

7) business-to-business electronic markets, and agents and brokers.

The CAPEX outputs were apportioned in similar fashion to the OPEX, using the same method and classification system, except in this case distributing along NAICS-classified commodities. The distribution for CAPEX was more complex and included 17 distinct commodity types determined to be necessary for AAM operations. Examples of these commodities include electric motors and generators, computers, computer peripherals and parts, and navigational and guidance instruments, among many others.

All of these OPEX industry and CAPEX commodity types are assigned a portion of the value produced by the four supply chains in the business case analysis, for each phase of development. These values are inputted into IMPLAN, applying the industry coefficients embedded in the system to produce economic impact values specific to industry and region (Ohio). Impacts of interest include GDP growth, jobs, and tax revenue.

Economic Impact: GDP

GDP, or gross domestic product, is defined as the total value of all domestic final goods and services produced within a specified period (typically a year). It is also known as value added, which according to IMPLAN, is defined as the difference between total output and the total value of intermediate inputs throughout an economy during a specified period. It is the total output minus intermediate inputs (see Figure 16).[15]. In the case of AAM, total output over 25 years calculated using the business case analysis model, is $12.9 billion. IMPLAN calculated the value added of this output at $11.4 billion (see Figure 17 for details). $4.6 billion is attributed to the direct impact; $2.9 billion is attributed to the indirect impact, and $3.8 billion is attributed to the induced impact. Together, this total represents a GDP increase of 1.63% for the State of Ohio, measured against the state’s 2019 GDP of $702 billion. Note that the contribution of the direct impact to GDP is 40% of the total. Indirect and induce make up the remaining 60%.

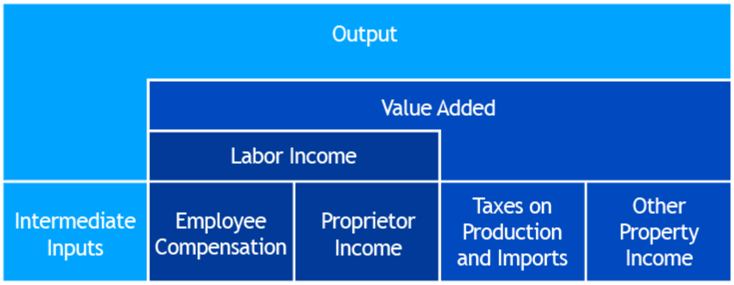

Figure 16: Representation of GDP

[15] https://implanhelp.zendesk.com/hc/en-us/articles/360017144753-Understanding-Value-Added-VA-

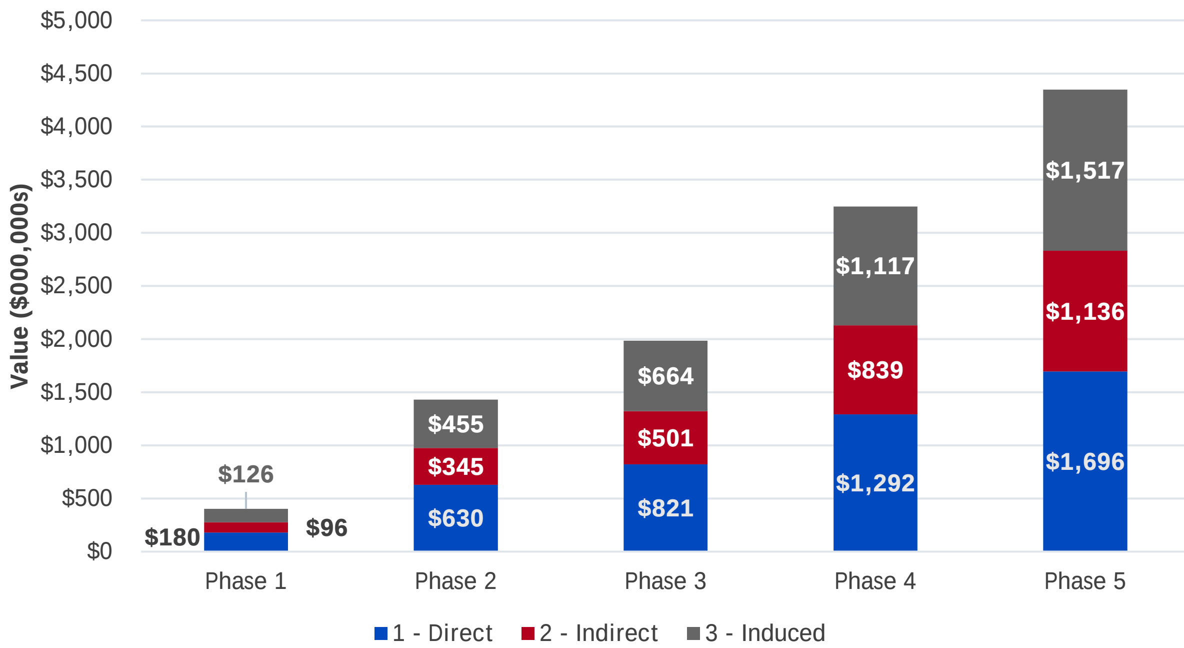

Figure 17: AAM Contribution to Ohio GDP

Economic Impact: Jobs and Occupation

Jobs were calculated first in terms of employment, which IMPLAN defines as including both part-time and full-time annual employment.[16] In this study, employment was derived from the total output produced by AAM at the direct, indirect, and induced levels. Since the employment count does not differentiate between type of employee, a conversion to full-time equivalent (FTE) is necessary to capture a tangible estimate of the labor count. IMPLAN provided a conversion sheet to identify the corresponding FTE count.

The jobs captured in the impact come in three tranches: the direct, indirect, and induced. The jobs gained directly from AAM, the jobs gained indirectly by the supply-chain industries supporting AAM, and the subsequent jobs gained from induced spending in all sectors of the economy. Together, they represent the total impact on jobs for the State of Ohio.

The job numbers in Figure 18 reflect cumulative jobs gained year over year. As the value of AAM increases every year, so does the labor required to support it. This means that by 2030, the value of AAM at the direct, indirect, and induced levels will require roughly 5,000 jobs to support it. In 2045, that number reaches just above 15,000. Note that this job forecast does not account for jobs that could be replaced by AAM jobs.

[16] https://implanhelp.zendesk.com/hc/en-us/articles/115009510967-Employment-Data-Details

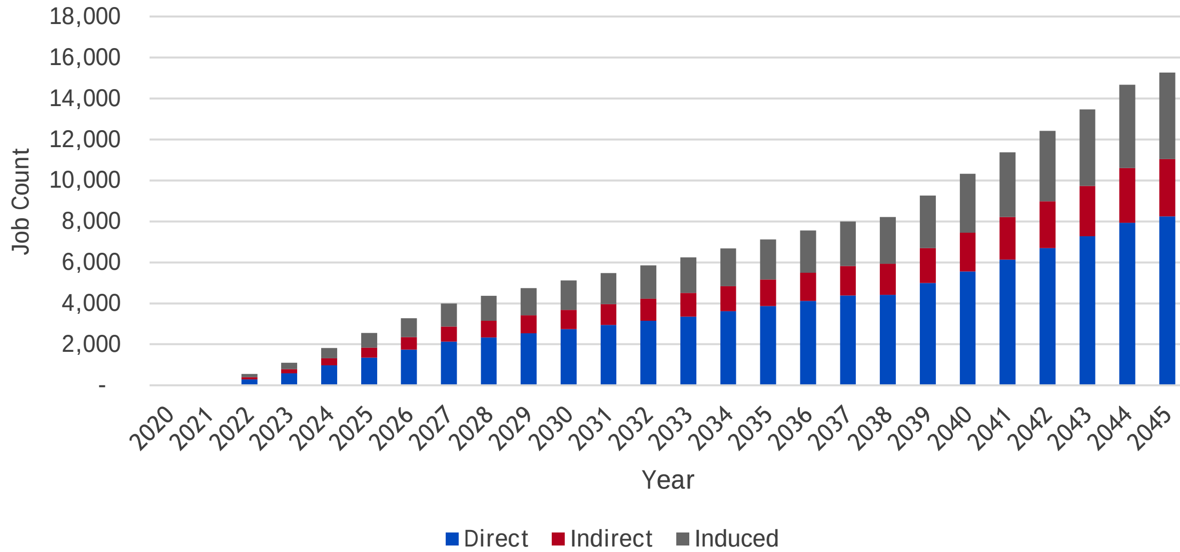

Figure 18: Cumulative Permanent Jobs 2021-2045

Since the direct and indirect effects of AAM account for roughly two-thirds of the impact, we see that job types, or occupations, closely align with the industries tied to AAM. Some of these occupations are reflected in the U.S. Bureau of Labor Statistics' Standard Occupational Classification system, such as business and financial operations. Other categories, like engineering and intelligence transportation systems, reflect an evolving technology sector that more accurately describes the type of jobs AAM will create. The top 10 occupation categories are listed in Table 9, in no particular order, with example occupations that were produced in IMPLAN.

Table 9: Top 10 Occupation Growth Categories

Engineering, Intelligent Transportation Systems	Quality Control and Safety Engineering
Architectural and Civil Drafters	Aircraft Mechanics and Service Technicians
Computer and Information Research Scientists	Software Developers and Software Quality Assurance Analysts and Testers
Computer Hardware Engineers	Computer Systems Analysts
AAM Operations	**Medical and Supporting Services**
Pilots (includes emergency)	Paramedics
Cargo Pilots	Emergency Dispatchers
Air Traffic Controllers	Registered Nurses
AAM Operational Support	**Travel Support Services**
Laborers and Freight, Stock, and Material Movers	Travel Agents
Security Guards	Tour and Travel Guides
First-Line Supervisors of Transportation	Reservation and Transportation Agents
Vehicle Design and Manufacturing	**Hospitality**
eVTOL Mechanics and Electric Engine Specialists	Waiters and Waitresses
Electrical Engineers	Cooks, Restaurant
Airline Pilots, Copilots, and Flight Engineers	Food Preparation Workers
Business and Financial Operations	**All Other**
Retail Salespersons	Clergy
Accountants and Auditors	Animal Caretakers
Financial Managers	Teachers

Economic Impact: Taxes

IMPLAN captured tax revenues at the local, state, and federal level. The local level represents totals for townships, cities, and counties for the entire state. Increased government revenues generally translate into additional government expenditures, which offers the state more investment opportunity into state infrastructure, economic and social programs, and so forth. Figure 19 depicts these revenues at the local, state, and federal levels over each phase of growth. These figures are additive, with total revenue of $2.5 billion gained over 25 years. The local and state governments account for $464 million and $542 million in revenue, respectively, totaling approximately $1 billion. Federal revenues account for about $1.5 billion.

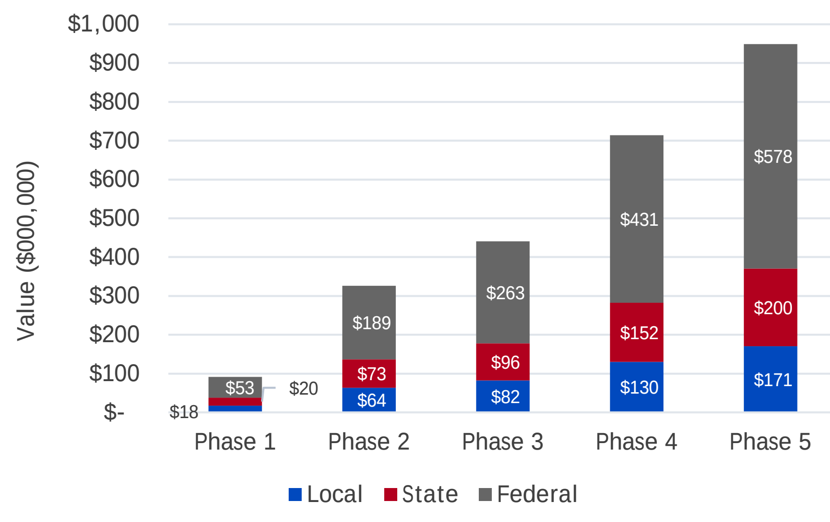

Figure 19: Total Tax Revenues by Level Over Each Phase of Growth

sUAS Forecast Analysis

As mentioned before, the assessment of the potential impact of the use of sUAS is informed not only by the team's own experience and interviews conducted for this project, but also on a national and global scale based on an industry-leading forecast by the Teal Group. While the team assessed a wide span of applications, they share an important similarity that differs markedly from the passenger AAM use cases: relative to AAM they are not expected to generate a large number of new jobs nor to provide significant additional revenue streams for the State of Ohio. Rather, all the non-passenger sUAS use cases will provide significant benefits by making more efficient use of resources while improving productivity, enabling higher fidelity of data, increasing social benefits such as workplace safety, and diminishing environmental impact.

How the non-passenger use cases, all of which demonstrate significant catalytic benefits, translate into precise numbers of sUAS in Ohio skies depends on a number of factors unique to each use case and unique to Ohio. For public use cases, budgets will be a large driver. For private entities, underlying economic conditions will play an enormous role in their ability to increase the utilization of sUAS. Meanwhile, package and medical delivery are only in nascent stages and will remain there until a robust beyond visual line of sight (BVLOS) operating environment is possible and safety and reliability challenges of small package delivery is addressed. Package delivery itself is highly exposed to consumer demand.

Therefore, a 25-year outlook invariably means that there will be a host of economic swings, potentially with one or more recessions, that are not predictable to a level that provides a meaningful picture of the sUAS fleet by use case over the entire period. Nevertheless, some broad, shorter-range analysis combined with an understanding of Ohio's role in the U.S. economy can provide some guidance on how each use case could affect the overall development of AAM and sUAS in Ohio.

The Teal Group Forecast estimates total UAS fleets by year through 2029 by use case for the United States and the world. While it is the most thorough year-by-year assessment of future UAS fleets, it does not break out small and large UAS (with overlapping definitions between prosumer UAS of under 55 pounds and several other small UAS categories). Furthermore, their growth assumptions by use case in some cases seem too optimistic, without detailed evaluation of the projected life cycle of sUAS and how this, combined with annual production, would affect the overall fleet. Nevertheless, the Teal Group forecast does provide a meaningful baseline for understanding the potential size of each use case market in the United States. Table 10 shows Teal Group's Forecast by use case for 2020 (the baseline) and 2029.

Removing the largest category, general photography/real estate, which already has a large installed base, cumulative annual growth to 2029 would be 26.8%. In general, this approach seems reasonable, but there is the possibility that industrial applications are too high and will depend on economic conditions over the course of this decade. Meanwhile, delivery is working from a small installed base, and the numbers for 2029 are perhaps the most difficult to estimate because the robustness of the BVLOS regime at that point in time will dictate fleet size. Most industry observers believe that the bulk of delivery sUAS growth will occur in the early 2030s.

An examination of current sUAS fleets shows that Ohio has 37,746 registered UAS (as of November 2020). This stands for 2.8% of the national fleet. Commercial UAS (which are reflected in Table 10 for Teal) represent 33.8% of all UAS, according to FAA estimates. Thus, Ohio is currently estimated to have 12,773 commercial service sUAS. This number could be substantially higher or lower depending on the size of industry, agriculture, and public service applications occurring in the state.

Table 10: Teal Group Forecast Summary – U.S. sUAS Units

Teal Group Forecast Summary – sUAS Units United States			
	2020	**2029**	**9-year CAGR**
US Government/Civil	1,638	11,066	23.6%
Industrial Applications	Construction		
Construction	11,000	108,500	29.0%
Energy	9,500	63,050	23.4%
Insurance	5,080	40,600	26.0%
Subtotal	**25,580**	**212,150**	**26.5%**
Agriculture	21,000	77,500	15.6%
Delivery	40	130,000	145.6%
Other use cases not similar to CCI			
Communications	105	3,850	49.2%
General Photography/Real Estate	400,200	600,600	4.6%
Other Industrial Inspection	1,760	18,800	30.1%
Entertainment	10,000	55,000	20.9%
Grand Total	**460,323**	**1,108,966**	**10.3%**

Other factors to consider are population and GDP. Ohio's population was 3.53% of the national total as of October 2019. Based on 2019 figures, Ohio's GDP was the seventh largest in the nation, representing 3.24% of the total for the United States. These two metrics are especially relevant to the package delivery use case. Population figures could drive the total sUAS need for law enforcement and public safety. Appendix C provides an in-depth analysis of the various sUAS use case and the relevance for Ohio.

Other Catalytic Impacts

Economic catalytic impacts are commonly studied when assessing air transport systems, and advanced air mobility is no exception. By definition, an "economic catalyst" is an entity that has:

(a) two or more groups of customers;
(b) who need each other in some way;
(c) can't capture the value from their mutual attraction on their own; and
(d) rely on the catalyst to facilitate value reactions between them.

Modern economists claim that in air transport, catalytic effects are even greater than the direct and indirect effects. In air transport, for example, catalytic impacts arise from connectivity and interaction benefits, among other things, and social benefits that lift communities with the jobs and spending that create new businesses. Table 11 presents four important catalytic impact elements further discussed in this section.

Table 11: Summary of Catalytic Impact Elements

Improved Labor Market Efficiencies	Suburban/Rural Access	Acceleration in STEM Funding and Educational Opportunities	Accelerated Demand for Alternative Power Sources such as Hydrogen
Improved mobility of the labor market better matching employees to employers	AAM will link the rural with urban, better integrating Ohio's economy and improving opportunities	New academic programs will be built around the AAM industry to support its growth and understanding	The growth of AAM will spur growth in energy R&D Alternative sources to power AAM
• Geography of labor market expands with AAM • "A 10% improvement in access to labor increases productivity and regional output by 2.4%"	• Meets JobOhio goals to "bolster economic growth in underserved regions" • Expanded customer base • Increased spending in the rural economy	• US is a powerhouse in the aerospace and defense sector • AAM will be a driver in recruiting and retaining talent in STEM • Many Ohio universities offer an expanding plethora of courses relevant to AAM	• Coincides with DOE 2020 Hydrogen Program • Complement and boost Ohio's existing energy sector and infrastructure • Reduce carbon footprint

A Tale of Two Economies: Improved Labor Market Efficiencies, and Improved Suburban and Rural Access

In addition to the near-term economic value for Ohio, AAM will provide catalytic benefits. For instance, the state has two distinct economies which can be better connected for mutual benefit. In 2019, Ohio's GDP was $702 billion, and its population approximately 11.6 million. According to the U.S. Health Resources and Services Administration, of Ohio's 88 counties, 50 are considered rural, the rest urban or suburban.[17] Despite the rural majority, these 50 counties have 2.4 million people, or 21% of the state's population. The urban and suburban portions have 9.2 million people, or 79% of the state's population. Unsurprisingly, the urban and suburban economy makes up 83% of GDP, with the rural economy contributing the remaining 17%. Often, the rural community is excluded from opportunities present in the more prosperous 83% of the economy. Due to the geographic isolation of the two disparate economies, people are compelled to work within their defined economic bubbles.

When convenient and affordable AAM travel is available, someone from London, Ohio, who would otherwise be limited to job prospects within roughly 10 miles of his or her hometown, can find gainful employment in cities across the state, such as Dayton and Columbus. Essentially, AAM will bridge the geographic gap between the two economies, creating a synergy that will improve employment prospects for all. Lower-income communities will also benefit from more rapid transportation to prospective employers. Employers will have a wider pool of

[17] https://www.hrsa.gov/sites/default/files/hrsa/ruralhealth/resources/forhpeligibleareas.pdf

talent to choose from—matching “the right talent to the right position at the right company,” a goal stated in the JobsOhio 2019 Annual Report.[18]

The expansion of AAM operations across the state would support key initiatives in the JobsOhio report designed specifically to curtail isolated economic bubbles. One such initiative would implement an inclusive economic development growth strategy to “bolster economic growth in underserved regions...initiatives designed to promote equal growth across the state.”[19]

A diversified labor pool and expanded economic geography allows for wealth to be created in one part of the state and spent in another part: employees will be able to work in the urban economy and spend in the rural economy. Increased consumer spending in the rural economy will necessarily attract new businesses and opportunities, thus contributing to rural expansion, and improving income for Ohioans across the state.

Ease of transportation from outlying areas will also expand the customer base for urban businesses, increasing revenues and helping to grow that economy. Securing America’s Future Energy (SAFE), an energy policy research organization, cited the following in its 2018 Autonomous Aircraft Study:[20]

- A 1% improvement in accessibility to a region’s central business district improves regional productivity by 1.1%.
- A 10% increase in average speed of transportation, all other things being constant, leads to a 15-18% increase in the labor market size, resulting in a 2.9% increase in productivity.
- A 10% improvement in access to labor increases productivity and regional output by 2.4%.

Clearly, improved transportation plays an essential role in enhancing economic growth and overall productivity. Affordable, quiet, low-emission AAM aircraft and systems will allow for residents to live further from their workspace, both decongesting inner-city traffic and diversifying labor in a cost-efficient, environmentally friendly, and equitable manner.

It is important to note that the reduction of commuting times only begins in the sixth mile from departure. In 2020, members of our team conducted a study comparing eVTOL flight times to ground vehicles commute times using ArcGIS real-time traffic analytics. At around the fifth mile of a commute in average traffic congestion (the average between peak and minimal congestion hours), it takes both cars and eVTOLs between 15-20 minutes to get to their destination. At the sixth mile, car commute times begin to increase at a faster rate than eVTOLs, reaching 20 minutes. If the commute is 10 miles—the average commute in the United States—it will take cars in average congestion just over 30 minutes to arrive at the destination. By comparison, an eVTOL would take approximately 20 minutes, as shown in Figure 20.

The 10-mile commute shows a 33% time reduction, which is three times larger than the 10% speed increase suggested in the SAFE study. It follows, then, that the labor market size for the

[18] JobsOhio, “2019 Annual Report, 2020 Strategic Plan”, 2020 https://www.jobsohio.com/annual-report-2019/
[19] JobsOhio, “2019 Annual Report, 2020 Strategic Plan”, 2020 https://www.jobsohio.com/annual-report-2019/
[20]https://avworkforce.secureenergy.org/wp-content/uploads/2018/06/Americas-Workforce-and-the-Self-Driving-Future_Realizing-Productivity-Gains-and-Spurring-Economic-Growth.pdf

impacted region could increase 45-54%, which then translates to a roughly 8.7% increase in regional productivity.

While members of the working public may not take an eVTOL to shave 10 minutes off their commute, those living further out would have a compelling reason to do so. Current AAM technology would allow for travel distances up to 200 miles and, as the graph shows, the time gap between cars and eVTOLs continues to grow exponentially with every additional mile, showcasing the potential of AAM to efficiently connect every region of the state.

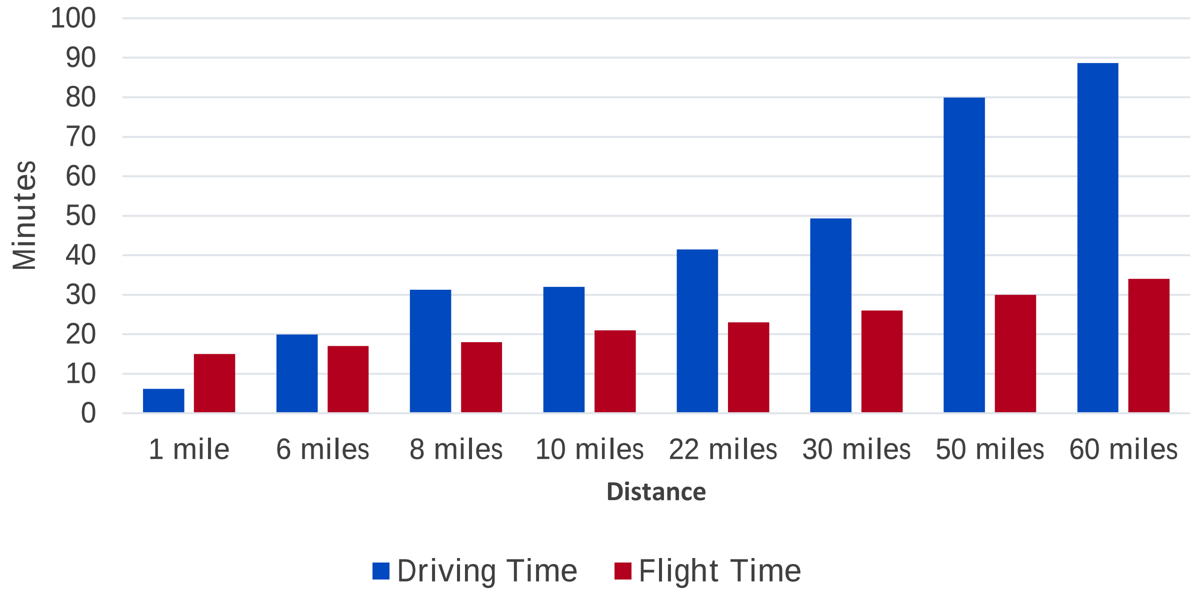

Figure 20: eVTOL-Ground Aircraft Commute Travel Time Comparison

In short, the potential to improve Ohio's labor market and connect its two economies into one highly efficient and equitable economy is a highly attractive prospect that AAM is uniquely capable of accomplishing.

Accelerated Demand for Alternative Power Sources

The Challenge

Though AAM technologies promise a revolutionary transformation of urban and regional transportation, significant challenges remain. One such potential challenge facing the technology is the current limitation of power sources. eVTOLs require massive amounts of energy for lift and for landing, as well as for maintaining altitude. Current battery technology is not capable of sustaining the amount of power required to operate an eVTOL at rates that are commercially viable. In a presentation to the Vertical Flight Society, BAE Systems posit that "While significant advancements continue to be made in battery technology, storage density, and cycle life, battery cells ideal for electric cars and most other common applications don't match the usage profile of eVTOLs."[21]

[21] https://www.aviationtoday.com/2020/02/03/battery-supply-problems-faced-electric-air-taxis/

Automakers look to procure battery packs for between $100-$150 per kilowatt-hour (kWh), but that price point is currently unattainable for aerospace.[22] Today, the price ranges more realistically in the thousands.[23] eVTOLs will struggle to operate at scale, becoming more affordable, until there exists an energy source with enough power and storage capacity to fulfill the rigorous demand of commercial flight.

The Need for Alternative Paths

Many in the AAM industry are well aware of this challenge and are working on alternative solutions. That is why some leading VTOL developers, such as Alaka'i, are pursuing aircraft concepts with other fuel sources in mind, such as hydrogen (hVTOL). Hydrogen is one of the most powerful forms of energy, with an energy density value of 120 megajoules per kilogram (mj/kg). In comparison, diesel has an energy density of 45.5mj/kg. The strongest current lithium-ion batteries obtain approximately 250 watt-hours of power per kilogram, which translates to approximately 0.9 megajoules. Thus, hydrogen fuel cells can hold 133 times more power per kilogram than the best batteries on the market. And hydrogen can be one of the cleanest power sources on Earth.

Though the exact route to powering hydrogen is still largely undefined, it is undeniable that hydrogen power remains one of the most promising forms of energy. The U.S. Department of Energy (DOE) believes it will play a leading role fulfilling future power requirements as well. It has created a national hydrogen program plan whose mission is "to research, develop, and validate transformational hydrogen and related technologies including fuel cells and turbines, and to address institutional and market barriers, to ultimately enable adoption across multiple applications and sectors."[24] Table 12 shows the current and estimated market demand for hydrogen power, by application from the DoE report. Today, an estimated 10 million metric tons (MMT) of hydrogen are produced for various applications. Notice that none can be attributed to transportation applications. But the expected demand for hydrogen power is forecasted to increase four-fold to 41 MMT by 2050, with transportation responsible for 55% of market growth. In addition to the DOE analysis, a group of more than 20 industry partners projected a two-fold increase in hydrogen demand, to

Table 12: Current Consumption and Future Economic Consumption Potential of Hydrogen in the United States (MMT/year)

		Today	R&D Success Scenario
Demand Applications	Oil refining	6	7
	Metals refining	negligible	4
	Ammonia production	3	4
	Biofuels/synfuels production	1	9
	Transportation FCEVs (LDVs, MDVs, HDVs)[25]	negligible	17
Total hydrogen market		**10**	**41**

[22] https://www.aviationtoday.com/2020/02/03/batery-supply-problems-faced-electric-air-taxis/

[23] https://www.aviationtoday.com/2020/02/03/battery-supply-problems-faced-electric-air-taxis/

[24] U.S. Department of Energy Hydrogen Program Plan

20 MMT, by 2050 as a base case scenario, and a six-fold increase in an ambitious scenario.[25] The growth of AAM, beginning with Ohio, may propel the forecast into the ambitious estimates.

Ohio Can Lead the Way

In adopting AAM technologies, the State of Ohio would begin its journey into hydrogen power in earnest, leaping ahead of its competitor states. And it will be able to do this for two reasons. First, Ohio has an existing capacity consisting of skilled labor, supply-chain networks, and infrastructure to support R&D and market application. Second, hydrogen energy and fuel cell projects and initiatives are already underway in the state.

Ohio is a leading state in energy production, with a highly skilled and diverse workforce. The state ranks tenth in the country in total energy production, sixth in electricity production, and fifth in natural gas production.[26] With this profile comes many skilled workers with technical knowledge of energy production and engineering. In 2018, Ohio held:[27]

- 100,000 jobs in traditional energy, about 3% of the nation's total.
- 82,000 jobs in energy efficiency, about 3.5% of the nation's total.
- 166,000 motor aircraft jobs, about 6.6% of the nation's total.

In addition:[28]

- In 2015, more than $100 million in fuel cell components were purchased from Ohio supply chain companies. Example company profiles include Plug Power, Johnson-Matthey Process Technologies, Nexceris, LG Fuel Cell, Crown Equipment, and Stark Area Regional Transit Authority.
- In 2015, $150 million was invested in fuel cell development by Ohio companies.
- More than $93 million has been invested by the State of Ohio for fuel cell R&D and market-readiness projects.

Ohio is also home to the Ohio Fuel Cell Coalition, an organization partnered with the DOE hydrogen program. Its objectives include to "build upon existing industry and academic strengths of research and development, advanced manufacturing, advanced materials technologies, components, and services to advance the integration of a coordinated, robust fuel cell infrastructure and supply chain."[29] The coalition highlights key attributes unique to Ohio:[30]

- Access to existing supply chains.
- Research and development: collaborations between companies and universities facilitated by programs like the coalition.
- Manufacturing and innovation infrastructure: boasting a legacy of advanced manufacturing assets/expertise and advanced materials technology.
- Central logistics: Ohio is within 500 miles of 60% of U.S markets.

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[25] U.S. Department of Energy Hydrogen Program Plan
[26] Ohio - State Energy Profile Overview - U.S. Energy Information Administration (EIA)
[27] Ohio (squarespace.com)
[28] http://www.midwesthydrogen.org/site/assets/files/1252/hydrogen_roadmap_for_the_midwest_09152017.pdf
[29] https://www.fuelcellcorridor.com/about-us-1
[30] https://www.fuelcellcorridor.com/why-ohio-1

Another key organization is the Renewable Hydrogen Fuel Cell Collaborative, a "regional ambassador for the advancement and adoption of hydrogen-powered, zero-emission aircraft and infrastructure in the Midwest."[31] It, along with the Stark Area Regional Transit Authority, released a roadmap that lays out a plan to deploy 135,000 fuel cell electric vehicles, build 250 hydrogen stations, and create 65,000 new jobs over the next 15 years.[32] Ohio was the standard-bearer in the roadmap, having been cited as *the* Midwestern state recognized for its dynamic fuel cell technology industry and extensive fuel cell supply chain.[33] The report echoes the findings of the Ohio Fuel Cell Coalition, as well as some of the figures reported above.

One example of this concerted push toward hydrogen power can be found in the Longridge Energy Terminal, a 485-megawatt powerplant in Lancaster, Ohio, which is currently under construction and scheduled to be operational in November 2021. It will run a blended operation combining natural gas and hydrogen power (the combustion turbine can burn up to 20% hydrogen), with the goal of operating at 100% hydrogen in 10 years.[34] The 1,600-acre site was once an abandoned aluminum smelter but has now found new purpose with a rising demand in green energy. When completed, it will power approximately 100,000 homes and serve as a steppingstone for the state's evolving energy market.

The introduction of AAM will add significantly to the existing momentum found in Ohio's hydrogen initiatives, supporting industries, and infrastructure. It will greatly enhance R&D, funding, and planning for the hydrogen market, further propelling Ohio to the forefront of hydrogen fuel cell technology.

Boost for Academic Growth in AAM Related Programs

Given the substantial potential economic impact of AAM in the State of Ohio, described in this report, coupled with Ohio's desire to set in motion the adoption of AAM through leadership in infrastructure and capability, there is a unique opportunity for academic institutions in Ohio to contribute to workforce development by creating new and effective educational programs.

The aerospace and defense advisor for the State of Ohio has stated that Ohio is a "powerhouse" in the U.S. aerospace and defense industry.[35] Furthermore, he broke down the governor's priorities as follows:

- Recruit and retain young talent in the STEM field.
- Increase Ohio's research portfolio.
- Attract new jobs within the manufacturing and defense sector to the state.
- Work to support and increase the local workforce.

Ohio has laid out a three-part strategy of essential initiatives to achieve these visions:

- Getting to know the local educational sector and understanding what the pipeline looks like at universities and colleges.
- Building on the state's economy by attracting new businesses.

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[31] http://www.midwesthydrogen.org/about/
[32] http://www.midwesthydrogen.org/about/
[33] http://www.midwesthydrogen.org/site/assets/files/1252/hydrogen_roadmap_for_the_midwest_09152017.pdf
[34] Long Ridge power plant in Ohio to use hydrogen and natural gas (dispatch.com)
[35] (https://www.bizjournals.com/dayton/news/2019/10/10/heres-why-ohio-is-a-powerhouse-in-the-u-s.html)

- Seeking advantageous alliances to grow the state's aerospace and defense reputation.

JobsOhio has singled AAM as one of the important targeted areas for growth by stating: "Ohio is a living lab for advanced mobility and integrated autonomous systems on the road and in the air. Here's how Ohio is prepared to test and deploy this technology in transportation and delivery."[36] Furthermore, according to JobsOhio, in Ohio one may "hire from a skilled and continuously expanding workforce—currently at nearly 38,000—prepared for in-demand careers. Ohio's colleges and universities educate, train, and upskill workers in engineering, UAS, aerospace manufacturing, technology and more."

The State of Ohio has been investing through the Ohio Federal Research Network (OFRN), with most funds in the past rounds invested in the area of UAV/AAM, where proposing teams need to have at least two collaborating academic institutions.

With the realization that AAM can serve as a substantial STEM catalyst, it is envisioned that the number of initiatives such as the OFRN will further strengthen the capability of the academic institutions across the State of Ohio in key AAM technologies.

A sampling of academic areas offered in Ohio's academia that can directly contribute to developing the desired AAM work force include:

- UAV Applications and Operations
- sUAS for Emergency Management Operations
- Unmanned Aerial Traffic Management Systems
- Automated Air/Ground Networked Mobility
- Multi-Agent systems & Optimal Swarming Strategies
- AI-based Assured Autonomy
- Human-AI Interaction
- Acoustics and Noise Mitigation
- Energy Transformation & Fuel Cells
- Traditional Aerospace Sciences: Aerodynamics; Flight Control Systems; Aerospace Structures & Materials; Electric, Internal Combustion or Jet Propulsions Systems
- Machine Vision, Big Data, and Machine Learning
- Cybersecurity
- Robotics and Intelligent Autonomous Systems
- Intelligent Maintenance Systems and Aircraft Maintenance Management
- Industrial Artificial Intelligence

Many Ohio universities contribute to the State of Ohio's aerospace and AAM capabilities with various active academic and research programs. These include in alphabetical order:

- Air Force Institute of Technology (www.afit.edu), Dayton
- Baldwin Wallace University (www.bw.edu), Berea
- Case Western Reserve University (www.case.edu), Cleveland
- Cedarville University (www.cedarville.edu), Cedarville
- Central State University (www.centralstate.edu), Wilberforce
- Cleveland State University (www.csuohio.edu), Cleveland
- Kent State University (www.kent.edu), Kent
- Marietta College (www.marietta.edu), Marietta

[36] https://www.jobsohio.com/industries/aerospace-aviation/

- Miami University (www.miamioh.edu), Oxford
- Ohio Northern University (www.onu.edu), Ada
- Ohio University (www.ohio.edu), Athens
- The Ohio State University (www.osu.edu), Columbus
- University of Akron (www.uakron.edu), Akron
- University of Cincinnati (www.uc.edu), Cincinnati
- University of Dayton (www.dayton.edu), Dayton
- University of Toledo (www.utoledo.edu), Toledo
- Wilberforce University (www.wilberforce.edu), Wilberforce
- Wright State University (www.wright.edu), Cayton
- Youngstown State University (www.ysu.edu), Youngstown

Community colleges in Ohio have also establish technical programs in relevant areas important for the advancement of AAM in the state. These include:

- Cincinnati State Technical and Community College (www.cincinnatistate.edu), Cincinnati
- Columbus State Community College (www.cscc.edu), Columbus
- Cuyahoga Community College (www.tri-c.edu), Parma
- Lakeland Community College (www.lakelandcc.edu), Kirtland
- Lorain County Community College (www.lorainccc.edu), Elyria
- Sinclair Community College (www.sinclair.edu), Dayton

It may be stated with high certainty that a meaningful investment in AAM-related academic programs will have a substantial catalytic effect on the State of Ohio, yielding an excellent return on investment (ROI), further boosting academic R&D investment.

Summary of Findings

The study produced a number of important findings intended to guide the State of Ohio and its policy deliberations. These findings are supported by in-depth analytics guided by the experience of the senior team members working in the global AAM field.

- Ohio will be able to grow and sustain profitable AAM operations in urban, suburban, and rural areas over the 25-year forecast period.
  - Commercial business activities among all pillars (revenues from operators and aircraft manufacturing, and capital and operational expenditures for PSU and ground infrastructure) are expected to approach $13 billion between 2021 and 2045 for six use cases of involving emergency services, passenger services and cargo movement.
  - About 66% of the forecasted $13 billion of value-added impact is considered direct and indirect; the remaining 34% from induced impacts
  - More than 15,000 direct, indirect, and induced permanent, high-paying, full-time jobs are forecasted. Since the direct and indirect effects of AAM account for roughly two-thirds of the impact, we see that job types, or occupations needed, are closely aligned with the industries tied to AAM.
  - More than $2.5 billion in federal, state and local tax revenues is expected over the 25 years of the analysis. Local and state governments revenues account for $464 million and $542 million, respectively, while the federal revenues account for about $1.5 billion. The local level represents totals for townships, cities, and counties for the entire state.
  - The overall state-wide infrastructure revenue to investment (R/I) ratio is in the range of 2.2, suggesting that private capital sources will be attracted to make infrastructure investment.
- sUAS holds promise in increased efficiencies and productivity, but relative to AAM does not offer significant direct economic benefits in terms of new jobs creation or direct cost savings.
  - sUAS operations provide significant benefits by making more efficient use of resources (i.e., improving productivity), enabling higher fidelity of data, increasing social benefits such as workplace safety, and decreasing the environmental impact of other operations.
  - Use of sUAS will also significantly enhance the mission of execution of ODOT and other government entities by improving infrastructure inspection, and workforce operating efficiency and productivity.
- Significant differences between the five major cargo logistics corridors are due to highly varied commercial activity concentrations. The team analyzed the cargo corridors along four major interstates (I-71, I-75, I-80, I-70) and along U.S. Route 33. Based on intrastate analysis, the I-71 corridor, connecting Cincinnati, Cleveland and Columbus, is the most promising for early adoption. However, all corridors have enormous potential for interstate routes for midwestern U.S. states. U.S. Route 33 has also special impact on rural access to the southeastern and the west-central regions of the state.

- The economic activity due to needed investment for ground and PSU infrastructure is estimated at more than $1.4 billion over the 25-year forecast period.
    - Investments in multiports, which are specially designed transportation hubs for AAM capable of servicing several aircraft at once and offering passenger amenities, will be needed in the future. Ohio's efforts with NASA Ames in vertiport planning are critical to better identify the most impactful locations of vertiports in urban environments within Ohio's largest cities. This work will inform future investments for new vertiports. However, immediate and near-term infrastructure investment will be concentrated in remediating existing heliports, adding airport multiport installations, and establishing logistic corridors PSU systems.
    - Current Ohio efforts such as SkyVision, Ohio UTM and Remote Tower provide a strong foundation for investment to low-altitude air traffic management and PSUs systems. These efforts must be physically expanded to other areas, including investments in the PSU systems along the interstate corridors.
- AAM will facilitate access to far suburbs and rural areas, helping to close the physical gaps and economic disparities between rural and urban populations, a key objective of the State of Ohio.
- AAM will capitalize and build upon Ohio's strong capabilities in aerospace, advanced manufacturing, materials technologies, and university and R&D capacity.

Recommendations for Implementation

The team's recommendations fall into four categories:

- Strategy, Policy and Legislative Framework
- Studies, Demonstrations, Pilot Programs, and Local AAM Planning Initiatives
- National AAM Leadership Activities
- AAM Supply Chain, Manufacturing, and Service Opportunities for Ohio.

Recommendation 1

Strategy, Policy, and Legislative Framework

Build upon Ohio's reputation and heritage as a first mover and visionary aviation leader, using AAM to bring the state (government and industry) to the next level by developing a policy, infrastructure, and R&D roadmap for state-wide AAM implementation.

a. Within the ODOT and Ohio UAS Center, establish a project office and advisory team, including state and federal policy making, investment banking, project financing, AAM supply chain, transportation engineering, regulatory and other expertise to advise ODOT and the State of Ohio. The advisory team will assist in the realization of the approximately $13 billion Ohio AAM opportunity.

b. Develop a **mission** [statement], **blueprint**, and related **roadmap** to strengthen ODOT leadership in AAM, with emphasis on: 1) Realization of the approximately $13 billion Ohio AAM opportunity; 2) Private-sector participation and capital with early-stage involvement from eVTOL suppliers; 3) Job creation, skills development, and improving labor market efficiencies; 4) Identification and investment strategies for addressing technological gaps for the adoption of AAM and 5) Ensuring R&D leadership for Ohio educational institutions.

c. Making use of this report, brief local, state and federal transportation leaders and policy professionals, and airports, on the specific economic and job creation benefits of AAM for the State of Ohio.

d. Develop AAM policy guidance for Ohio city and county governments, economic development agencies, and airports.

e. Form a broad-based coalition of AAM stakeholders able to meet monthly and provide consistent input to the Ohio UAS Center (See recommended key stakeholders in Table 13).

Table 13: Key AAM Stakeholders

State/Municipal Agencies	Federal Agencies	eVTOL Manufacturers	AAM Supply Chains	Ohio P135 and P91 Operators	Financial, Investment and Institutional	Universities and Colleges
ODOT FlyOhio DriveOhio JobsOhio Municipal Economic Development Agencies Regional and Local Planning Authorities Airports Transit Agencies *Others*	USDOT FHWA FAA NASA Volpe Center DOD/AFWERX AFRL *Others*	Kitty Hawk Moog Reliable Robotics Joby Archer Beta Lilium Boeing VEA Vertical *Others*	Ground Infrastructure PSU/UTM Infrastructure ANRA Technologies CAL Analytics Raytheon Thales L3 Harris Skyward AirMap Crown Consulting Ohio-specific suppliers *Others*	UPS Fedex Ohio P135 Operators Corporations /P91 flight departments NetJets *Others*	Incubators Infrastructure Funds Venture Funds Family Offices Project Financing, e.g. NEXA Capital Partners *Others*	University of Cincinnati Ohio State University Ohio University Sinclair College & Other Community Colleges *Others*

f. Identify the elements of and further develop state and municipal linkages to federal legislative strategies to steer AAM legislative programs including: 1) The Advanced Air Mobility Coordination and Leadership Act[37]; and 2) (Future) Federal Infrastructure Programs[38], where some $2 trillion in funding can be tapped to advance AAM programs for Ohio.

g. Evaluate and continue to employ options available through USAF, AFRL, AFWERX and Agility Prime for matters such as use of military flight release (MFRs), vehicle certification, access to DoD bases and airspace, and others.

h. Work with state and municipal agencies and advise The Ohio Legislature to develop and implement programs to memorialize the roadmap and strengthen industry participation for the four key AAM supply chains:

   i. eVTOL manufacturing – electric vehicles and critical Tier 1 and 2 supply chain participants.

   ii. Ground infrastructure (e.g. vertiports, airport multiports, electrical charging systems, lighting systems, etc.). Capitalize on the UAS Center's current vertiport design activities with NASA Ames to inform the appropriate location of vertiport for the future.

   iii. PSU/UTM low-altitude air traffic management infrastructure, including communication, navigation and surveillance systems and staffed network operations centers. Current Ohio efforts led by the Ohio UAS Center such as SkyVision, Ohio UTM and Remote Tower provide a strong foundation for investment in low-altitude air traffic management and PSU systems. The State must physically expand these efforts to other

[37] *"Advanced Air Mobility Coordination and Leadership Act"* U.S. Senate, sponsors Senators Moran and Sinema, introduced March 2, 2021
[38] *"America Jobs Plan"*, tabled March 31, 2021, the White House

areas, including providing additional investments in the PSU systems along the interstate corridors.

   iv. Eventual eVTOL operations, making use of Ohio Part 135 and Part 91 helicopter operators, whose trained pilots, safety, and quality programs, training curricula, dispatch capabilities, etc. will help ensure the highest industry safety standards.

i. Using the project office and advisory team (Recommendation 1a.), evaluate private capital options for infrastructure financing using innovative financing structures and potential public-private partnerships (PPP).

   i. Allocate state funding for studies in the formation of innovative financing structures and PPPs.

   ii. Pursue regulations, evaluations, and adjustments that would enable development of project financing for AAM infrastructure.

Recommendation 2

Studies, Demonstrations, Pilot Programs, and Local AAM Planning Initiatives

Work with state and local community planning organizations and with heavy involvement of Ohio universities and colleges.

a. Identify long-term opportunities to partner with federal agencies to explore how AAM will impact the nation's passenger and cargo transportation in the future.

b. Engage Ohio airports early and through all stages. Pursue legislative assessment and action on the Ohio Airport Protection Act (Ohio Administrative Code) to include vertiports. This focuses on protecting the airspace around vertiports, including the approach and departures paths.

c. Understand local and regional passenger demand, cargo/freight transportation arteries, and intermodal connectivity that will flourish with AAM. With that information, plan and pursue early prototype vertiports for demonstrations.

d. Undertake studies to select locations within the downtown cores of Cincinnati, Cleveland, and Columbus for prototype vertiports. Build prototype vertiports for early demonstrations:

   i. Identify commercial incentives for vertiport construction in Ohio to attract early adopters.

   ii. Choose one or more phase 1 locations within the downtown core of Cincinnati, Cleveland and Columbus for AAM launch vertiports.

e. Investigate transportation patterns in and out of major airports and their connection to suburbs. Airport delivery has a strong opportunity due to its established safety and public mitigations for air travel.

f. Work with The Ohio Legislature to seek clarity of the role of state and local government in management and control of low-altitude airspace.

g. Advance rural/urban integration:

i. Understand regional healthcare network operations and delivery, especially intra-facility and urban-to-rural delivery for potential early adopters.

ii. Continue development of air mobility services, including health care delivery, to rural areas of Ohio.

iii. Identify small airports that may serve as rural service centers for early adopters.

Recommendation 3

National AAM Leadership Activities
Demonstrate national leadership through Ohio-based AAM projects underway today or starting shortly.

a. Develop concepts of operation in concert with federal concepts and policies and incorporation of environmental and community integration considerations.

b. Focus initial ODOT and UAS Center efforts in three of the most promising AAM use cases that will produce early results: regional air mobility, emergency services, and heavy cargo logistics.

c. Continue development of low-altitude airspace design led by the Ohio UAS Center (Skyvision, Ohio UTM, and Remote Towers) in support of the three use cases, with initial emphasis in the I-71 corridor and its three major metropolitan areas.

d. Produce a regular series of white papers, guided by complementary technical, industry, and economic themes, for national publication, demonstrating Ohio-based leadership in AAM:

e. Emphasize ways and means to ensure that catalytic benefits are captured for the State of Ohio with respect to 1) improved labor market efficiencies, 2) suburban/rural access, and 3) acceleration in STEM funding and educational opportunities.

f. Identify linkages to important initiatives such as Smart Cities, SMART Columbus, etc., and climate change initiatives led by organizations such as the Ohio Environmental Council.

g. Sponsor conferences in the state at least annually to showcase Ohio leadership in the field.

h. Capitalize on the presence of federal laboratories in Ohio.

i. Establish and credentialize the Ohio AAM Center of Excellence. The Center will ignite a transition to daily operations that can scale to provide affordable price points and position Ohio as a clear leader, attractive to technology firms, OEMs and operators.

j. Extend operations and demonstration beyond the UAS Center in Springfield and into real-world demonstrations and operations across the logistic corridors and into rural areas.[39]

k. Address the integration of local and state government policies and regulations with the federal government.

Recommendation 4

AAM Supply Chain, Manufacturing and Service Opportunities for Ohio
Position Ohio to attract participants within each of the four supply chains for the AAM industry.

a. See Recommendation 1h.

b. Undertake a program to encourage R&D and manufacturing partnerships between auto makers, eVTOL developers and Tier 1 and Tier 2 supply chain participants.

c. Identify and pursue future AAM job categories and establish suitable training programs in conjunction with higher education institutions, capitalizing on the strong base of courses and programs already in existence.

d. Retain highly skilled AAM-oriented talent in Ohio to fill the more than 15,000 potential full-time jobs by 2045, with 80 percent of those jobs expected in supply chain categories.

e. Study the establishment of a state-funded R&D granting organization and incubator to anchor entrepreneurs for the AAM sector in Ohio.

f. Capitalize on Ohio leadership in energy production, and on current initiatives, such as the Ohio Fuel Cell Coalition, to lead the nation in the transition to alternative energy sources such as Hydrogen power.

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[39] Current UAS test sites partnered with the FAA around the country are testing various use cases, scenarios, vehicles and supporting technologies. With only minor exceptions operations are limited by the constraint of the Centers without exploration into non-sterile environments. Operations over dense populations creating noise and public perception issues are needed, as well as operations in regular airspace without the sterilization (and protection) that is put in place at test sites.

Appendix A: High-Level Task Descriptions

Task 1: Structure the Economic Model

- Assemble infrastructure data elements
- Identify passenger and cargo demand for Ohio corridors with AAM
- Define economic structure and supply chain

Task 2: Gather Information on Industry Use Expectations

- Review Ohio Studies and initiatives
- Identify key stakeholders
- Conduct selected interviews with operators and OEMs
- Develop interview report

Task 3: Define Service and Use Case Scenarios for Demand Estimates

- Develop people movement and package delivery scenarios
- Assess source and demand constraints for noise pollution
- Document concept of operations for corridors

Task 4: Adjust Model and Generate Demand and Benefit Forecasts

- Incorporate demand, inventories
- Validate operations and assumptions for corridors
- Adjust assumptions to identify cash flows and determine break-even point horizons

Task 5: Perform Analysis with SME Review

- Analyze and adjust use cases based on economic forecasts and break-even point horizons

Task 6: Prepare Report

- Prepare draft and fFinal reports
- Prepare article and research papers for dissemination

Figure 21: Summary of Study Tasks

Appendix B: Noise and AAM

There may be the potential for a significant economic impact of AAM and eVTOL aircraft for the transportation of cargo and passengers. However, if AAM systems create unacceptable noise pollution in their operational communities, the economic impact could be severely limited.

The vision for AAM operations would realize hundreds or thousands of daily operations in populated urban, suburban, and rural environments. These aircraft would take off from vertiports in densely populated urban environments and fly over neighborhoods and communities at altitudes much lower than current commercial aircraft. The noise signature of these aircraft will be unlike any existing airplane or helicopter, and the human response to these noise signatures is still unknown, but early research indicates that annoyance levels will be much higher due to the specific frequencies and tonal nature of the acoustic signatures.

History offers many examples of limited economic impact of aircraft due to unacceptable noise pollution. This includes the Concorde Supersonic Transport (SST) aircraft that was prohibited from flying over land due to the sonic boom and deafening engine noise, which resulted in limited flight routes overseas and eventually failure of the business model. Another example is the constant battle over helicopter noise in dense cities such as Chicago, Los Angeles, and New York. Noise regulations have restricted helicopter use primarily to emergency services and law enforcement activity.

To ensure that proposed AAM visions are realized, a comprehensive approach to understanding the impact of noise on urban, suburban, and rural communities is paramount.

A high-level technical summary of aircraft noise is presented here to assist in assessing the complex landscape of noise impacts and regulation. The purpose of this section is to highlight the challenges that eVTOL noise may face in terms of widescale adoption, acceptance, and ultimately the realization of the economic projections laid out in this report.

New aircraft classes and designs

The field of aeroacoustics focuses on the acoustics or noise generated from aerodynamic phenomena, which is the primary acoustic source for aircraft. The aircraft envisioned to operate in the eVTOL market are radically new aircraft designs that are as varied and diverse as the hundreds of companies vying to develop these aircraft. The aircraft payloads may range from small cargo deliveries to four-to-six passengers to larger regional passenger and cargo transportation. The noise of these aircraft will be dominated by the propulsion systems, including the propellers, rotors, and electric motors (hybrid-electric powerplants may also find application). Distributed electric propulsion (DEP) is an enabling technology, allowing aircraft designers to use anywhere from four to 20 or more propulsors distributed across the aircraft. For a given aircraft mission and payload, there may be multiple aircraft with vastly different propulsion system architectures and aircraft configurations that will result in different noise signatures.

Helicopters generate all lift and thrust from a single main rotor. Airplanes generate forward thrust from the propulsion system and lift from the wings in forward flight. Current proposed AAM eVTOL concepts use combinations of lift from propulsors and airframe and thrust from forward facing propellers/rotors or by tilting the rotors and transitioning from vertical to forward flight regimes. The primary noise-reducing design change for eVTOLS comes from using multiple smaller distributed rotors that can operate at lower tip speeds (M_{tip} = 0.3 – 0.6), compared to helicopters, which tend to operate with transonic tip Mach numbers. This design change alone nearly eliminates the primary noise sources (blade-vortex interaction and high-speed impulsive noise) of helicopters. By distributing the thrust load over multiple propulsors, an aircraft designer can add more rotors to achieve the required thrust, while helicopters often need to increase the rotor speed. The general consensus among the aeroacoustics community is that this is a very powerful design change, but further advancements must be made in reducing the remaining noise sources throughout the flight mission in order to enable operations near populated areas without adversely affecting the noise landscape and achieving community acceptance.

Lower Altitude Flights and Unique Operations

The noise problem for eVTOL aircraft is unique in many ways. This emerging market will increase aircraft operations at low altitude (500–3,000 ft ASL). To achieve market viability and large-scale adoption, flight operations on the order of hundreds to thousands of daily operations in a metropolitan area have been projected. This outpaces current aircraft operations and, in terms of noise, eVTOL aircraft will need to be imperceptible at cruising conditions to gain widespread acceptance. The aircraft noise emission to achieve imperceptibility on the ground will vary by location based on the ambient soundscape and background noise.

The value proposition for eVTOL operations is strongly linked to the unique capability of being able to take off and land in populated urban city centers. This will likely be the limiting case for aircraft noise levels since the vertical portions of flight require the highest loading (thrust) from the propulsion system and this operation will be closest to the populations. Vertiports are envisioned to be constructed on top of parking structures, high-rise buildings, and near ground level, distributed throughout urban and suburban regions around cities. This is in contrast with the legacy strategy of locating airports away from the most populated urban areas to control noise pollution and limit community exposure. Noise standards for VTOL operations in populated areas will be required.

Unknowns on Aircraft Noise Signatures

A unique hurdle for assessing and predicting the noise impact of eVTOL aircraft is that most of these aircraft are very early in their development, many existing only as concepts or prototypes, particularly the larger-scale aircraft for transporting passengers. In line with this report, we will discuss aircraft noise for two eVTOL classifications: 1) sUAS aircraft for small payloads and 2) AAM aircraft capable of passenger transport and larger payloads. This discussion will mostly focus on AAM aircraft due to the potential for higher sound levels and higher numbers of operations.

For AAM aircraft that are further along in the development cycle, the acoustic signatures are held as proprietary information with the company. There are some publicly known data sharing agreements between companies and federal agencies such as NASA and the FAA, but the data is not widely available to the community. Since AAM aircraft are effectively a new class of aircraft from helicopters, jet aircraft, and general aviation airplanes, it is very difficult to predict noise using existing modeling tools. Additionally, higher fidelity tools that can capture the flow physics related to the acoustics sources are not practical for capturing all the complex aeroacoustics interactions. This points to a significant effort needed in terms of characterizing the aeroacoustics of these aircraft across operational conditions, flight modes, operating environments, and for various sizes and payloads. These efforts should encompass all aspects, from fundamental research all the way to aircraft certification and flight test. These technical hurdles and needs are laid out in detail in the NASA Urban Air Mobility Noise: Current Practice, Gaps, and Recommendations (NASA/TP-20205007433).

Another unique issue with AAM aircraft is based on the projected business model for this new class of aircraft, which hinges on a high number of operations in densely populated areas. This contrasts with past approaches of constructing airports away from densely populated areas in much of the United States. Obviously, airport noise is more pronounced in large cities and in Europe, which has more land constraints. The issue of conducting many operations in densely populated areas will likely result in the most stringent noise limitations for these aircraft being applied for the takeoff and landing phases of the mission. In conjunction with densely populated areas, this will likely occur in reverberant environments surrounded by tall buildings and populated structures. This will require creative engineering and architectural solutions, as well as methods and standards for regulating AAM aircraft noise for these critical phases. This consideration goes beyond the current regulations and must be considered for the business models and economic projections for AAM to be realized.

Literature Review

A summary of the fundamentals of measurements and standards used in aircraft and helicopter noise regulation is provided here. These metrics will be described at a high level to aid in understanding an example noise study that has been conducted by Booz Allen Hamilton[40].

Noise Metrics and Regulation for Aircraft and Helicopters

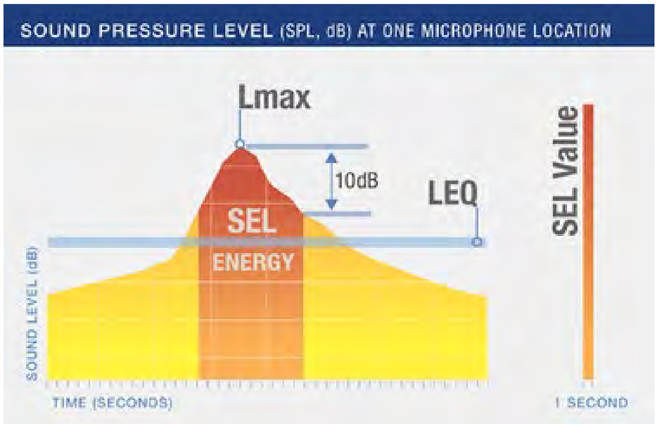
There are a few primary noise metrics used in the regulation of aircraft and helicopter noise, described below.

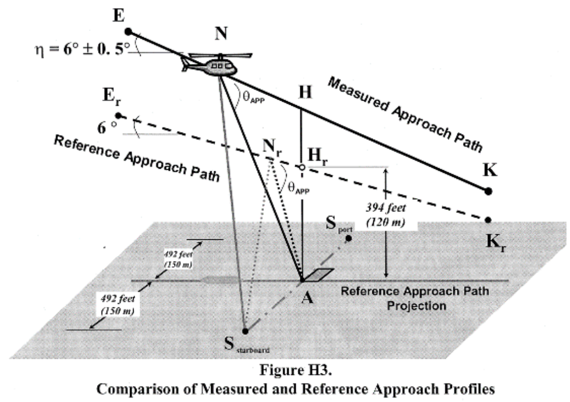
Sound Exposure Level (SEL): A noise metric used in helicopter certification. SEL is a normalized time integration of the A-weighted sound pressure level in decibels (dBA) that spans at least +/- 10 dB from the maximum SPL level measured. A-weighted SPL weights the measured SPL to approximate human hearing response to the frequency content of the sound. Figure 22 shows the equation (L_{AE}) and some diagrams for SEL calculation. Noise limits are set based on the maneuver (takeoff/landing/flyover) and maximum takeoff weight.

Effective Perceived Noise Level (EPNL): A noise metric used for commercial jet aircraft which takes into account duration of the noise event and tones in the acoustic spectra. The units of EPNL are EPNdB. The calculation for EPNL corrects the measured sound pressure to noisiness in units of 'noys' for human perception instead of A-weighting, but the two methods are similar. The weighted pressure-time history is corrected (penalized) for tones based on the frequency and amplitude of the dominant tone in the third-octave band spectra. Another correction (penalty) for the duration of the event is computed to account for the time-variation of the noise around the maximum. It is not anticipated that EPNL will be used for AAM certification, however, there is some credence to a similar metric that accounts for tonal content in the acoustic signature to be penalized, based on psychoacoustic research conducted by NASA[41].

[40] BAH Market Study - NASA HQ-E-DAA-TN65181 (https://ntrs.nasa.gov/citations/20190001472)
[41] NASA Advanced Air Mobility Noise White Paper NASA/TP-20205007433 (https://ntrs.nasa.gov/citations/20205007433)

$$\int_{t_1}^{t_2} \left(\frac{P_A(t)}{P_0}\right)^2 dt\ dB$$





(a) (b)

Figure 22: Diagrams Showing (a) Calculation Limits of SEL and (b) Helicopter Landing Approach Used in Noise Certification

Day-Night Average Sound Level: The Day-Night Average Sound Level (DNL) is metric used in airport planning which is the average A-weighted sound pressure level over a 24-hour period. The metric penalizes noise levels by 10 dB between the hours of midnight-7 A.M. and 10 P.M-midnight. Figure 23 shows the distribution of hourly averaged sound levels that average to a 65 DNL level, which is a threshold that most residential and public use areas aim to stay below. The equation for computing DNL over the 86,400 seconds in a 24-hour day is shown in Equation 1 which requires continuous data-logging.

As the number of flight operations increase, the maximum SEL of each individual event will need to be lower. Figure 24 provides an example showing that to maintain a DNL of 65 dBA, if there is one event/day then an SEL of 104.4 dBA can be endured. For 10x increase in operations, the SEL needs to decrease by 10 dBA (10 events/day @ SEL=94.4 dBA or 100 events/day @ SEL=84.4 dBA). Keeping in mind that dBA is log-scale, a 10 dBA reduction is reducing the sound pressure to 1/3 of the original level, which is not trivial. This example maintains certain assumptions which could change the result, such as the time of occurrence of each event, the background noise level, and it assumes each event is equally loud.

Figure 23: Hourly Sound Levels in dBA Illustrating the 10 dB Penalty Applied During Evening Hours

$$L_{dn} = 10\log_{10}\left[\frac{1}{86400}\left(\int_{0000}^{0700} 10^{[L_A(t)+10]/10}dt + \int_{0700}^{2200} 10^{L_A(t)/10}dt + \int_{2200}^{2400} 10^{[L_A(t)+10]/10}dt\right)\right]$$

Equation 1: Equation for Calculating DNL Over 86,400 Seconds of a Day

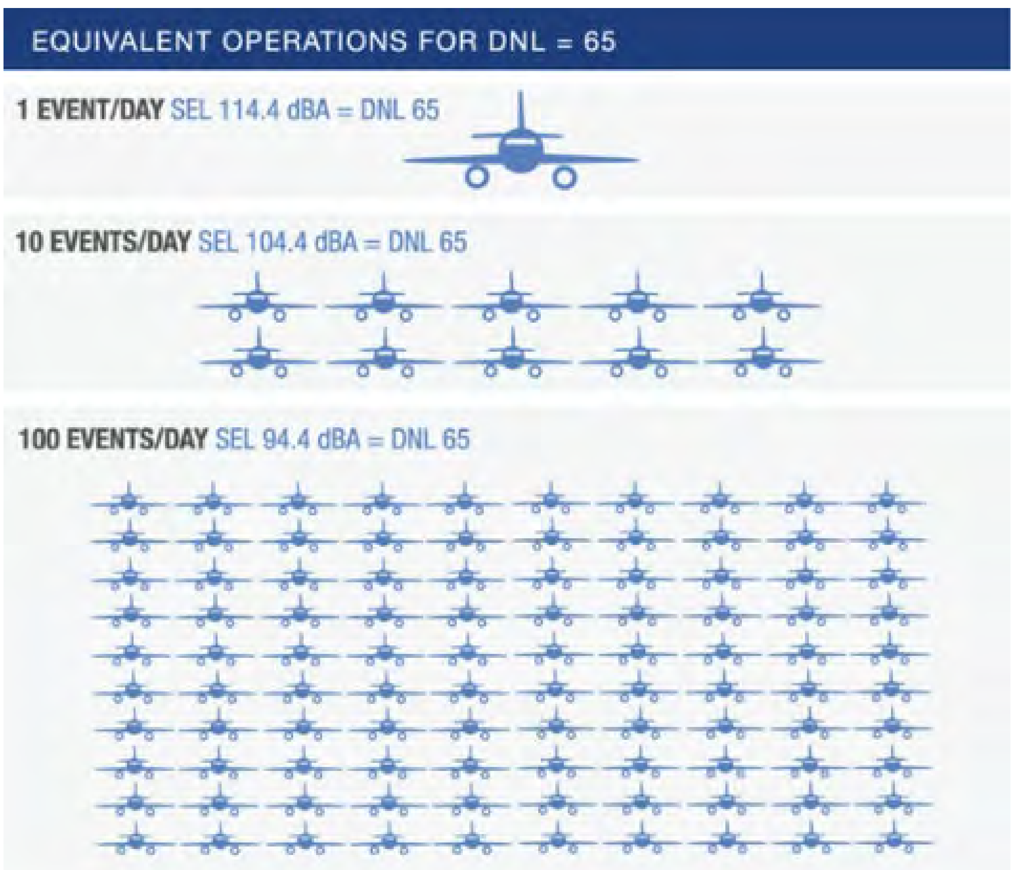
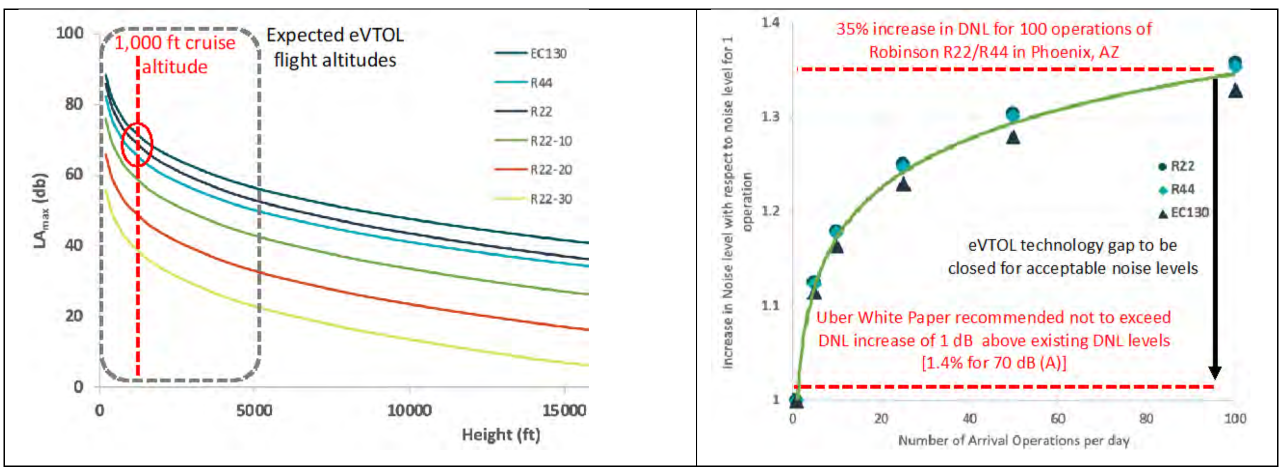


Figure 24: Illustration of the Number of Events That Can Be Incurred at a Given SEL Level for a DNL Level of 65 dBA

Booz Allen Hamilton AAM/UAM Market Study

Booz Allen Hamilton conducted a preliminary noise modeling assessment using the FAA's Aviation Environment Design Tool (AEDT), which is a software tool used in regulating aircraft based on noise exposure on the ground.[42] The study utilized data on the Robinson R22, R44, and Eurocopter EC130 helicopters for the analysis. The noise levels were decremented for a R22 helicopter by 10, 20, and 30 dB for a conceptual study of the impact on noise metrics, shown in Figure 25a with $L_{A,max}$ at 1,000 ft altitude indicated. For a R22 helicopter decremented by -30 dB (very optimistic), the 65 dBA $L_{A,max}$ ground contour decreased by a factor of 10 for arrival and by a factor of three for departure. The 65 dBA DNL ground contour was reduced slightly, particular for a 30 dB reduction. It should be noted that a 30 dB reduction of the R22 reduces the $L_{A,max}$ noise level near the aircraft from 95 dB to 65 dB. This will require significant technology advancement to achieve over a 30x reduction in sound pressure, which most likely will need to be achieved through a combination of aircraft noise reduction and flight path optimization for low noise. This further highlights the importance of takeoff and landing noise, which will be governed by aircraft noise and the surrounding physical environment. The study also demonstrated that for the 100 operations per day, the increase in DNL level is 22% for departure operations and 35% for arrival operations, as shown in Figure 25b, for the standard helicopters studied (no noise decrement). These levels would far exceed the suggested one dBA maximum increase in DNL for a given area recommended by existing regulations per the Uber White Paper,[43] corresponding to 1.4% for 70 dBA. Further research and operational studies are needed, with much greater detail and rigor to adequately assess the noise impact of these air mobility operations.



(a) (b)

Figure 25: (a) SEL Levels for Low-Noise Helicopters and the R22 Hypothetically Decremented by -10, -20, and -30 dBA (b) Increase in 65 DNL Noise Contour Area as a Function of the Number of Operations (no noise decrement)

Noise Risk to Economic Projections

Noise is inherently a human issue; if there are no humans to be annoyed, it is only sound. There are real and major risks that the noise from AAM aircraft may significantly impact the economic

[42] BAH Technical Outbrief Slides (https://core.ac.uk/download/pdf/189597661.pdf)
[43] Uber Elevate White Paper (https://www.uber.com/elevate.pdf)

projections presented in this report. This should be a major incentive to invest in noise reduction across the ecosystem, from aircraft engineering to policy making. Some of these risks are summarized below.

Aircraft Noise: Individual Events

The aircraft is the inherent source of acoustic energy, the majority of which will come from the propulsion system. There are distinct flight regimes for AAM aircraft that include vertical takeoff and landing, maneuvering, transition to forward flight, and steady level flight. Each of these flight regimes have the potential to drastically alter the acoustic levels and directionality (propagation direction). The propulsion system generates noise from the motors and from the aeroacoustics of the propellers due to flow acceleration and blade-wake interaction. Additionally, interactions of the propeller flow with the aircraft structure, and surrounding propellers will generate secondary acoustic sources. All of these phenomena need to be understood in much greater detail in order to understand the noise sources that result in the highest levels of annoyance and to engineer the system for minimal acoustic signature. With the massive number of proposed aircraft configurations, this is a significant undertaking, but will be critical to making measurable advancements in reducing the noise of the aircraft to the desired levels. This is the first step in ensuring that the number of operations needed for a viable business model can be realized.

Operations Noise: Multiple Events

Limitations of operations based on existing noise metrics (EPNL, SEL, DNL) may artificially constrain operations due to the inadequacies of these metrics to properly capture annoyance from eVTOL noise signatures. In order to create accurate models for operations noise, accurate and relevant spectrally resolved acoustic data is needed during all of the critical flight modes and mission phases. Additionally, knowledge of the background noise along proposed flight paths and in areas surrounding vertiports are needed to accurately model the impact of an AAM aircraft operation in the relevant operating environment. With models grounded in data, meaningful recommendations and goals can be laid out for aircraft designers in terms of noise levels during specific operations.

Vertiport Noise in Populated Environments

Noise levels in and around vertiports and areas for takeoff and landing of AAM aircraft will be critical for ensuring acceptance of AAM operations. The design of structures and surrounding landscaping for acoustic mitigation are some ideas for reducing the acoustic footprint of a vertiport. However, there will undoubtedly be areas where vertiports will be in reverberant environments and minimizing the aircraft noise will be the primary need to minimize noise on while operating at low altitudes prior to takeoff or landing.

Local Noise Ordinances

While the (FAA) sets the limits for aircraft noise during certification, there is no guarantee that those noise levels will be acceptable for a given community. Noise ordinances are controlled at a local level and there is a large risk that AAM operations could be artificially constrained by local ordinances. There should be a concerted effort to reach out to local communities and local policy makers in communities that are anticipated to be impacted by high levels of AAM operations. Activities could include educating communities on what to expect and the benefits that AAM would bring, surveys of the community background noise levels throughout the day, pilot programs to test flight operations and gauge annoyance for full-scale systems, and more.

Recommendations for Potential ODOT AAM Noise Related Activities

- Utilize state resources such as the Ohio UAS Center to create a center of excellence for conducting field acoustic measurements.
- Incentivize companies to fly their sUAS and AAM systems at the Ohio UAS Center to generate acoustic data for sharing with the broader community.
- Advocate for state-funded research at universities and with companies to advance the knowledge and technology related to AAM aircraft noise.
- Advocate for and support noise surveys along interstates, highways, and in anticipated high traffic vertiport locations.
- Guide policy making and outreach to local communities about noise ordinances.
- Conduct community noise surveys and pilot programs in local communities to assess sUAS and AAM annoyance.

Appendix C: Discussion of sUAS Operations

Small UAS (sUAS), as defined by the FAA under Part 107, are autonomous aircraft weighing less than 55 pounds, including payload. Their small size enables them to fly within constricted areas, and Part 107 restricts operations to less than 400 feet above ground level without a waiver. When fitted with sensors, sUAS provide enhanced capabilities for inspections, monitoring, mapping and surveillance. Some package delivery sUAS can be used for delivery methods for smaller payloads, including medical supplies.

There are a range of these aircraft in development and in production, as shown below.

Amazon Prime Air delivery drone

- Seattle, Washington – www.amazon.com
- Targeted use case: Package delivery
- Max payload: 5 pounds
- Range: 15 miles
- Max speed: 50 mph
- Max flight time w/payload: 0.5 hours

DJI Matrice 200 Series V2

- Shenzhen, China – www.dji.com
- Targeted use case: Infrastructure inspection
- Max payload: 3.2 pounds
- Range: 5 miles
- Max speed: 50 miles
- Max flight time w/payload: 38 minutes

DJI P4 Multispectral

- Shenzhen, China – www.dji.com
- Targeted use case: Agriculture
- Max payload: 0
- Range: 4.3 miles
- Max speed: 31 mph
- Max flight time: 27 minutes

DJI Matrice 300 RTK

- Shenzhen, China – www.dji.com
- Targeted use case: Law enforcement/Public safety
- Max payload: 5.95 pounds
- Range: 9.3 miles
- Max speed: 51 mph
- Max flight time: 55 minutes

Drone Delivery Canada Sparrow

- Vaughan, Ontario, Canada – www.dronedeliverycanada.com
- Targeted use case: Package delivery
- Max payload: 9.9 pounds
- Range: 18.6 miles
- Max speed: 50 mph
- Max flight time: *unspecified*

Matternet M2

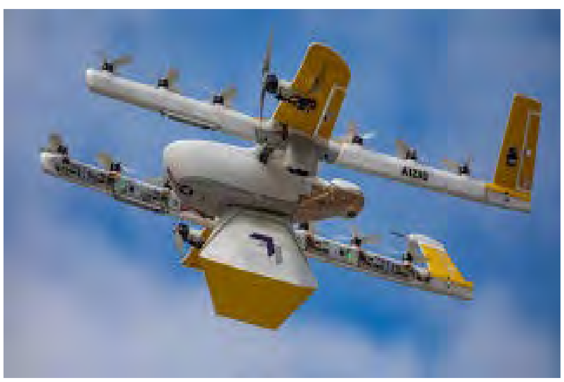
- Mountain View, California – www.matternet.com
- Targeted use case: Medical/Package delivery
- Max payload: 4.4 pounds
- Range: 12.4 miles
- Max speed: 31 mph
- Max flight time: 30 minutes

Skydio 2 Enterprise

- Redwood City, California www.skydio.com
- Targeted use cases: Infrastructure inspection, Law enforcement/Public safety
- Max payload: n/a
- Range: 2.1 miles
- Max speed: 36 mph
- Max flight time: 23 minutes

UPS Flight Forward/Wingcopter 178 Heavy Lift

- Wieterstadt, Germany www.skydio.com
- Targeted use case: Package delivery
- Max payload: 13.2 pounds
- Range: 75 miles
- Max speed: 93 mph
- Max flight time: 3 hours



Wing Delivery Drone

- Palo Alto, California – www.wing.com
- Targeted use case: Package delivery
- Max payload: 3.3 pounds
- Range: 12 miles (roundtrip distance)
- Max speed: 70 mph
- Max flight time: *unspecified*

For this study, the term "targeted use case" is important because several sUAS targeted to a particular use case may be suitable for multiple use cases. This has certainly been true in the first decade of sUAS commercial deployment as first adopters are using aircraft designed for mapping, for example, in surveillance/public safety roles. As use cases have become better defined and as sensors have become more customized to specific applications, many aircraft have become more tailored to an application. We expect some versatile enterprise sUAS such as the Skydio 2 to be employed across a variety of use cases. Package delivery, however, as evidenced by some of the above models, will have the most customized sUAS as a necessary function of their mission and operating environment.

Definition of sUAS Use Cases

Our assessment of the potential for each use case is informed not only by the team's own experience with sUAS and interviews conducted for this project, but also on a national and global scale based on an industry-leading forecast by the Teal Group. We discuss each of the non-passenger UAS use cases individually below. While they span a variety of applications, they share an important similarity that differs markedly from the passenger AAM use cases: they are not expected to generate a significant number of new jobs nor to provide additional revenue streams for the State of Ohio. In fact, even though sUAS are likely to provide cost savings in a variety of use cases, even that is not the primary reason businesses are adopting sUAS technology. Rather, all the non-passenger sUAS use cases will provide significant benefits by making more efficient use of resources (i.e., improving productivity), enabling the fidelity of data, increasing social benefits such as workplace safety, and diminishing environmental impact. This was a key finding in a recent survey by Drone Industry Insights that asked businesses that use sUAS their top reason for adopting them. As shown in Figure 26, while 47% of respondents said saving costs was a very important reason, 60% said saving time (a proxy for improved productivity), and 59% cited improved quality as very important reasons.[44]

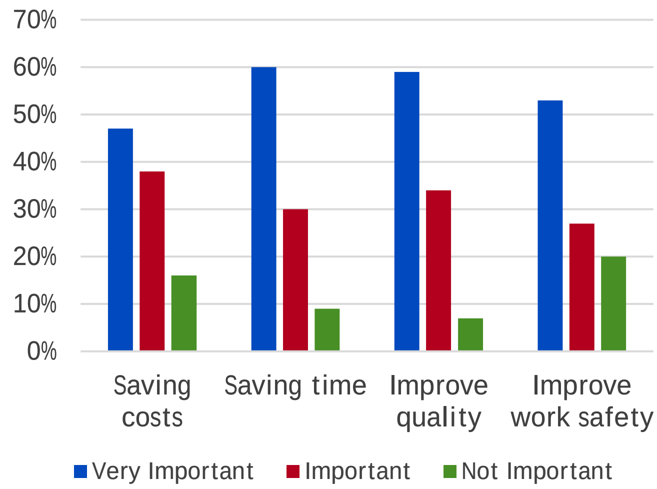


Figure 26: Reasons for Adopting sUAS

The sUAS will serve as a tool that is one of several solutions utilized to accomplish the tasks of the given use case. Fundamentally, sUAS are another tool in the toolkit of practitioners in specific fields.

The non-passenger use cases also all provide catalytic benefits with both primary and secondary effects. These catalytic benefits are considerable and, particularly in the case of package delivery, will have a significant impact on their sectors. These benefits are realized within the use case domain itself (e.g., for the medical delivery use case, the benefit is within the medical establishment), as well as beyond the use case, for example by improving public safety or the environment. Generally, these catalytic benefits increase with greater adoption of UAS technology and with advances in the technology itself.

The team reviewed numerous use cases for UAS, resulting in seven key categories determined to be most relevant to Ohio:

- Infrastructure Inspections: Bridges, Highways, Tunnels.
- Infrastructure Inspections: Airports.
- Infrastructure Inspections: Powerlines, Towers, Pipelines.
- Law Enforcement and Public Safety.

[44] Drone Industry Barometer 2020, Whitepaper, September 2020. Hamburg: Drone Industry Insights. Sample size = 227.

- Agriculture and Livestock.
- Package Delivery.
- Medical Non-Patient Delivery.

Infrastructure Inspection and Mapping: Bridges, Highways, Tunnels

Bridges, highways, and tunnels are inspected both at regular intervals, as well as on emergency bases for structural integrity. In the United States, this function is carried out by state highway agencies as well as local jurisdictions. In addition photogrammetry and technology such as LiDAR are use to map roads and large areas using a wide variety of sensors.

In Ohio, most of these inspections are carried out by the Ohio Department of Transportation (ODOT), which already operates a fleet of sUAS, on an increasing basis.

ODOT provided information to the team about its bridge inspection efforts, which have begun to incorporate UAS. There are approximately 45,000 bridges in Ohio, most of which are inspected by cities and counties.[45] ODOT inspects 14,500 annually at varying levels of detail. About 400 inspections per year require the use of snooper trucks that contain a bucket that lifts the inspector close to the underside of the bridge. For ODOT, use of the snooper trucks requires lane closures and, in the average about eight employees working eight hours per bridge inspection. With a UAS, the same bridge inspection requires only an average of two employees working four hours each. Though lane closures may still be required with UAS, they are fewer and lower in duration than when using a snooper truck.

Bridge inspection is a good example of the UAS as an additional tool; it does not replace all existing methods. Indeed, ODOT believes that only about half of the 400 snooper truck inspections could be handled by UAS. Yet, this is enough to generate considerable savings: ODOT conservatively estimates annual savings of just over 58% by splitting bridge inspections between snooper trucks and UAS evenly.[46] A less conservative estimate comes from Michigan where, according to a survey by the American Association of State Highway and Transportation Officials (AASHTO), use of UAS in lieu of snooper trucks resulted in a 74% reduction in costs.[47]

From a process standpoint, tunnel inspections with UAS experience similar benefits as bridge inspections. There are very few tunnels classified as such—approximately seven—in Ohio. The major inspection concerns are leaks and overall structural integrity. Snooper trucks may be used in cases where the logistics of lane closures pose the same challenges as they do for bridges. Many tunnel-like culverts exist by major roads and are sometimes inspected via sUAS. According to ODOT, most tunnel-like structures are the underside of bridges and are included in bridge inspection.

Highway inspections will benefit from UAS implementation as well, but the metrics are more varied than for bridges and tunnels. This is because highway inspection costs vary by location and features. A highway that is straight and flat is, in most respects, easier to inspect than one that changes elevation or curves, or both. This is not to say that a UAS cannot still be a useful tool in highway inspection, rather that its advantages may be diminished in certain conditions.

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[45] According to the ODOT Administrator of Structural Engineering, the number of bridges statewide that meet the federal definition of a bridge is 28,269 (email from David Gallagher, February 2, 2021).

[46] "How Ohio Department of Transportation Overcame 4 Major Roadblocks to Build a Drone Program", Ohio Department of Transportation, Ohio Unmanned Aircraft Systems Center, webinar, November 10, 2020.

[47] Cited in Teal Group

On a curved highway, for example, an additional visual observer may be required if the UAS must fly at a low elevation to carry out the inspection. Once BVLOS is allowed, however, it is likely that many such disadvantages in the highway arena will decrease.

In addition to the cost savings, inspectors' time is freed up, enabling them to spend more time on data analysis and developing solutions for any structural problems they identify.

The catalytic benefits of this use case include:

- Lower accident rates generated by the improved quality of inspections, as well as reduced lane closures (which can contribute to accidents) when inspections take place.
  - Lower insurance costs stemming from lower accident rates.
- Reduced traffic congestion, stemming from fewer lane closures, which generate several secondary benefits:
  - Reduced user delay costs (time savings).
  - Improved air quality.
  - Increased trade as lower congestion enhances the ability to move goods by road efficiently.

Table 14 summarizes the characteristics of the use case for Infrastructure Inspection of Bridges, Highways, and Tunnels.

Table 14: sUAS Use Case Characteristics – Infrastructure Inspection of Bridges, Highways, and Tunnels

Characteristic	Characteristic Details
Use Case	Infrastructure Inspection – Bridges, Highways, Tunnels
Payload	1-3 pounds
Infrastructure	sUAS fleet storage
Scheduling	Regular intervals and ad hoc
Locations of Flight	• Urban, suburban, rural • Low altitude
Range	Under 5 miles, possibly as far as 20 for highway w/BVLOS
Density of Operations	• Urban, suburban, rural • 1 vehicle flying per dispatch
Diversity of Vehicle Types and Procedures	• Approximately 10 different vehicle types • Multiple sensor configurations • VLOS and BVLOS

Infrastructure Inspection: Airports

Airport runways are inspected both for general runway conditions, as well as for the presence of foreign object debris (FOD). FOD is anything that could interfere with the safe operation of flights and consists of everything from broken pavement to animals to litter. Checking for FOD is primarily done with a car or truck driving at high speed down the runway. Although these inspections are generally brief, while a runway is being inspected, no take-offs or landings can take place on it. Furthermore, ground vehicles moving across active taxiways can add to airport congestion at large commercial airports. An alternative method for FOD detection is the use of small wavelength radar and cameras that minimize the need for vehicular dispatch for detection, although personnel must still be dispatched to remove any debris identified. Such systems have had limited uptake and may not be reliable in all weather conditions.

Although use of an sUAS still closes the runway to departures and arrivals, its deployment is quicker than for a road vehicle and can be done by overflying taxiways. As technology develops, it may be possible for sUAS to remove low payload debris without putting personnel on the runway. Additionally, sUAS can perform inspections of other airport areas such as perimeter fences, windsocks, and buildings as well as verification of runway and taxiway markings.

While a major commercial airport checks runway conditions several times per day, smaller general aviation airports may only do so twice per day. It is unlikely these smaller facilities will acquire a commercial sUAS for that purpose, though they may be contracted in when reviewing potential maintenance, signage, and marking work.

Additional sUAS uses include aircraft inspections after a lightening or bird strike, perimeter inspections, navigational aid inspections, and facility inspections, including parking lots and buildings.

Operation of sUAS for airport work may reside in different areas depending on the airport. FAA recently selected Rickenbacker International Airport in Columbus, Ohio as one of five host airports to test and evaluate sUAS aircraft detection and mitigation systems as part of the agency's Airport Unmanned Aircraft Systems Detection and Mitigation Research Program.[48] These airports meet FAA requirements for diverse testing environments and represent airport operating conditions found across the United States. The research will lead to the implementation of new technologies that will make airports safer for passengers and manned aircraft.

At Cincinnati Northern Kentucky International Airport (CVG), the airport's fire and police departments each have an sUAS aircraft that can be deployed for various inspection functions. An outside contractor is also used for facility inspections.[49] It is reasonable to assume that all the major commercial passenger and cargo airports in Ohio will have at least one and likely two sUAS in operation by the end of this decade. Additionally, large general aviation airports such as Burke Lakefront in Cleveland and Cincinnati's Municipal Lunken Airport would be likely to incorporate sUAS into their operations by 2045.

The catalytic benefits of the Infrastructure Inspection—Airport use case are:

- Improved aircraft arrivals and departures.
  - Reduced user delay costs.
- Reduced airfield incursion risk by removing road vehicle from taxiway.

[48] https://www.faa.gov/news/press_releases/news_story.cfm?newsId=25780
[49] Interview with Naashom Marx, Cincinnati Northern Kentucky International Airport, Dec. 15, 2020.

Table 15 summarizes the characteristics of the use case for Infrastructure Inspection of Airports.

Table 15: sUAS Use Case Characteristics – Infrastructure Inspection of Airports

Characteristic	Characteristic Details
Use Case	Infrastructure Inspection – Airports
Payload	1-5 pounds
Infrastructure	Ground station
Scheduling	Minimum 4x/day and ad hoc
Locations of Flight	• On-airport • Low altitude
Range	Under 3 miles
Density of Operations	1 vehicle flying
Diversity of Vehicle Types and Procedures	• Approximately five different vehicle types • Sensors could be integrated with existing FOD systems • VLOS, BVLOS unlikely on active airfield

Infrastructure Inspection: Powerlines, Towers, Pipelines

The infrastructure cases we have discussed thus far for sUAS involve operation by public entities. Inspection of powerlines, towers, and pipelines, however, is conducted by private industry. The Teal Group notes that this characteristic has made this use case one of the primary drivers of sUAS technology development as several entities, from large aerospace companies to smaller service companies, have sought to meet the needs of this market, and growth is expected to remain robust through the end of this decade.[50] Energy revenues have taken a hit in the wake of the COVID-19 pandemic, but the business case for accurate and cost-effective inspection has not. Environmental regulation is only expected to increase, and the energy firms are keen to ensure vigilant monitoring of their transmission and fuel transport assets. These firms not only contract in sUAS services, but they also establish large sUAS fleets of their own.

Powerlines, towers, and pipelines often traverse areas off roadways, quickly entering rural, hilly, forested areas that can be time-consuming for crews to access and navigate. Overflight by helicopter is costly and does not provide the sUAS's ability to get up close to an asset for further inspection if need be. Nevertheless, until BVLOS is established, the cost-savings of UAS will be limited, especially for transmission line inspection.

Powerline inspection includes not just inspection of the line itself, which can become damaged over time from a variety of factors, including birds, but potentially encroaching hazards such as trees. Power lines are increasing in the United States as demand for energy has increased.[51] These lines must be inspected twice per year. While LIDAR is used in some aspects of the inspection, approximately 70% of the current work involves visual inspection. DroneHive, Inc.,

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[50] Teal Group at 184
[51] Teal at 192

a U.S. service provider, recently estimated that a two-person line inspection team can inspect three utility poles per hour. It is important to note that distance between poles varies by location and topography. Separately, for the linear asset, they can cover two miles of linear asset per hour.[52] The latter could be accomplished more quickly in a BVLOS environment. Ohio has 6,983 miles of high voltage line and 112 miles of low voltage lines.[53]

Towers are also threatened by trees, but the structure itself must be inspected for cracks and corrosion on a vertical basis. Prior to the development of sUAS technology with associated sensors, the only means to accomplish this was for personnel to climb the tower. With the sUAS, the risks associated with climbing are highly minimized, if not fully eliminated. The inspector can conduct real-time analysis safely on the ground, thereby saving time in the identification of tower issues.

On pipelines, sUAS are valuable resources for detecting methane and other chemical leaks. Inspections do not just involve pipeline above ground, but thermal imaging of underground pipelines in conjunction with vegetation mapping. Frequency of inspection varies by location and use, and whether the pipeline is wholly within a state. According to Teal, a typical petroleum pipeline is patrolled (checking rights-of-way for leaks, damage, or incursions) 26 times per year to meet federal guidelines; a natural gas pipeline only requires one patrol per year. These are often conducted using fixed-wing aircraft and occasionally helicopters, which are more expensive but considered more accurate. sUAS will capture more of the market if they can deliver a high level of accuracy with improved costs, but they will need BVLOS to provide that efficiency.

Ohio plays a crucial role in the nation's shale oil and gas industry; it is fourth in terms of the 24,066 miles of natural gas gathering lines, based on a 2017 estimate. In terms of larger lines that transmit oil and gas out of state, Ohio ranked seventh at 9,796 miles.[54]

The catalytic benefits of the Infrastructure Inspection – Powerlines, Towers, Pipelines use case are:

- Higher grid reliability, less downtime.
    - Increased business and trade.
- Greater energy security.
- Improved employee safety resulting from:
    - Fewer tower climbs.
    - Fewer piloted aircraft.
        - Frees up airspace at airports and heliports.

[52] Data provided by Paul Huish, DroneHive, Feb. 8, 2021
[53] https://www.energy.gov/sites/prod/files/2015/05/f22/OH-Energy%20Sector%20Risk%20Profile.pdf
[54]https://www.bizjournals.com/columbus/news/2017/06/28/ohio-has-among-the-most-natural-gas-pipelines-in.html

Table 16 summarizes the characteristics of the use case for Infrastructure Inspection of Powerlines, Towers, Pipelines.

Table 16: sUAS Use Case Characteristics – Infrastructure Inspection of Powerlines, Towers and Pipelines

Characteristic	Characteristic Details
Use Case	Infrastructure Inspection – Powerlines, Towers, Pipelines
Payload	1-5 pounds
Infrastructure	Ground station, sUAS fleet storage
Scheduling	• Annual schedules for routine inspection • Ad hoc flying, especially post-storm
Locations of Flight	• Suburban • Rural • Low and medium altitude
Range	< 20 miles
Density of Operations	• Large fleets for oil and gas • 1 vehicle flying, possibly 2 in combined powerline/tower inspections
Diversity of Vehicle Types and Procedures	• 10-20 vehicle types • Linear and vertical assessments • BVLOS, limited VLOS

Law Enforcement and Public Safety

The small footprint of sUAS combined with new collision-avoidance technology enable law enforcement and public safety (LEPS) to better conduct operations and provide more effective security while reducing the exposure of personnel to risks. Although helicopters and fixed-wing aircraft are considered common police assets, they are used by only about 2% of U.S. law enforcement agencies because of the high cost of operation.[55] Although sUAS costs are lower, they still represent an additional cost for many fire and police departments dealing with limited budgets for equipment acquisition and training. Police agencies also face a public relations challenge when sUAS are used for routine surveillance as the public often views them as overly intrusive and a risk to privacy. Yet in those cases where sUAS have proved effective in high-risk situations and averting crises, they have fostered good will and great interest by a number of agencies. The events of 2020 stemming from the COVID-19 pandemic and political protests as well as natural disasters helped highlight some of the potential advantages of sUAS technology for this use case.

Search and rescue is one area of this use case where there is strong support. The flooding which often follows large storms and hurricanes can quickly strand victims and knock out regular communications. Public safety officers using a small sUAS equipped with speakers can fly to a stranded area, communicate updates, and get up-close photographs of the conditions affecting victims. Based on this data, rescuers can best prepare their mission and remotely triage which

[55] Teal at 102

persons need attention and which areas are most in need of immediate assistance. In more extreme circumstances, sUAS may be able to drop small survival kits and emergency supplies.

Missing person searches are expedited via sUAS. Thermal imaging sensors not only show where a person is, they also indicate where a person is not, which is particularly useful in helping eliminate areas that do not need to be searched. Such a strategy was successfully used last year in Minot, North Dakota to help locate a missing child.[56]

Firefighting has also been incorporating sUAS to get visual assessments of conditions at fires of both structures and forests. Hot spots can quickly be identified to help direct firefighters away from danger, as well as to areas that require suppression. Despite current cost considerations, we believe it is likely that every one of Ohio's 1,116 fire stations will have one sUAS by 2045, with some large stations having two or more.

Crowd control and monitoring are areas where sUAS provide much more efficient coverage than helicopters and have the advantage of much lower noise. While their use at some protests may be viewed as controversial, their demonstrated flexibility should benefit monitoring safety for popular gatherings such as large sporting events, concerts, and parades. It is possible that the trajectory of their acceptance will follow that of security cameras which, though initially viewed by some as intrusive, have become more accepted and fairly ubiquitous.

For high-risk law enforcement situations, sUAS can help limit law enforcement officers' exposure to potential harm. SWAT teams responding to hostage or barricade situations must assess the environment where a perpetrator is located as close as possible before attempting any entry or apprehension. Occasionally this requires trying to position heavily protected staff dangerously close to the perpetrator and exposure to possible booby traps. In recent decades, SWAT teams could deploy radio-controlled robots on such missions, but their slow speeds and limited use on varied terrain or on stairs negated their effectiveness. Using sUAS however, SWAT teams have been able to stay hundreds of feet away from the target, maneuver the aircraft through trees, and quickly view directly into windows and over fences to assess and diffuse situations. In fact, some departments have found the mere presence of the sUAS is enough to make a perpetrator realize their position is not tenable, thus leading to a quick and relatively safe resolution of the situation.[57]

The catalytic benefits of the Infrastructure Inspection – Powerlines, Towers, and Pipelines use case are:

- Better use of public funds.
- Increased trust/public well-being.
- Enhanced public safety.
- Quicker disaster recovery.
- More successful search and rescue operations:
    - Lives saved.
- Employee safety, ability to go where humans are otherwise in danger.
    - Lives saved.
    - Fewer injuries.

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[56] https://www.suasnews.com/2020/06/how-a-missing-child-was-found-with-help-from-drones/
[57] Skydio Round Table with First Responders – Stories from Autonomous Drones in the Field (Webinar), Dec. 16. 2020.

Table 17 summarizes the characteristics of the use case for Law Enforcement and Public Safety.

Table 17: sUAS Use Case Characteristics - Law Enforcement and Public Safety

Characteristic	Characteristic Details
Use Case	Law Enforcement and Public Safety
Payload	• 1 to 5 pounds
Infrastructure	• Ground station
Scheduling	• Ad hoc
Locations of Flight	• All areas • Low and medium altitude
Range	• < 20 miles
Density of Operations	• SWAT – 1 vehicle flying • Fire, rescue, events – 1-5 vehicles flying
Diversity of Vehicle Types and Procedures	• 10 vehicle types • Close-in and surveillance flying • Mostly VLOS, BVLOS for search & rescue

Agriculture and Livestock

Small UAS are able to perform a number of functions in this use case, including thermal mapping, crop monitoring, and livestock tracking. They can also perform seeding and spraying, but these applications, especially spraying, require additional regulatory authority.

According to the Teal Group, agricultural spraying represents the largest installed base of sUAS worldwide, but in the United States this is likely to remain a niche market because of FAA and environmental regulations. It is proving worthwhile for high-value crops such as wine grapes and berries and has gained some traction in Napa Valley, California, although with UAS that are slightly over 55 pounds. For lower-value crops, ground-based spray booms provide a more effective coverage area than low-capacity sUAS, which require multiple re-loading.

As for crop monitoring, additional improvements are required in existing sensors and software to address the myriad crops and pests that exist. The costs of hyperspectral sensors best suited to this work are high but are expected to come down over time, fostering eventual adoption. Many farmers currently rely on satellite-based imaging that meets needs to an extent, but the fidelity is measured in meters and does not work in cloudy conditions, which is where sUAS offer an advantage.

Although many farmers in the United States were among the first groups to express interest in the potential for sUAS, costs and the time needed to learn the systems were greater than anticipated. At the time the technology began to establish itself, many farmers were still struggling from the financial effects of the 2008 financial crisis. Teal estimates, however, that more farmers will take on the technology as costs lower, but that they are only likely to be farmers who generate annual income of over $100,000. It is possible seed companies will provide the equipment for seeding only, but not for general use by the farms.

The livestock sector has not yet adopted sUAS at a significant level because of VLOS requirements. Once BVLOS regulations permit, the sector will be better to take advantage of the technology for both monitoring and herding. Helicopters are occasionally used in such functions, especially the latter, though their noise can be disruptive to herds. The quieter hum of sUAS may encourage cattle to move, but at a gentler pace.

The catalytic benefits of the Agriculture and Livestock use case are:

- Better crop yield at lower cost.
- Automation of farm tasks as work force declines.
- Increased investment in crops and livestock.
    - All the above lead to enhanced food supply and food security.
- Reduced environmental impacts through:
    - Better water management.
    - Smarter use of pesticides and other chemicals.

Table 18 summarizes the characteristics of the use case for Agriculture and Livestock.

Table 18: sUAS Use Case Characteristics - Agriculture and Livestock

Characteristic	Characteristic Details
Use Case	Agricultural and Livestock
Payload	1-5 pounds
Infrastructure	Ground station
Scheduling	• Schedules based on monitoring need • Ad hoc for seeding, spraying, livestock
Locations of Flight	• Rural • Low and medium altitude
Range	< 20 miles
Density of Operations	1 vehicle flying
Diversity of Vehicle Types and Procedures	• 10-20 vehicle types • Very low altitude for specialty crops • Low altitude for spraying and seeding • Low and medium altitude for monitoring • VLOS, BVLOS for larger areas

Package Delivery

Package delivery using sUAS is the least developed of all non-passenger use cases. This is because BVLOS operations are required for the technology to be cost-effective. Flights, by necessity, must eventually take place above people and residential structures, and must ultimately safely land or otherwise deposit their payloads near residences and places of work. Yet limited trials of such applications are underway, and the potential for sUAS is a game changer for the package delivery industry.

The largest drivers of an sUAS solution for package delivery are the big shippers UPS and FedEx, as well as the world’s largest online retailer, Amazon. Each is developing its own sUAS solution, and even the parent company of Google, Alphabet, has its own delivery sUAS, known as Wing. Wing’s aircraft are already providing limited deliveries in Australia, Finland, and Christiansburg, Virginia, where it offers deliveries of coffee, food, FedEx shipments, and materials from the public school system.

In package delivery, grounds costs as a share of total shipment cost have been estimated at 30--33% for FedEx and UPS.[58] The largest portion of that cost is covering the last mile. Jenkins has estimated that cost at $2.50 based on Amazon's costs with the U.S. Postal Service, but this varies widely.[59] Except in the densest of urban settings, multiple packages are not sharing costs over the last delivery mile as the package reaches a unique address. Even urban settings pose challenges on the last mile because of traffic congestion. Teals cites figures from UPS that state last-mile delivery within a city can cost $20 to $75.[60] That cost is not directly recaptured on the shipment. To the extent an sUAS can cover this last mile at a cost below that of current road methods, it could generate significant cost savings for shippers, but the industry is not quite there. As recently as early 2019, a member of UPS's Flight Forward effort told an industry webinar that they "were still solving the economics issue."

The delivery firms are not only interested in direct cost reduction, but also in minimizing some of the hazards posed to their drivers by reaching the last mile. The less distance they drive, the less likely they are to risk collisions. They would no longer be required to enter individual properties, where they risk falls, trips on sidewalks, and threats from animals. By parking their vehicles in convenient spots for sUAS launch, they will reduce road congestion, and not just while driving. In metropolitan areas, drivers are often forced to double park their vehicles to attempt deliveries. And while delivering packages to buildings, drivers often leave large shipments temporarily unguarded.

What is the best structure for sUAS operations? One vision is to have a fleet of sUAS at numerous mini-hubs responsible for deliveries in a given range, perhaps 15 miles in the case of Amazon. Another, which is being examined by all of the firms, is for delivery vans to operate as mobile bases. The driver positions the van at a logical launching point from which they launch and monitor the sUAS to cover the last miles. In such a scenario, the precise launch location and optimum route could change each day and even on the same route to optimize the economics of the service.

On the revenue side, firms might be able to charge more for sUAS services, especially if they allow speedier delivery of items, than the case would otherwise be. Consumers have shown a willingness to pay for next day delivery versus two days or longer. A study in Utah showed that about two-thirds of online shoppers are willing to pay more for goods to be delivered faster than the standard delivery time. The study further estimated that these consumers are willing to pay an additional $10 per delivery for the faster delivery.[61] To maximize revenue potential, the ability to capture consumer surplus via sUAS delivery may depend on offering items that are already deliverable the same day, such as groceries, but with a delivery time of one or two hours instead of several hours.

In addition to the large companies providing sUAS package delivery as a replacement for truck delivery, it is envisioned that a new industry will develop with small businesses providing local package delivery, replacing courier services today.

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[58] Jenkins at 10.
[59] Ibid at 13.
[60] Teal at 164.
[61] George Mason University Study 2019: Design of On-Demand Drone Transportation System for Tooele, UT
http://nebula.wsimg.com/3f7efdc65dbe545c4bc29a7b1a2fc367?AccessKeyId=0609873DEB58FF70A0BF&disposition=0&alloworigin=1

The catalytic benefits of the Package Delivery use case are:

- Lower traffic congestion from both delivery vehicles and shoppers choosing to buy from home:
  - Greater trade as goods move more efficiently and greater variety of goods moved
  - Higher propensity to use delivery services.
  - Fewer traffic accidents and road deaths.
  - Improved environmental conditions.
  - Time savings for all road users.
- Consumer time savings.
- Lower warehousing and inventory carrying costs.
- Improved employee safety from lower traffic accidents and delivery injuries.

Table 19 summarizes the characteristics of the use case for Package Delivery.

Table 19: sUAS Use Case Characteristics - Package Delivery

Characteristic	Characteristic Details
Use Case	Package delivery
Payload	Up to 5 pounds
Infrastructure	• Fixed ground station • Mobile grounds stations (delivery trucks) • Regional control centers • Storage facilities for fleets
Scheduling	• Function of specific delivery logistics • Some on-demand
Locations of Flight	• All areas • Medium altitude
Range	• Most within 15 miles • Max 75 miles
Density of Operations	• Multiple vehicles airborne in large networks • Potentially 5-10 simultaneously from ground station
Diversity of Vehicle Types and Procedures	• 5-10 vehicle types • Delivery by landing and gentle air drop • Low and medium altitude operations • BVLOS essential

Medical Non-Passenger Transport

The medical delivery use case covers transport of blood, lab samples, organs, and pharmaceuticals. The sensitive nature of such deliveries and the dynamics of various operating environments (including socioeconomic factors) make medical delivery substantially different from standard package delivery in general, and for sUAS applications, as well. Yet these challenges have actually benefitted the sUAS case. Pilot programs in the United States and throughout the world have demonstrated that they can enhance the overall medical delivery system and public health as a result.

Zipline has pioneered dispatch of blood in Rwanda. The African nation has very poor road infrastructure outside the capital of Kigali. Yet using a specialized sUAS and proprietary UTM system, blood deliveries to rural clinics take as little as five minutes. An advantage in Rwanda is the ability to fly BVLOS, where the potential has proven itself: between October 2016 and the middle of 2020, Zipline had flown 13,000 deliveries in Rwanda and has since expanded the service to Ghana.

On medical campuses, Matternet of Mountain View, California has deployed its sUAS with four hospital groups in Switzerland. In Zurich, the system is delivering blood and lab samples on a two-kilometer network in four minutes, twice the speed of the existing road courier service. Multiplied over many such journeys per day, the time savings is significant. A similar deployment has also been established with the WakeMed Health & Hospitals system in North Carolina. The quicker delivery times of lab samples by sUAS enable quicker turnaround time of lab results, which means patients get care more rapidly.

The speed of the lab turnaround time stemming from the sUAS is not just because of the direct difference in travel time versus a road vehicle, it is because that speed generates a change in the working model of lab operations that is more efficient overall. With road deliveries, in most cases at most hospitals, lab samples are gathered into batches that are moved from the hospital to the lab two or three times per day. In addition to the drive time, the courier has to exit and enter secure areas, sometimes having to walk a significant distance and show credentials to obtain and deliver the lab specimens. With an sUAS, the cargo (sample) is loaded in a secure area close to the point it was acquired and flies to a secure location, where it is closer to lab staff. Because hospitals can send the sUAS many times per day, the labs are able to increase utilization with minimize down-time. In turn, this has led some labs to avoid batch rushes, offer more lab services, and generate additional revenue throughout the day.

Another advantage may include reducing medicine strength because of faster delivery. When a patient receives treatment sooner rather than later, they often require lower-strength medication, and less medication overall, resulting in fewer side effects. Rapid organ delivery, meanwhile, is especially valuable because every minute saved increases the potential to save a life.

While the aircraft are ostensibly similar to other sUAS, their unique cargo means their structure for cargo protection is unique. Many high-end medical products such as isotopes have to be strongly protected to maintain their integrity. Therefore, the cargo hold of an sUAS used for delivering isotopes is the bulk of the payload—much more than the isotope itself.

The catalytic benefits of the Medical Delivery use case are:

- Improved patient care through timelier test and supply deliveries.
- More lives saved through faster organ delivery.
- Decreased spoilage of time-sensitive medical cargo.
- Maximization of blood supply at critical locations.
- More efficient use of lab capacity.
- Lower traffic congestion:
    - Reduced environmental impact.
    - Time savings for all road users.

Table 20 summarizes the characteristics of the use case for Medical Delivery.

Table 20: sUAS Use Case Characteristics - Medical Delivery

Characteristic	Characteristic Details
Use Case	Medical Delivery
Payload	Up to 5 pounds
Infrastructure	• Fixed ground stations • Storage facilities for fleets
Scheduling	• Multiple daily flights for lab/blood • On demand for organs
Locations of Flight	• Within medical campuses • Urban, suburban, rural
Range	• Most under 3 miles, but longer range for rural • Max 75 miles
Density of Operations	• 1-3 vehicles simultaneously on medical campus • 1 vehicle flying in most other cases • Potentially 5-10 simultaneously from ground station
Diversity of Vehicle Types and Procedures	• 3-5 vehicle types • Significant cargo reinforcement is bulk of payload • Low and medium altitude operations • BVLOS essential

Appendix D: Ohio AAM Initiatives

The Ohio UAS Center, operating as part of the DriveOhio initiative of ODOT, is focusing on the future of mobility, managing and performing all unmanned aircraft operations for ODOT and serving as the state's one-stop shop for developing, testing, and deploying AAM technologies. Through synergy with DriveOhio and working collaboratively under one umbrella on both aircraft and ground vehicle advances, Ohio leverages resources from both sectors to make smarter decisions enhancing the diversity of a three-dimensional transportation system.

The following programs and initiatives highlight the leadership of the state in AAM efforts.

FlyOhio

The FlyOhio initiative focuses on the expansion of AAM technologies in Ohio by enabling the use of the lower-altitude airspace above cities and rural areas. This initiative, supported by OFRN, unites Ohio's aviation stakeholders to promote and advance Ohio's strong aviation history and to leverage its investments to continue its lead in the aviation industry. FlyOhio seeks to address AAM technological gaps by coordinating ongoing UAS research throughout Ohio, while identifying and pursuing future research opportunities, to make Ohio airspace among the first in the nation ready to adopt AAM.

Ohio UAS Traffic Management (UTM)

The Ohio UTM project was formed to develop a framework that can be scaled to manage lower-altitude airspace for all aircraft and all levels of autonomy. The objective is to develop a robust UTM system for the State of Ohio. Under the leadership of Ohio State University (OSU), this vision will first be implemented along the 33 Smart Mobility Corridor, offering abundant opportunities for innovative teaming of autonomous aircraft with autonomous ground vehicles.

Ohio's UTM infrastructure is a comprehensive solution for ensuring safety of flight and enabling the promise of autonomous unmanned aircraft operations in concert with the Smart Cities initiative. The envisioned UTM system is based on industry-leading active radar technology, with advanced signal processing and data fusion strategies optimized for UTM.

SkyVision

ODOT has partnered with AFRL to field and operate the award-winning ground-based detect-and-avoid (GBDAA) system at Springfield-Beckley Municipal Airport (KSGH). This system, known as SkyVision, enables UAS operations beyond visual line of sight (BVLOS) and supports detect-and-avoid (DAA) services for optionally piloted aircraft.

At KSGH, SkyVision is connected with the FAA Air Traffic Control network. Specifically, real-time data is provided from three local radars (the ASR-9 at Dayton International Airport, the ASR-9 at Columbus International Airport, and the CARSAR long-range radar at London, Ohio). Overlapping coverage provides high probability of detection (Pd) of manned aircraft flying in the unrestricted airspace southeast of KSGH.

Several aircraft OEMs have recently conducted research and development with AFRL and the Ohio UAS Center, addressing all the DoD groupings, as well as optionally piloted vertical takeoff and landing (VTOL) and conventional takeoff and landing (CTOL) concepts.

Remote Tower Plans

The concept of remote or virtual tower (R-TWR) has entered the world of air traffic control within the past decade. This concept uses an array of sensing and communication technologies on the airfield and in the surrounding airspace, while performing the control functions using certified controllers in a separate facility at the same airfield or remotely at a considerable distance. In the case of low-activity airports, it is possible to locate controllers responsible for several small airports in a single remote tower center.

The State of Ohio's strategy includes implementing an R-TWR infrastructure for deployment at selected airports in Ohio, incorporating the FAA selection criteria for the pilot program outlined in the 2018 FAA Reauthorization Act. This approach will enhance the safety of manned aircraft operations and will become part of the infrastructure enabling unmanned operations under positive control throughout the state. The remote tower pilot program provides a cost-effective alternative to control air traffic without the need for a brick-and-mortar air traffic control tower, enabling the rural-to-urban transportation mode of AAM.

Vertiport Planning with NASA Ames

The Ohio UAS Center is working with NASA Ames, using their vertiport design tool to identify vertiport locations in urban environments within Ohio's seven largest cities. The work includes community outreach working with cities, local representatives, and planning commissions to gain support for NASA AAM NC by demonstrating vertical take-off and landing (VTOL) operations, collaborating on location analysis, defining business use cases for UAS technology, and providing a better understanding of how UAS will change the transportation landscape.

33 Smart Mobility Corridor

The 33 Smart Mobility Corridor serves as a real-world proving ground for autonomous and connected aircraft with high-capacity, fiber-optic cables and roadside sensors to link researchers and traffic monitors. Smart corridor initiatives like these will help accelerate the deployment of AAM in Ohio.

Combined Aircraft Sensor Network to Detect and Track Lower Altitude Aircraft

Ohio has the goal of creating a comprehensive framework combining all low-altitude airborne sensor data (including data from local, state, and federal entities) into a centralized clearinghouse. This data will be kept and managed through a statewide low-altitude air traffic monitoring center and be accessible to all interested parties. This project will enhance the safety and security of aircraft operations in lower-altitude airspace throughout the State of Ohio.

Elevating West Virginia: a Vision for Advanced Air Mobility

January 2024

Deloitte.

Contents

Glossary of Acronyms and Abbreviations

AAM	Advanced Air Mobility
ACI	Advanced Composite Institute
AHP	Analytical Hierarchy Process
AIP	Airport Improvement Program
ARC	Appalachian Regional Commission
ASSURE	Alliance for System Safety of UAS through Research Excellence
BEAD	Broadband Equity Access and Deployment
BKW	Raleigh County Memorial Airport
CKB	North Central West Virginia Airport
CRW	West Virginia International Yeager Airport
C2	Command and Control
DAA	Detect and Avoid
DARPA	Defense Advanced Research Projects Agency
DOT	Department of Transportation
EAS	Essential Air Service
EBD	Southern West Virginia Regional Airport
EMS	Emergency Medical Services
FAA	Federal Aviation Administration
GDP	Gross Domestic Product
I28	Innovate28
LAM	Low-Altitude Mobility
MAAC	Mid-Atlantic Aerospace Complex
MOF	Mobile Operations Facility
NASA	National Aeronautics and Space Administration
NPIAS	National Plan of Integrated Airport Systems
NRQZ	National Radio Quiet Zone
NTIA	National Telecommunications and Information Administration
RAM	Regional Air Mobility
RCC	Remote Control Center
SIRN	Statewide Interoperable Radio Network
STEM	Science, Technology, Engineering and Math
SWVCTC	Southern West Virginia Community and Technical College
UAM	Urban Air Mobility
UAS	Uncrewed Aircraft Systems
VTOL	Vertical Takeoff and Landing
WV	West Virginia
WVU	West Virginia University
WV-AEIM	West Virginia Advanced Energy and Industrial Technology Manufacturing

Executive Summary

Advanced Air Mobility (AAM) is a step-change in aviation that is revolutionizing the transportation of people, goods, and services throughout the United States and transforming the economy. In the U.S. alone, the AAM market is estimated to reach $115 billion annually by 2035, employing more than 280,000 high-paying jobs.[1]

In 2023, the FAA released their Innovate28 (I28) plan, targeting AAM integration in key locations by 2028. This plan represents a call to action for states by highlighting the importance of state and tribal government leadership in enabling AAM operations.[2] Several states are responding to this call and recognizing the benefits AAM can provide to their communities and economies. States that enable safe, sustainable, scalable AAM deployments can become early adopters and beneficiaries of this revolutionary technology. With many state and industry efforts focusing on AAM for complex urban environments, West Virginia has the chance to pioneer rural AAM integration.

West Virginia's strategic location, situated within a 500-mile radius of 40% of the U.S. population, positions it as a promising hub for regional connectivity. The state's challenging topography and rugged landscape have historically created obstacles for traditional transportation systems, providing a demand for innovative solutions. With remote areas, diverse demographics, and varied weather conditions, West Virginia offers a range of testing environments for AAM aircraft as they mature through type certification.

West Virginia also has unique assets and accelerators that could provide a foundation for AAM, spanning a diverse aerospace and innovation ecosystem, unique funding mechanism and incentives, conducive policies, and supporting infrastructure. Strategically leveraging and building upon these assets and accelerators would offer a once in a generation opportunity to strengthen the state's technology and innovation capabilities.

Enabling AAM in West Virginia would unlock several economic and societal benefits, assuming technology maturation and integration will be realized. Establishing an AAM industry could create almost 5,500 jobs and generate an additional $29 million in annual state tax revenue. Additionally, AAM could reduce costs for operators by $40 million annually, including public operators spanning state and local government applications. AAM would present high-paying job opportunities, encouraging upskilling of the current workforce and attracting new residents to the state. Lastly, AAM would improve the quality of life for West Virginians by providing a safe, affordable, accessible, and equitable form of transportation for people and cargo, connecting historically isolated or underserved communities with essential goods and services.

Economic Benefits of AAM in WV

Create Jobs

5,417 NEW JOBS created in West Virginia by enabling high-priority AAM applications.

Increase Tax Revenue

Over **$29 MILLION IN ANNUAL STATE TAX REVENUE** generated by AAM-related jobs, business revenue, and property.

Reduce Costs for Operators

Over **$40 MILLION IN ANNUAL COST SAVINGS** for operators, including operational savings and hazard savings by leveraging AAM.

Societal Benefits of AAM in WV

Upskill, Retain and Grow Workforce

AAM creates a wealth of **SPECIALIZED, HIGH-PAYING JOBS**, offering an avenue for **UPSKILLING CURRENT WORKFORCE & DRAWING NEW RESIDENTS** to the state.

Improve Access to Transportation, Goods, & Services

AAM enhances **QUALITY OF LIFE FOR RURAL RESIDENTS** by bridging gaps in access to transportation options & delivery of vital goods & services.

To unlock the full spectrum of benefits that AAM can offer the state, West Virginia needs a state government-led approach to strategically capitalize on and enhance its existing assets, fostering the development and maturation of the AAM industry within its borders. As such, Vertx retained Deloitte to develop this report to introduce AAM capabilities, highlight and benchmark West Virginia's current assets and accelerators, identify high-priority AAM application for the state, and outline potential next steps for West Virginia (below).

While the AAM industry is still emerging, West Virginia should take next steps and act swiftly to build momentum toward the early development and adoption of AAM. A failure to act quickly and decisively may result in a lost opportunity as other states make significant investments in AAM development and infrastructure.

NEXT STEPS FOR WEST VIRGINIA

- Engage with Stakeholder Groups Aligned with High-Priority AAM Applications
- Expand the West Virginia UAS Advisory Council to Include Working Groups
- Establish an AAM Focal Point within State Government
- Scale Mingo County K-16 AAM Curriculum across the State
- Integrate AAM Applications into Government Operations with Standardized Training
- Coordinate with Regional Players in Neighboring States
- Designate State Funding for AAM
- Maintain Harmonization of State AAM Legislation with National Frameworks
- Leverage Mobile AAM Infrastructure while Developing Permanent Infrastructure
- Establish Facilities for AAM Training and Testing

Ecosystem
Funding
Policy
Infrastructure

Introduction

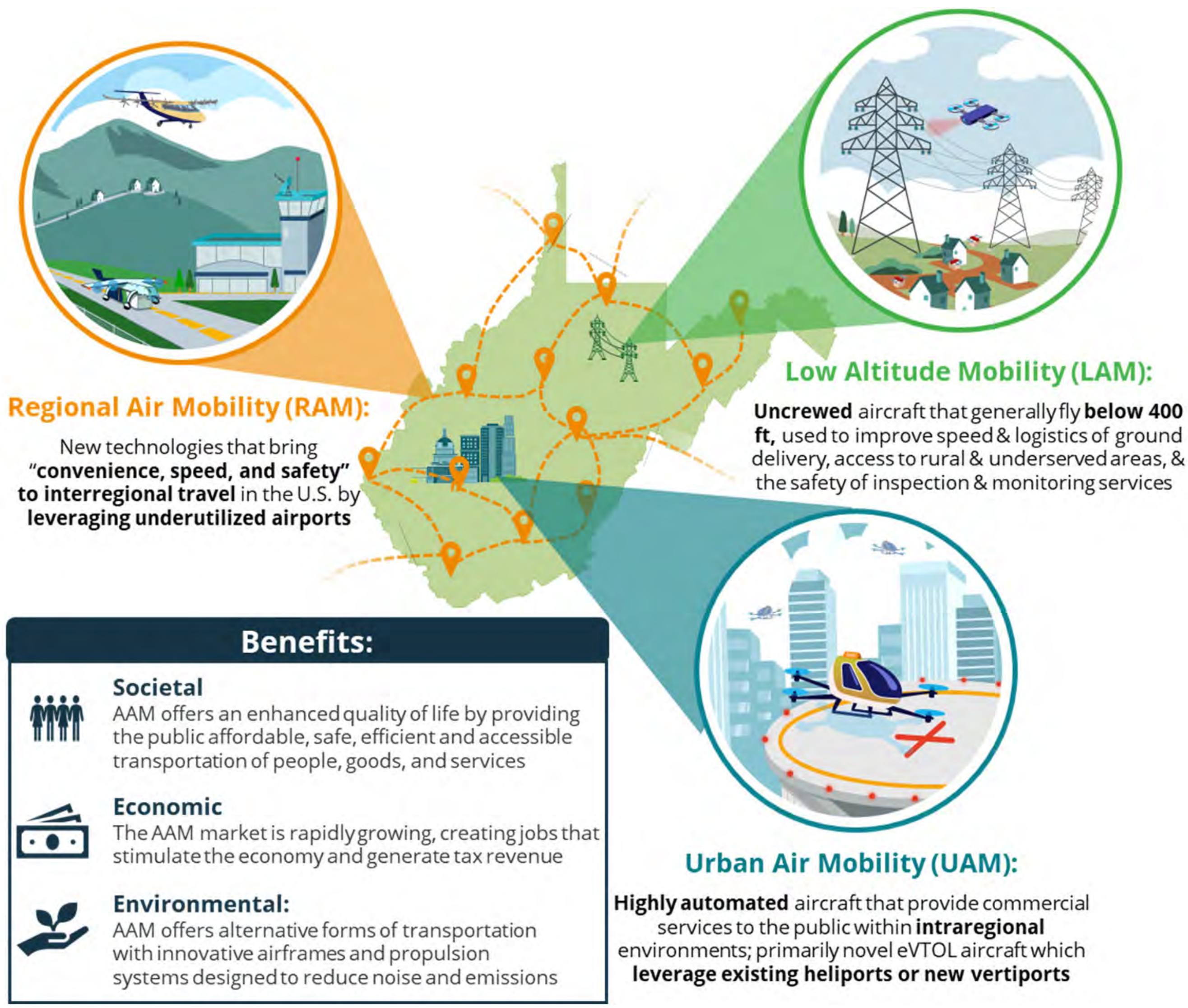
Advanced Air Mobility: the next inflection point in transportation is here

Advanced Air Mobility (AAM) is a rapidly evolving field, encompassing a range of technologies that offer the potential for safe, sustainable, affordable, and accessible aviation transportation.

NASA's vision for AAM is to use emerging aircraft and technology to safely develop an air transportation system that reaches places throughout the United States that were previously not served or underserved by aviation. [3]

These enabling technologies include novel airframe designs, innovative propulsion systems (e.g. electric aircraft), increased levels of automation and connectivity (e.g. uncrewed or autonomous aircraft), and the supporting infrastructure needed to integrate AAM into a broader multimodal transportation network. Experts expect AAM to apply to three main application categories: Regional Air Mobility (RAM), Urban Air Mobility (UAM), and Low Altitude Mobility (LAM).

Exhibit 1: Advanced Air Mobility Defined by Three Application Categories



Regional Air Mobility (RAM) - the concept of directly transporting people and goods between regions - has been around for decades but is on the verge of a resurgence with a heightened demand and new possibilities offered by new technologies. RAM is envisioned to provide convenient, fast, and safe interregional transportation by leveraging underutilized aviation assets, including airports, to address the needs of underserved communities.

Low-Altitude Mobility (LAM) - is an aviation application category that has gained momentum in recent years. In general, LAM refers to uncrewed aircraft systems (UAS) that operate at altitudes below 400 feet. These UAS are instrumental in expediting ground delivery logistics, asset monitoring and inspection, and providing vital links to rural and traditionally underserved communities. Furthermore, LAM plays an increasingly pivotal role in public safety, where first responders can utilize these systems for swift aerial assessments during emergencies and rescue operations.

Urban Air Mobility (UAM) - is an application category that aims to provide commercial intra-regional flights to the public using highly automated aircraft. UAM aims to leverage advanced technologies and new operational procedures to enable practical, cost-effective air travel as an integral mode of local transportation.

Within these three application categories, numerous applications exist that could enhance the quality of life for communities. AAM has the potential to enable greater mobility and access through alternative transportation options to travel to new connection points. Studies also suggest AAM will connect rural hubs and provide delivery options for greater equitability and accessibility. Additionally, AAM could reduce aviation's operational impact on the environment making it more sustainable through innovative propulsion systems (e.g. electric or hydrogen) and airframe designs that may reduce emissions and noise during operation.[4]

A booming market: the U.S. AAM market is poised to grow to approximately $115 billion annually by 2035

The breadth of AAM applications and enabling technologies offers new and extended business opportunities for industry players spanning the infrastructure, manufacturing, supply chain, fleet management, and software spaces. In addition to the commercial utility these technologies provide, many aspects of AAM offer dual use with military applications, driving the demand for AAM even further.

Several industry players are harnessing these opportunities and showing that AAM is no longer a far off, futuristic concept, but rather is a very real step-change in transportation happening today.

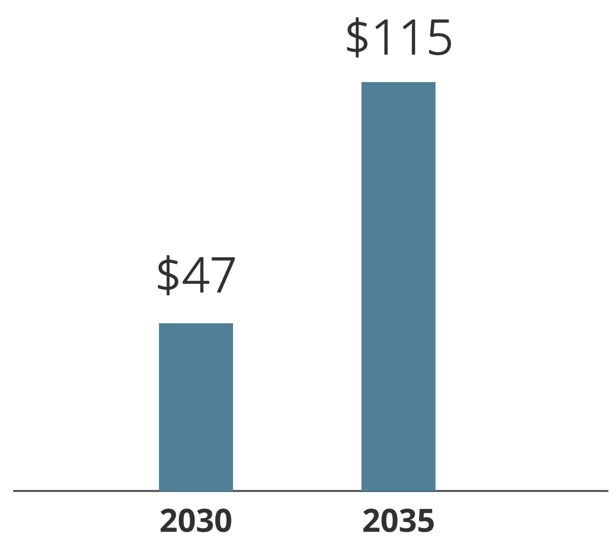
Public-private partnerships across the country are actively designating, planning, or constructing RAM and UAM vertiports for vertical take-off and landing (VTOL) AAM aircraft, as seen in Los Angeles, California,[5] Arlington, Texas,[6] and Orlando, Florida,[7] to name a few. Several energy and utility companies are already performing LAM operations, such as ExxonMobil[8] and Dominion Energy,[9] using UAS to inspect and monitor their infrastructure.

With such a breadth of technologies and applications being developed and used, the AAM market is expansive and rapidly growing.

In the U.S., the national market is projected to grow sevenfold by 2035, reaching $115 billion annually and generating $8 billion in tax revenue by employing more than 280,000 high-paying jobs.

The tax revenue from AAM related jobs will only continue to increase over time for state and local governments that enable the industry.[1]

Exhibit 2: Projected U.S. AAM Market (in billions of USD)[1]



A Call to Action: the FAA's 'Innovate28' Plan for AAM integration by 2028

2023 was a banner year for AAM with the FAA's release of their Innovate28 (I28) plan, which aims to enable AAM operations at scale at one or more "key sites" by 2028. The FAA plans to identify these key sites based on locations and AAM applications of interest to AAM industry stakeholders while promoting an all-hands-on deck approach to guarantee the necessary steps are taken to enable these operations. The I28 plan outlines a "crawl-walk-run" approach which will leverage existing infrastructure, regulations, and procedures to support earlier entry into service.

Innovate28 highlights the importance of local, state and tribal government leadership in the coordination, logistics, zoning, licensing of infrastructure, and the community engagement necessary to support AAM operations.[2]

Navigating the new horizon: state government roles in advancing AAM

This nascent new era of aviation, poised to redefine mobility across urban and rural landscapes alike, is drawing significant attention and action from various state and tribal entities aiming to get ahead of this rapidly advancing field (Exhibit 3).

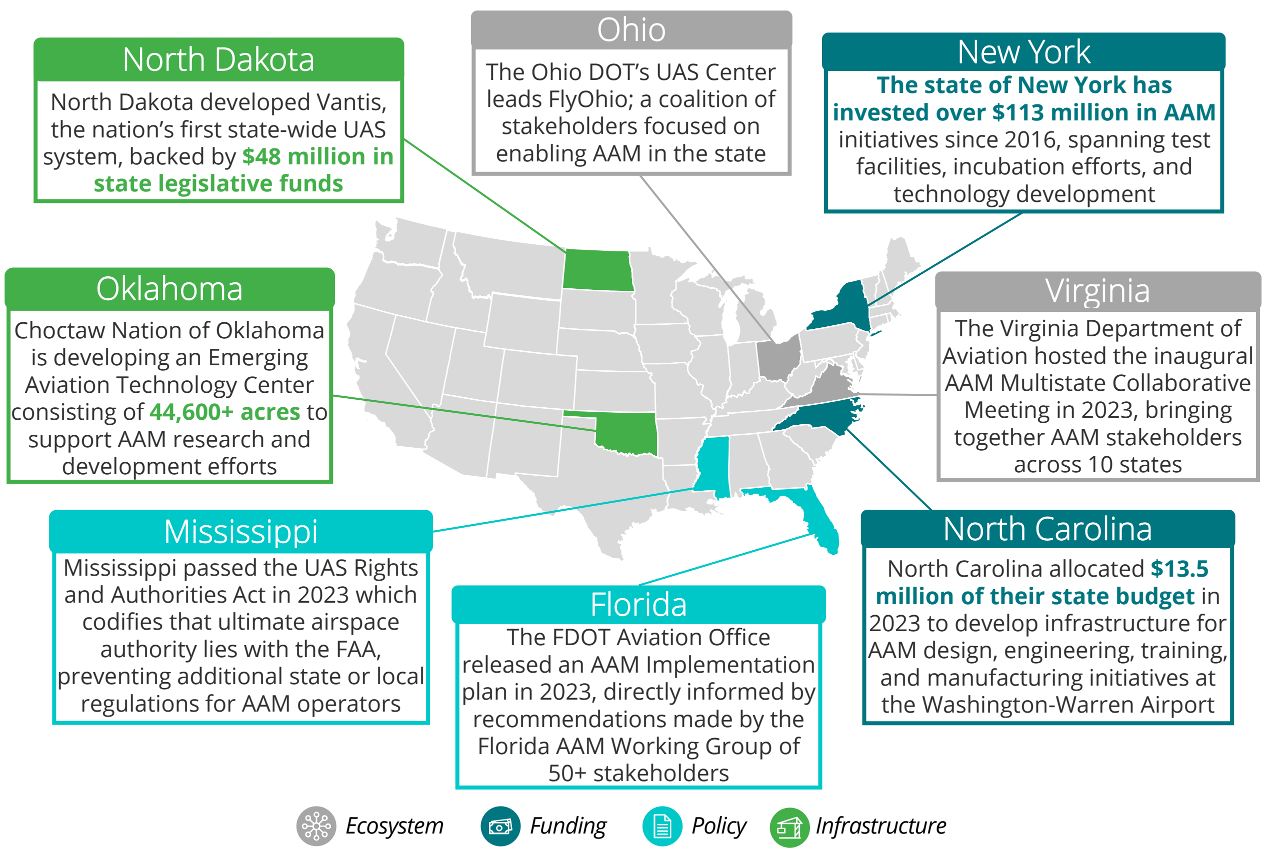
Four common and interdependent themes emerged as key pillars when considering state and tribal roles in AAM efforts:

- **Ecosystem:** Active state support of and engagement with the AAM ecosystem
- **Funding:** Diverse funding channels and mechanisms to support AAM
- **Policy:** Proactive policies that are conducive to AAM testing and operations
- **Infrastructure:** Development and maintenance of essential infrastructure to support AAM testing and operations

Attracting and maturing the AAM industry will occur faster in regions with strong assets and accelerators across these four pillars, offering industry support and incentives, conducive policies, lower barriers of entry, and supporting infrastructure.

One such state that holds potential to become a driver and early adopter of AAM is West Virginia. If the state acts strategically, West Virginia has an opportunity to shape their role as a contributor to the national AAM plan and tap into the projected $115 billion market.

Exhibit 3: Examples of State and Tribal AAM Efforts



West Virginia: potential to be the next proving ground for AAM

West Virginia's location, rugged landscape, and local demand for accessible, multimodal transportation provide many opportunities for early AAM research and operations.

West Virginia is strategically located between numerous major metropolitan centers[10] including Washington, D.C.; Pittsburgh, Pennsylvania; Lexington, Kentucky; and Columbus, Ohio. Bordering five states, West Virginia lies within a 500-mile radius of 40% of the U.S. population[11] and is home to 23 airports included in the FAA's National Plan of Integrated Airport Systems (NPIAS). This positioning is particularly significant considering the current range limitations of many RAM aircraft, which is typically less than 300 nautical miles.[12]

West Virginia could serve as an essential connection point in the AAM network, effectively bridging the Midwest to the East coast.

The state's topography - characterized by steep mountains, narrow valleys, and winding roads - has historically hindered the development of efficient and cost-effective traditional transportation systems in West Virginia, prompting a need for innovative solutions to address these challenges. Over 81% of West Virginia's population lives in rugged terrain (measured by road topographical variations), which is the highest proportion in the United States,[13] and more than 24% of West Virginia's rural residents lack access to intercity transportation including air, rail, and bus services.[14]

The state's extensive road system, overseen by the West Virginia DOT, comprises of 34,420 miles of roads and highways, representing the sixth-largest state-maintained system in the nation.[15] Annually, West Virginia's road system costs the state about three times more than the revenue it generates.[16] In comparison, West Virginia's aviation system only costs the state about two times more than the revenue it generates, showing a promising return on investment.

Exhibit 4: West Virginia's AAM Potential

Positioned to be a Regional Hub

Situated within 500-mile flight radius of 40% of the U.S. population, bridging several metropolitan centers in the Midwest and East Coast.

Demand & Opportunity for Innovative Transportation

More of the population lives in rugged terrain than any other state, as measured by topographical variations in roadways, posing challenges to road development and maintenance as well as overall access to ground-based transportation access.

Rugged Landscape offering Diverse AAM Testing Environments

Remote areas, rugged landscape, diverse demographics, and weather conditions offering a range of testing and operating environments for AAM aircraft as they mature and pursue type certification

West Virginia's neighboring states have seen a resurgence in commercial air travel in recent years, with Virginia experiencing a 49% increase in deplanements from 2021-2022, equating to 9 million more passengers arriving in Virginia annually. Ohio, Kentucky, and Pennsylvania have also seen double digit growth within that time, whereas West Virginia saw a modest growth of 7%.[17] The promising return on investment for aviation in West Virginia, paired with the slow growth of passenger air traffic in the state, offers demand for affordable AAM routes to drive growth in passenger traffic and state revenue.

West Virginia's landscape and demographics – spanning urban, suburban, and rural areas - offer a range of testing and operating environments for AAM aircraft as they mature and pursue type certification. As the National Academy of Sciences noted in its 2020 AAM National Blueprint, there is no suitable test airspace available on a dedicated basis for aerial mobility developers focused on commercial applications,[18] showing demand for a commercial test environment.

Over two dozen AAM aircraft and propulsion system manufacturers are currently engaging with the FAA, with nearly half of them reaching maturity levels for flying testbed prototypes.[2] West Virginia's mountainous regions and diverse topography paired with varying weather conditions throughout the seasons offer opportunities to test the agility, maneuverability, and stability of these aircraft in challenging landscapes and climates.

Additionally, remote areas in West Virginia where ambient noise levels are relatively low could provide test environments to assess environmental impact of AAM including noise, which the FAA deems as one of the primary environmental challenges to the continued growth of aviation.[2]

The state's geographic hurdles and underserved communities create an opportune space for AAM services to bridge accessibility gaps. By leveraging the existing infrastructure and meeting the demand for alternative transportation, AAM services have the potential to revolutionize travel in the state.

With little competition in this sector and a receptive environment buoyed by state incentives, West Virginia has the opportunity to address its historical transportation limitations and potentially pioneer a futuristic approach to mobility, offering efficient, accessible, and innovative transportation solutions for its residents as a crucial hub for regional connectivity.

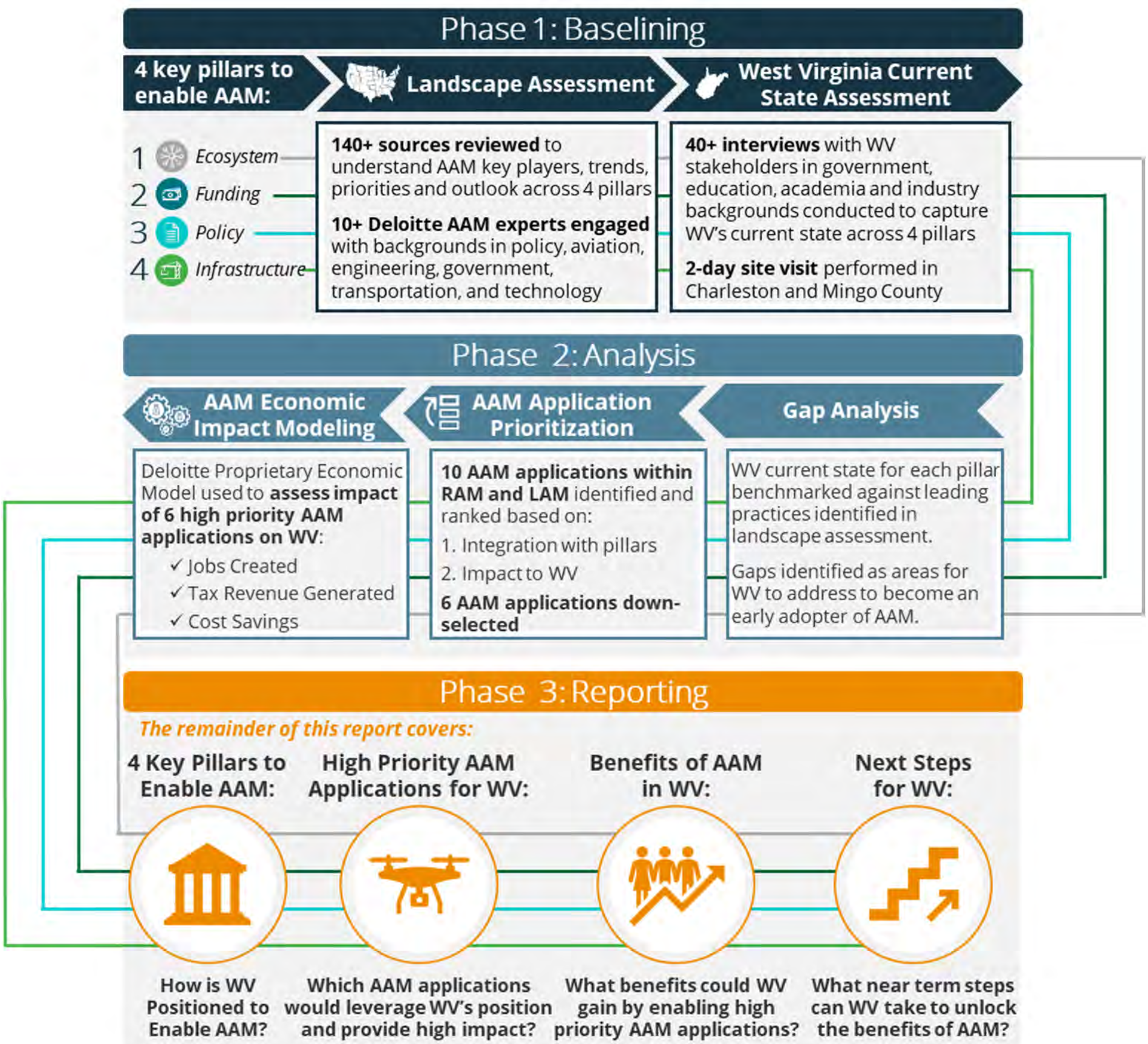
Project Methodology

A three-phase approach to assess and harness AAM's potential in West Virginia

A three-phased approach was conducted to gain a holistic understanding of West Virginia's capabilities, needs, and advantages regarding AAM, as outlined below (Exhibit 5).

The common thread between each phase are the four key pillars for enabling AAM in a state - Funding, Ecosystem, Policy, and Infrastructure – which were considered throughout every project step.

Exhibit 5: Project Methodology



Phase 1 established a baseline by an AAM landscape assessment and a current state assessment of West Virginia. The landscape assessment included leveraging over 140 online sources and over ten AAM experts and SMEs to identify AAM players, state trends, national priorities and industry outlooks across the four key pillars. The project involved conducting over 40 interviews with West Virginian AAM stakeholders spanning government, education, academia, and industry backgrounds paired with a two-day site visit in Charleston and Mingo County. Insights from the interviews and site visits identified West Virginia's current assets and enablers across the four pillars that could be leveraged for AAM.

The baseline established in Phase 1 was analyzed in Phase 2 through a gap analysis, AAM application prioritization, and economic impact modeling. The gap analysis benchmarked West Virginia's current state of each pillar to leading practices identified by the landscape analysis; comparing West Virginia to other states and AAM leaders. The discrepancies between West Virginia's current state and the benchmarks were categorized as gaps, pointing to opportunities for development for West Virginia to address in each pillar to position itself as an early adopter of AAM.

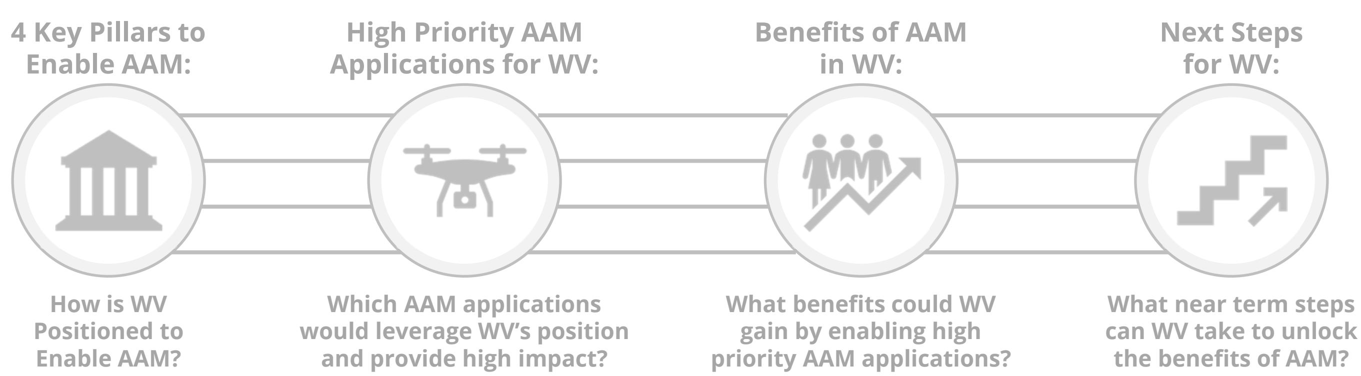
The AAM application prioritization step identified and ranked ten AAM applications within the RAM and LAM application categories (e.g. last-mile package delivery or regional commuter transportation) considered most relevant to West Virginia's capabilities and needs. The applications were assessed based on two goals:

1) Integration into West Virginia's current assets across each pillar
2) Impact to West Virginians

Six AAM applications emerged as high priority for West Virginia, which were then inputted to a proprietary economic model to determine the economic benefits that would be generated in West Virginia if the state enabled those AAM applications.

The insights from Phase 2 were used to inform the remainder of this report, which outlines West Virginia's current position and progress towards becoming an early adopter of AAM, the high-priority AAM applications West Virginia should consider, the benefits West Virginia would gain by enabling the high-priority AAM applications, and next steps for West Virginia to unlock those benefits.

The following section will highlight and benchmark West Virginia's current AAM enablers across four key pillars: Ecosystem, Funding, Policy, and Infrastructure, answering the question **"How is West Virginia currently positioned to enable AAM?"**



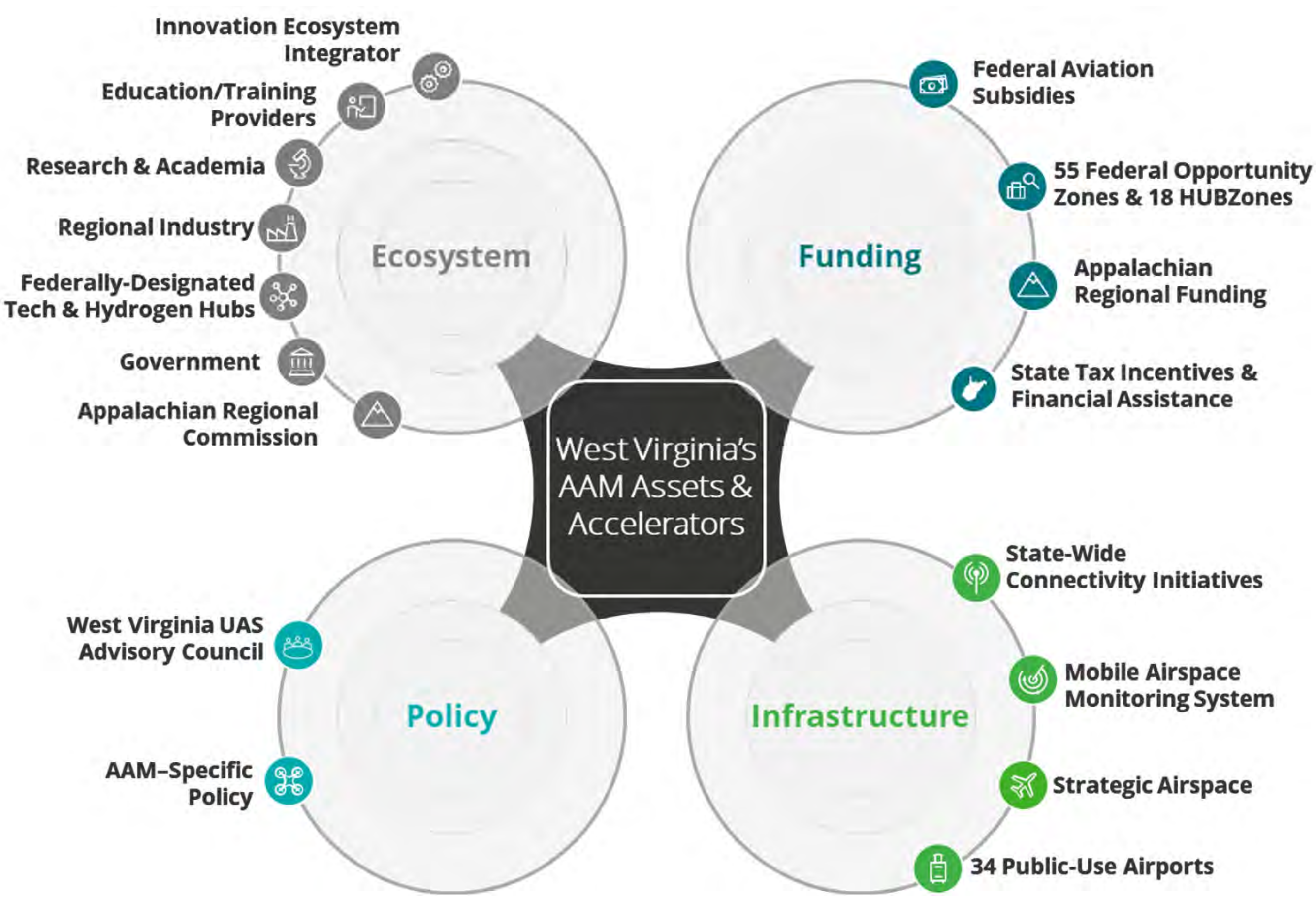
Four Key Pillars for Enabling AAM in West Virginia

How is West Virginia currently positioned to enable AAM?

With several nationally recognized assets and accelerators (Exhibit 6), West Virginia holds potential to become an early adopter. This segment delves into a comprehensive examination of West Virginia's capabilities within the foundational pillars that are vital for fostering AAM: Ecosystem, Funding, Policy, and Infrastructure.

By methodically comparing these assets to the established benchmarks from leading states in AAM, this section aims not only to map out West Virginia's current standing, but also to pinpoint strategic areas that require attention and development. Through this analytical benchmarking, the report seeks to craft a pathway for West Virginia to fully realize and harness its potential in the AAM space.

Exhibit 6: West Virginia's AAM Assets and Accelerators



Ecosystem

West Virginia's Current AAM Ecosystem

A diverse and collaborative ecosystem across the state is needed to enable AAM. As the industry continues to mature, the environment required to accelerate and sustain AAM capability will also expand.

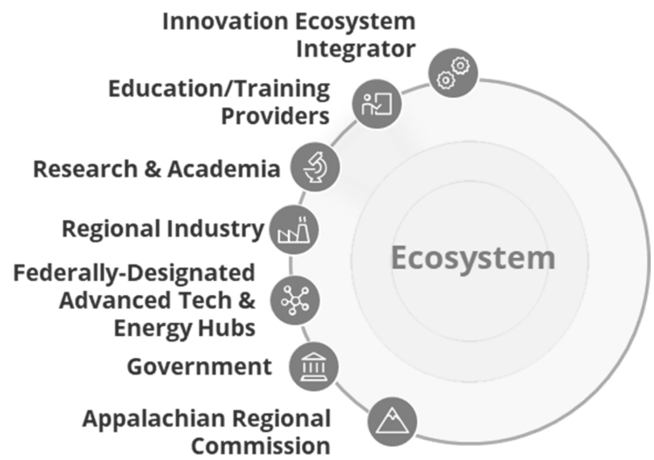
West Virginia has a vast network of organizations across academia, private industry, and government that could each play a role in the development of AAM capabilities, generating distinct benefits for each stakeholder if properly coordinated (Exhibit 7).

Innovation Ecosystem Integrator
Vertx Partners is an innovation ecosystem integrator, providing leadership in the advancement of AAM in West Virginia. By forging strategic partnerships across industry, academia, and government, Vertx Partners is dedicated to fostering innovation, collaboration, and sustainable economic growth in the state. Their role as an integrator is evident in initiatives like orchestrating the inaugural Aerospace, Aviation, and AAM Coalition meeting in 2023, emphasizing the intersection of statewide education and industry to propel the growth of AAM. [19]

Education/Training Providers
Foundational to this extensive network, West Virginia provides an array of educational and training programs, encompassing primary through post-secondary levels. While not specifically established for AAM, these programs have the potential to be aligned and effectively utilized to develop a robust and resilient workforce.

For grades K-16, the Mingo County Redevelopment Authority, in collaboration with Marshall University and Vertx Partners, is developing and will pilot a NASA-funded AAM curriculum to be deployed across the entire state.[20] West Virginia also offers several post-secondary programs for vocational training, apprenticeships, or advanced degrees in AAM-related fields.

Exhibit 7: West Virginia's AAM Ecosystem



Innovation Ecosystem Integrator
Vertx Partners builds partnerships to foster innovation, collaboration, and sustainable economic growth in WV

Education & Training
K-16 AAM & STEM curriculum, Marshall Advanced Manufacturing Center, Bill Noe Flight School, Southern West Virginia CTC Drone Technology Course, Blue Ridge CTC Applied UAS Technologies Certificate, Fairmont State University Aviation Center of Excellence, Pierpont CTC Aviation Maintenance Program

Research & Academia
West Virginia University, Marshall University, ASSUREd Safe

Regional Industry
Mid-Atlantic Aerospace Complex (MAAC), Aerospace, Manufacturing, Energy

Federally-Designated Advanced Tech & Energy Hubs
Ecosystem clusters to drive rapid growth in advanced industrial technology and alternative energy

Government
State & local government efforts for transportation & infrastructure development, economic growth

Appalachian Regional Commission
Economic development partnership between Federal government and 13 state governments in Appalachia

For example, Marshall University's Advanced Manufacturing Center provides hands-on training in advanced machining and welding[21] – trades that are essential for fabricating AAM technologies. Marshall also offers the Bill Noe Flight School and the Aviation Maintenance Technology program, both integrating UAS into their curriculum and using commercial-grade UAS for hands-on training.

Additionally, both Southern West Virginia Community and Technical College (SWVCTC) and Blue Ridge Community and Technical College offers UAS courses which have been selected by the FAA's UAS College Training Initiative as programs that prepare students for careers with drones.[22] These are just a few examples of programs that build knowledge, complementary to traditional research and academia, to develop a well-rounded AAM education across the workforce.

Research & Academia

Multiple universities in West Virginia are also conducting research in technologies that will be integral to AAM advancement. This includes West Virginia University's (WVU) research in UAS – a category of AAM aircraft – spanning UAS design, flight testing, and mission planning with support from federal agencies such as NASA and the Defense Advanced Research Projects Agency (DARPA).[23] Researchers at Marshall University received funding from the NASA West Virginia Space Grant Consortium to investigate potential vulnerabilities and threats to wireless communications for drones,[24] which must be mitigated for safe AAM operations. Mississippi State University and their Centers and Institutes such as the FAA's Alliance for System Safety of UAS through Research Excellence (ASSURE) and the Advanced Composite Institute (ACI) are also actively engaged in West Virginia. Through the ASSUREd Safe program, West Virginia is helping to advance the standards, education, training, testing, certification and credentialing of first responders' use of UAS for public safety and disaster operations while advancing innovative and high-tech composite manufacturing through the ACI.[25]

Regional Industry

Complementing these academic efforts, West Virginia's well-established manufacturing and aerospace industry could support several phases of the AAM supply chain or leverage AAM in their current operations. Examples of aerospace manufacturing facilities throughout the state include Pratt & Whitney, Aurora Flight Sciences – a Boeing Company, Lockheed Martin, Northrop Grumman and Collins Aerospace[26] which significantly contribute to West Virginia's $1.35 billion annual aerospace industry. Historically adding $486 million to the state's GDP and over $24 million in state and local taxes.[27]

The Mid-Atlantic Aerospace Complex (MAAC) and the North Central West Virginia AeroTech Park, both strategically located at North Central West Virginia Airport (CKB), additionally contribute significantly to this network. MAAC is home to 11-member aerospace companies specializing in maintenance, overhaul, manufacturing, or training capabilities. The complex is a major economic driver for the region, employing over 1,300 in aviation jobs and generating an economic impact exceeding $1 billion.[28] The impact of the aerospace industry presence at CKB continues to grow, with the AeroTech Park planning the construction of a new airport terminal, a 100-acre Tech Park, and a new parking facility. The development of the park is projected to create over 1,000 jobs, and potentially double the airports annual economic impact to more than $2 billion.[29] [30] Both entities aspire to significantly increase their economic contribution to the region, and depending on market appetite, could play a big role in expanding and welcoming industry to the state to play within the AAM space

Federally-Designated Advanced Tech & Energy Hubs

Supporting West Virginia's manufacturing and aerospace sectors, there are federally designated industrial technology manufacturing and energy ecosystem clusters. These clusters function as enablers, providing critical technologies and resources for the manufacturing and powering of AAM aircraft and infrastructure. The West Virginia Advanced Energy and Industrial Technology Manufacturing (WV-AEIM) Hub was awarded in 2023 under the CHIPS and Science Act to bring together members from industry, academia, and government to establish advanced energy and material manufacturing and emerging technologies in United States while building a resilient supply chain across West Virginia.

This includes a focus on advanced energy storage solutions and carbon and graphite materials,[31] which are supporting components for various AAM aircraft designs. The Appalachian Regional Clean Hydrogen Hub (ARCH2) was established with $925 million in 2023 by the Department of Energy to create a network of hydrogen-based energy and products manufacturing.[32] Programs such as these bring together ecosystem players that could provide alternative energy for powering AAM aircraft and significantly reduce carbon emissions.

Government

In additional to Federal efforts, West Virginia hosts several state and local government departments and initiatives that could contribute to AAM efforts in the state. For example, by combining previously separate divisions in 2022, the West Virginia DOT established their Division of Multimodal Transportation Facilities - focused on ports, aeronautics, public transit, and the railway - to promote close cooperation between agencies.[33] This streamlined approach allows for more effective coordination and communication between sectors such as aeronautics and public transit, creating an environment conducive to AAM development. Shortly after its establishment, the Division of Multimodal Transportation Facilities provided a funding match for the expansion of West Virginia International Yeager Airport (CRW), demonstrating a priority of expanding the aviation sector in the state[34], which is a critical component of AAM. This integrated approach not only enhances infrastructure development but also signals a strategic priority to bolster the state's aviation capabilities, aligning with the broader goals of AAM expansion and regional connectivity. The West Virginia DOT also conducts LAM operations with a dedicated team of two full-time and 20 part-time pilots, managing a fleet of 18 aircraft for mapping and media operations.[35] This showcases a proactive approach to leveraging AAM technologies and recognizing the benefits they can provide.

The Mingo County Redevelopment Authority stands out as a significant advocate for AAM, with the previously mentioned K-16 AAM curriculum development being just one of three initiatives they are advancing through a $2.9 million NASA grant secured via Congressionally Directed Spending. The Mingo County Redevelopment Authority is also supporting the development of state-wide programs that encourage AAM-related entrepreneurism (e.g. tourism activities) as well as a low-cost, mobile airspace monitoring system[36] that is discussed further in the Infrastructure Section. Each initiative is set to start in Mingo County and then be scaled state-wide, demonstrating Mingo County's commitment to leading the way in AAM for West Virginia.

Appalachian Regional Commission (ARC)

As the only state completely within the Appalachian region, West Virginia has access and involvement in the Appalachian Regional Commission (ARC), which is an economic development partnership between the federal government and 13 state governments that make up Appalachia. In West Virginia, the ARC grant program is managed by the State Development Office, which collaborates with the Governor's office and local participants to provide financial and technical assistance for various projects aimed at economic development and infrastructure enhancement.[37]

AAM Ecosystem Benchmarks: Learning from other states

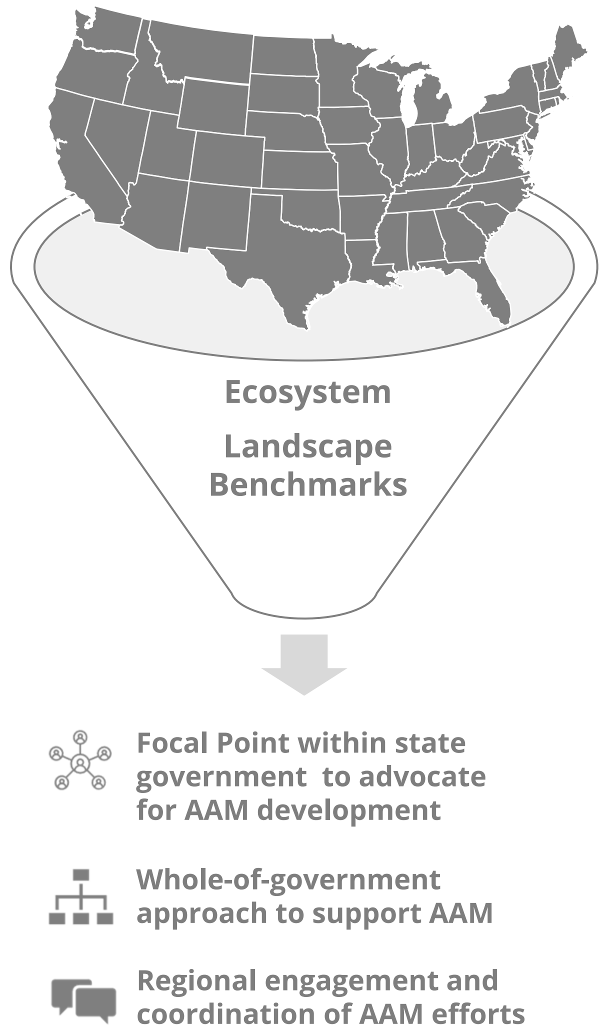
West Virginia has a distinct ecosystem across the state that could enable AAM and generate benefits for each stakeholder if properly organized and mobilized. A landscape assessment of other states' AAM ecosystems uncovered three primary benchmarks to assess West Virginia's progress towards becoming an early adopter of AAM (Exhibit 8).

AAM Focal Point within State Government
A designated full time AAM focal point within state government plays a pivotal role in coordinating AAM efforts across departments to enable tailored policies, efficient resource allocation, and targeted stakeholder engagement.

By serving as a liaison between industry, academia, and government entities, this focal point advocates for AAM, attracts investments, and drives economic development. Its overarching aim is to harness the transformative potential of AAM technologies by ensuring cohesive strategies, fostering partnerships, and promoting the state's commitment to innovation and economic growth. The positioning of the AAM focal point within state government varies based on state government structure and priorities, with many leading states establishing an AAM focal point within an agency, authority or department closely tied to transportation, economic development, or technology innovation. An example of this is the Ohio DOT's UAS Center, which serves as the state's hub for uncrewed aircraft and advanced aviation technologies and sits within the National Advanced Air Mobility Center of Excellence. The UAS Center manages innovation initiatives including the FlyOhio initiative – a coalition of stakeholders focused on enabling AAM in the state – while also performing all UAS operations for the DOT.[38]

Whole-of-Government Approach
A whole-of-government approach at the state level is critical as AAM spans multiple sectors and jurisdictions including technology, transportation, infrastructure, economic development, and regulations. A coordinated and strategic AAM approach across state agencies and departments – with leadership by the AAM focal point – promotes policy

Exhibit 8: Ecosystem Landscape Benchmarks



consistency, streamlined resource allocation, and stakeholder collaboration.

This coordinated strategy prevents conflicting policies, fosters a supportive regulatory environment, and maximizes economic impact by attracting investments, driving innovation, and creating job opportunities. Moreover, it promotes protocols, efficient airspace management, and the seamless integration of AAM aircraft, positioning the state to leverage the transformative potential of AAM across diverse sectors.

Regional Engagement and Coordination of AAM Efforts

Successful development of AAM, especially for regional travel beyond state lines (such as RAM), requires vital coordination across state governments. To unlock the full potential of AAM at a national level, states must harmonize their efforts in areas including policy, funding, and infrastructure development. A unified approach facilitates consistent regulations, streamlining operations for AAM providers and promoting safe and efficient cross-border transportation. Additionally, collaborative funding mechanisms can optimize resource allocation, preventing disparities across states in infrastructure development and enhancing the overall reliability of the AAM network.

By aligning their strategies, state governments can collectively propel AAM forward, fostering a cohesive and mature ecosystem that transcends individual state boundaries, offering a more connected and accessible regional transportation network. An example of this is the AAM Multistate Collaborative launched in 2023, consisting of state aviation and aerospace officials from eight states, three of which border West Virginia: Virginia, Ohio, Pennsylvania, Oklahoma, Texas, Utah, Oregon and Alaska. The Collaborative is working to identify and harmonize the governance and regulatory mechanisms that are within each state's jurisdiction as a focal point to ensure continuity of operations. The group aims to expand its membership with representatives from additional states and to become a key information resource for others regarding methodologies and technologies to develop a nationwide AAM ecosystem [39]

West Virginia's Ecosystem Opportunities for Development

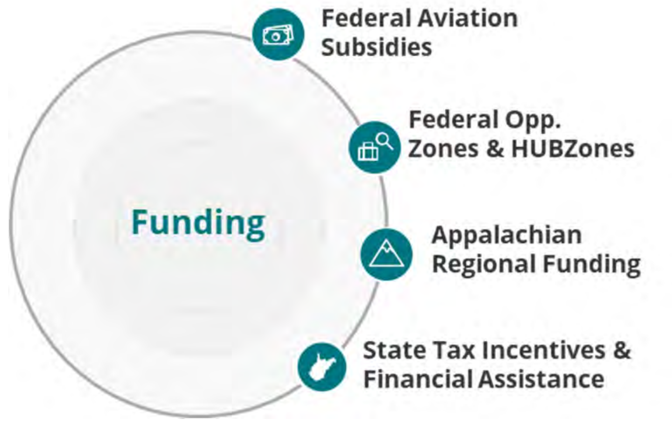
Although West Virginia has several AAM advocates and stakeholders across industry and academia, the state government does not currently have a designated, full time AAM focal point that is dedicated to advocating for and coordinating AAM efforts across agencies and departments for a whole-of-government approach. West Virginia does have a UAS Advisory Council (which is described in further detail in the Policy section); however, the Council is not a full-time entity of government personnel. The West Virginia state government has strong ties to the broader Appalachian Region and engages in several regional coordination efforts for economic development, however, is not actively involved in AAM-specific regional efforts. By addressing these gaps, West Virginia can position itself as an early adopter of AAM.

Funding

West Virginia's Current AAM Funding Enablers

Dedicated funding for AAM activities and endeavors is essential for fostering a successful AAM industry in the state. This funding can come in various forms, such as financial support, incentives, or grants from federal, state, and local governments. West Virginia currently has several funding sources and financial mechanisms that could be leveraged to pioneer and foster the growth of AAM in the state (Exhibit 9). Each funding source or mechanism - whether public or private - offers opportunities and plays a distinctive role in shaping the trajectory of AAM development in the state.

Exhibit 9: West Virginia's AAM Funding



Federal Aviation Subsidies
Many airports and communities in West Virginia qualify for DOT's Essential Air Services (EAS) Program, FAA's Airport Improvement Program (AIP)

55 Federal Opportunity Zones, 18 HUBZones
Tax incentives and contract perks for investors or small businesses focusing on rural & low-income areas to support recovery and growth in distressed communities

Appalachian Regional Funding via ARC
Congressionally-appropriated grants to for economic development in Appalachian region, with emphasis on infrastructure and workforce development

State-Tax Incentives and Financial Assistance
Support for high-tech UAS manufacturers, aircraft valuation, creating economic opportunity, tourism development, infrastructure development and more

Federal Aviation Subsidies

West Virginia currently benefits from federal aviation subsidies, which could potentially bolster AAM infrastructure development and operations. The FAA's Airport Improvement Program (AIP) provides funding for eligible airport infrastructure projects, aiming to enhance safety, capacity, and environmental sustainability of the airport. In 2022, this support was exemplified as four West Virginia airports collectively received nearly $14 million from the AIP for various upgrades, including runway rehabilitation and extension.[40] For many small regional airports, the AIP provides a vital infusion of resources that maintain updates to the airport, which is an economic engine for the local area. When an airport falls below a certain enplanement threshold such as 10,000 boarding passengers, the funding can reduce significantly including close to a million dollars.[41] The loss of these funds can be detrimental to airports like Greenbrier Valley airport, which witnessed a drop to just 10,048 enplanements in 2022, down from the previous year.[42]

The U.S. DOT's Essential Air Service (EAS) program aims to maintain essential air service in smaller and remote communities. It subsidizes airlines for routes that might not be financially viable, maintaining air connectivity in underserved areas.

In West Virginia, the EAS supports communities like Clarksburg, where SkyWest operates flights under the United Express brand. Additionally, services by Contour Airlines at airports such as North Central West Virginia Airport in Clarksburg and Greenbrier Valley Airport in Lewisburg exemplify the EAS's role in enhancing accessibility and connection for these areas[43] [44]

With the current regulatory environment, it is unclear if EAS and AIP can be leveraged specifically for AAM, but those subsidies provide a potential avenue for expanding infrastructure and subsidizing commercial network of AAM operations in a high-demand, low-competition region. AAM could revitalize the aviation sector in West Virginia and keep airport deplanement numbers above required thresholds to qualify for these subsidies across the state's airport network. Such a network would not only exemplify accessible and sustainable air travel but also guarantee the vitality of smaller airports and communities, setting a precedent for future AAM frameworks.

55 Federally-Designated Opportunity Zones and 18 HUBZones

The federal government has also designated 55 Opportunity Zones, certified by the U.S. Department of Treasury, [45] offering federal tax deferral benefits on capital gains for investors focusing on rural and low-income areas. The AAM industry has a significant opportunity in West Virginia's designated Opportunity Zones; by leveraging tax incentives within these zones, AAM companies can accelerate research and operation efforts while fostering job creation within these economically distressed areas and potentially enhancing mobility of people, goods and services in regions that have high demand for accessible transportation.

Similarly, West Virginia's HUBZones complement the Opportunity Zones, offering additional incentives and support for small businesses. HUBZones, or Historically Underutilized Business Zones, offer small businesses the opportunity to bid on federal contracts that are exclusively set aside. Additionally, HUBZones receive a 10% price evaluation preference when bidding on federal contracts, making them more competitive. [46] The program which aims to stimulate growth and development, could provide advantages for AAM companies looking to set up shop in West Virginia.

Appalachian Regional Funding via ARC

In addition to federal resources, West Virginia also has access to regional funding mechanisms only available to the Appalachian region. The ARC's grants and initiatives use congressionally appropriated funds for economic development efforts in Appalachia. In 2022 alone the ARC and the West Virginia Development Office supported 61 projects in West Virginia with an ARC investment of $42.9 million, resulting in the creation/retainment of over 2,550 jobs, training 7,590 students and workers, and benefitting 1.8 million residents in the state. [47] The ARC has five Core Investment Priorities – Building Business, Workforce Ecosystems, Community Infrastructure, Regional Culture and Tourism, and Leaders and Local Capacity – all of which can be supported by enabling AAM in the region. The ARC has supported AAM efforts in the past, including their 2023 grant to Ohio University to explore AAM opportunities for the region's business, transportation, medical and logistical needs. [48] Complementing these efforts, West Virginia's Local Development Districts within the ARC are dedicated to enhancing regional development through funding. Their strategies include upgrading transportation infrastructure, road safety, and managing the increase in general aviation traffic, which are particularly conducive to the integration of AAM. [49] [50]

State Tax Incentives and Financial Assistance

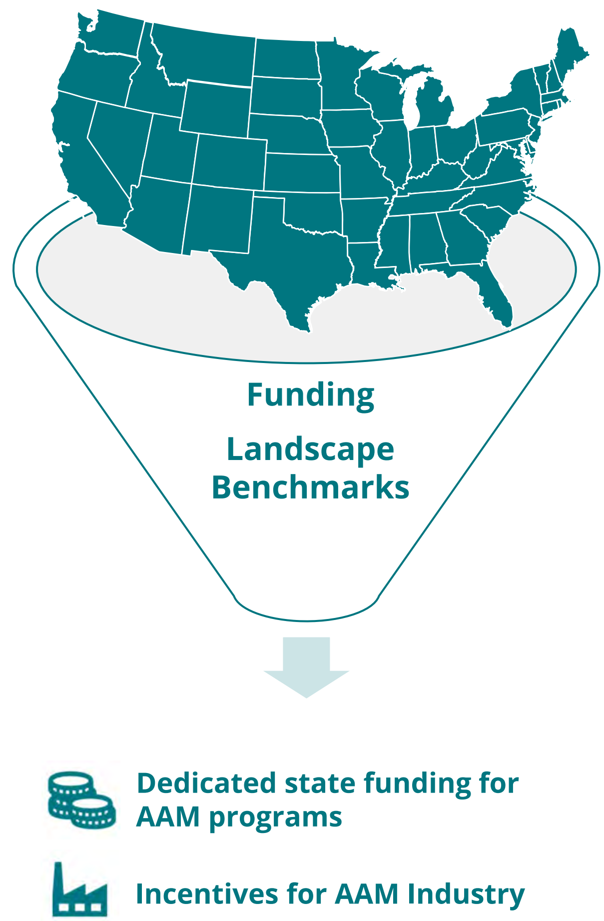
In addition to federal and regional funding opportunities, West Virginia offers several state tax incentives and financial assistance programs that could benefit the AAM industry. For instance, under WV Code §11-13Q-10a (2021), West Virginia provides a tax incentive for high-technology manufacturers. Eligible businesses engaged in the manufacturing of drones, uncrewed aircraft, autonomous motor vehicles, or high technology can utilize this incentive to receive a 100% tax credit against state taxes. [51]

Additionally, West Virginia provides an aircraft valuation benefit, allowing aircraft owned or leased by commercial airlines, charter carriers, private companies, and carriers to be assessed for property tax at the lower of the fair market salvage value or 5% of the property's original cost. Furthermore, West Virginia provides various business incentives, such as tax benefits for companies establishing corporate headquarters, tax credits for job creation, and financial assistance for tourism sector expansion, all conducive to attracting the AAM industry.

AAM Funding Benchmarks: Learning from other states

West Virginia has an array of funding mechanisms already in place that could enable AAM if properly leveraged. A landscape assessment of other states' AAM funding practices uncovered one primary benchmark to assess West Virginia's progress towards becoming an early adopter of AAM (Exhibit 10).

Exhibit 10: Ecosystem Landscape Benchmarks



Dedicated state funding for AAM is needed to foster innovation, infrastructure development, and workforce training specific to AAM technologies. This funding allows the state to actively participate in shaping the regulatory framework, invest in infrastructure conducive to AAM operations, attract industry stakeholders through incentives, and cultivate a skilled workforce, thereby stimulating economic growth and technological advancement while securing a competitive edge in the burgeoning AAM sector.

An example of this is the state of New York, which has dedicated state funds to a variety of AAM initiatives. Since 2016 their funding includes a $35 million investment to develop a 50-mile UAS flight traffic management system, $9 million for the Skydome indoor drone testing facility, and more than $25 million for the GENIUS NY competition, which supports UAS entrepreneurs. New York also committed $21 million in CNY Rising Upstate Revitalization Initiative funding to develop a UAS industry hub, including a partnership to create an international AAM Corridor between Syracuse International Airport and Quebec, Canada. [52] [53]

Incentives for AAM Industry

AAM Industry incentives stimulate innovation, investment, and adoption of AAM technologies. These incentives provide the necessary financial support and motivation for private companies to invest in research, development, and infrastructure for AAM. By offering incentives, governments and regulatory bodies encourage the emergence of a competitive and dynamic market, fostering an environment ripe for the growth of AAM solutions. These initiatives not only attract established aerospace companies but also incentivize startups, leading to a diverse ecosystem that drives technological advancements and cost reductions.

An example of state and local AAM incentives in action is evident in Joby Aviation's announcement in 2023 to establish their first scaled manufacturing facility in Dayton, Ohio, facilitated by up to $325 million in state and local incentives. Joby Aviation, a California-based AAM aircraft manufacturer, plans to invest up to $500 million and create up to 2,000 jobs with their Ohio facility. Joby is expected to deliver up to 500 aircraft per year at the Dayton International Airport and use existing infrastructure to begin near-term operations. [54] This example highlights the impact of targeted financial support in positioning states as favorable hubs for AAM development, driving economic growth, job opportunities and enhanced transportation options for communities.

West Virginia's Funding Opportunities for Development

West Virginia has access to a spectrum of federal and local funding sources, and several incentives in place that could be applied to the AAM industry. These existing mechanisms have laid a foundation for initial investments and have demonstrated the capacity to support AAM endeavors to some extent. However, to capitalize and sustain the growth of AAM, there is a discernible need for dedicated state funding streams to signal strong governmental commitment to the industry, attract additional private investment and stimulate job creation. By addressing these gaps, West Virginia can position itself as an early adopter of AAM.

Policy

West Virginia's Current AAM Policies

Policy is a key driver towards the development and support of an AAM R&D environment and commercial operations capability. Maturation of the AAM industry depends on policy and regulations that clearly define how this technology will be certified and integrated into an intermodal transportation system. In this regard, West Virginia currently has several policies and legislative measures that foster an environment for AAM testing and operations. It is necessary, therefore, to have focused leadership who become stewards of these AAM policies. This s they are necessary and relevant, preventing them from becoming barriers (Exhibit 11).

West Virginia UAS Advisory Council

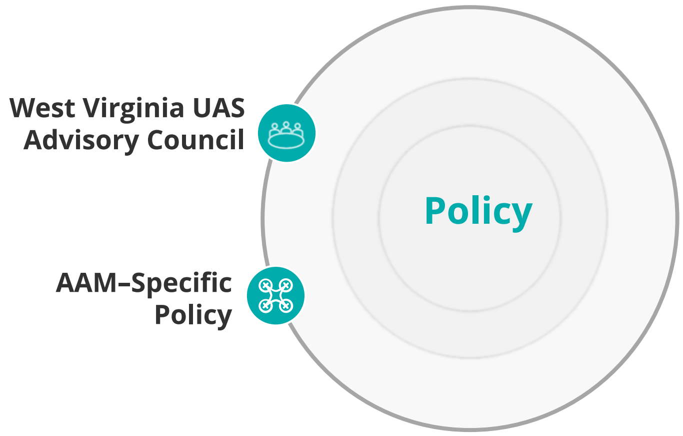
Central to these measures is the West Virginia UAS Advisory Council, which was formed in 2022 within the Department of Economic Development.[55]

Comprising volunteer members from diverse sectors like transportation, the UAS and AAM industries, and academia, the council focuses on staying current with trends and technologies. This knowledge enables them to develop targeted strategies for the AAM industry's growth in the state, and by recommending legislation tailored to the unique needs of AAM, the council promotes a supportive regulatory environment. Their efforts go a step further in fostering public awareness and cross-sector collaboration for sustainable advancement of the sector, aligning innovation with public and government expectation.

AAM-Specific Policies

West Virginia's legislative framework includes two statutes that are specific to AAM: WV Code § 5B-2-18a (2022) and WV Code § 5B-2M-1 (2022). WV Code § 5B-2-18a (2022) prohibits counties and municipalities from independently regulating or restricting AAM activities, promoting a unified AAM regulatory approach across the state.

Exhibit 11: West Virginia's AAM Policies



West Virginia UAS Advisory Council
Council within the WV Department of Economic Development, representing UAS and AAM industry, academia, and transportation. Tasked with informing policy and strategy

AAM-Specific Policies
WV Code § 5B-2-18a (2022) prohibits local restrictions on AAM aircraft. WV Code § 5B-2M-1 (2022) promotes the development of a network of vertiports to provide equitable AAM passenger and cargo operations access to citizens.

WV Code § 5B-2M-1 (2022) promotes the development of a network of vertiports that will provide equitable access to citizens of West Virginia who may benefit from AAM operations for cargo and passenger service.[56] Together these bills enable the safe and equitable integration of AAM into West Virginia's transportation system, mitigating the risk of fragmented local barriers.[57] In developing these policies, lawmakers in West Virginia showed receptiveness to the perspectives and advocacy efforts of major organizations representing the AAM industry.[58]

AAM Policy Benchmarks: Learning from other states

A landscape assessment of other states' AAM policy practices uncovered two primary benchmarks to assess West Virginia's progress towards becoming an early adopter of AAM (Exhibit 12).

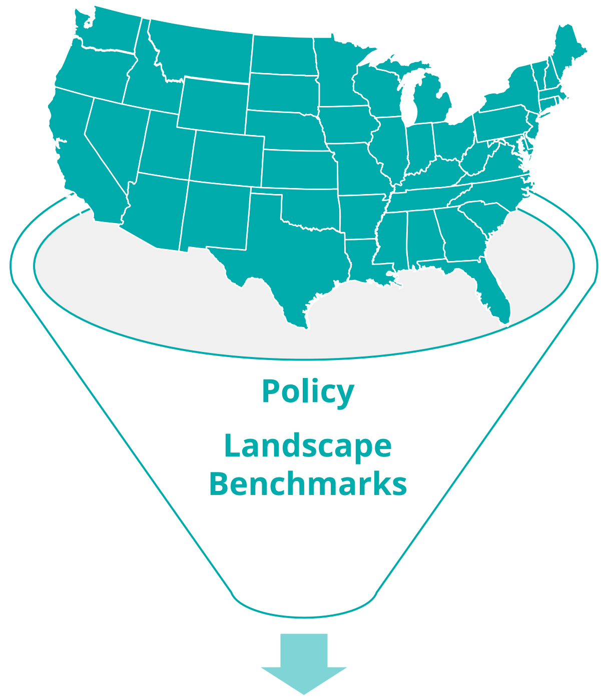
AAM Working Group Dedicated to Coordination & Integration

An AAM Working Group, comprising a diverse group of stakeholders, is essential for a thriving AAM industry. Working Groups play an important role in shaping a comprehensive strategy and recommend policies by bringing together industry experts, community representatives, and policymakers to collaboratively discuss, analyze, and consider all stakeholder perspectives. This collaborative approach facilitates the identification of potential challenges, addresses concerns, and maximizes the overall benefits of AAM for everyone involved, leading to more effective, informed, and equitable policies.

An AAM Working Group serves primarily in an advisory and coordination capacity, informing and recommending state strategy and legislation. Once the Working Group provides recommendations, a designated AAM Focal Point within state government (described in the ecosystem section) has the authority to act on those recommendations, coordinating across state government in developing regulations, overseeing AAM operations, ensuring safety and compliance, managing related funding and resources, and integrating into relevant state plans and strategies.

For example, the Florida DOT Aviation Office published an AAM Implementation Plan in 2023, which details and prioritizes 18 recommendations made to them by the Florida AAM Working Group. The plan identifies state departments that would be responsible to execute each recommendation,[59] demonstrating effective coordination between the advisory role of the AAM Working Group and the authority of the FDOT Aviation Office as an AAM Focal Point within state government.

Exhibit 12: Ecosystem Landscape Benchmarks



- AAM Working Group dedicated to shaping legislation
- Legislation to support the growth of AAM industry

Legislation to Support AAM Industry Growth

Legislation plays a crucial role in fostering the growth of the AAM industry by providing a structured framework that addresses safety, regulatory compliance, and operational standards.

Clear and supportive legislation establishes a predictable environment, instilling confidence among investors, manufacturers, and operators. It mitigates uncertainties, facilitates innovation, and guarantees the safe integration of AAM technologies into existing transportation systems. Moreover, well-crafted legislation helps streamline approval processes, reducing barriers for market entry and encouraging competition. This legal foundation not only safeguards public safety and privacy but also promotes responsible industry development, attracting talent, investment, and collaboration essential for the sustained and successful evolution of the AAM sector.

As demonstrated in the development of West Virginia's AAM policies, there are AAM industry advocacy groups that engage with federal, state, and local law-makers to promote AAM regulations that foster innovation and U.S. competitiveness. One example of state legislation that such advocacy groups recognized as favorable to AAM is Mississippi's UAS Rights and Authorities Act passed in 2023, which codifies that ultimate airspace authority lies with the FAA fostering a harmonized regulatory environment.[60] Supportive legislative environments that arise from participation in AAM industry groups pave the way for innovation, investment, and the collaboration needed for sustained growth and competitiveness.

West Virginia Policy Opportunities for Development

West Virginia's establishment of the UAS Advisory Council as well as supportive policies provide a promising foundation for attracting and maturing the AAM industry. However, without an AAM Focal Point within the state government (as highlighted previously in the Ecosystem Section), recommendations made by the UAS Advisory Council may lack traction or coordinated execution across state government efforts. By addressing this gap, West Virginia can position itself as an early adopter of AAM.

Infrastructure

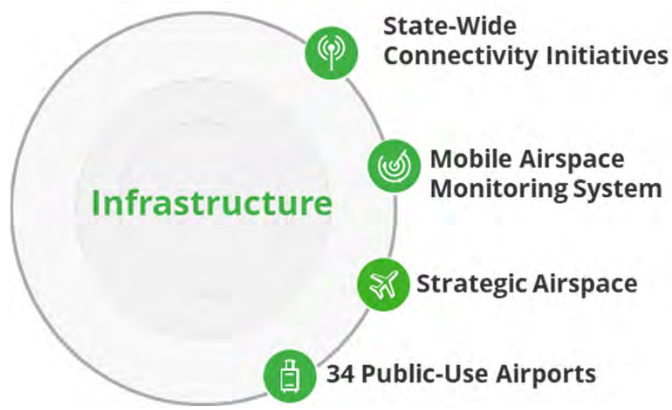
West Virginia's Current AAM Infrastructure

A network of technologies, systems, and supporting structures/facilities are needed to enable safe AAM R&D and operations. As AAM technologies and capabilities continue to develop and mature, states need to strategically plan and develop proper supporting infrastructure. West Virginia currently has development efforts that could be leveraged for AAM R&D and operations if properly coordinated (Exhibit 13).

State-Wide Connectivity Initiatives
West Virginia has multiple state-wide connectivity initiatives to promote communications, system interoperability, and expand network coverage, which are central for AAM command and control capabilities. The West Virginia Statewide Interoperable Radio Network (SIRN) forms an important part of the state's communication infrastructure. SIRN, a collaboration among various public safety entities, aims to provide interoperable radio network coverage across the state. While its extensive coverage supports most of West Virginia, there are ongoing efforts to expand this reach, acknowledging the state's challenging terrain.[61] There are also limitations imposed by the National Radio Quiet Zone (NRQZ), which limits certain frequencies to protect radio telescope operations.[62] For AAM, SIRN's interoperability and expanding coverage are key for reliable cross-agency communication, vital in managing complex aerial mobility operations safely and efficiently.

Another state-wide connectivity initiative is the Broadband Equity Access and Deployment (BEAD) Five-Year Action Plan. With a $1.2 billion backing from the National Telecommunications and Information Administration (NTIA), BEAD is set to revolutionize West Virginia's connectivity infrastructure.[63] This plan is pivotal for AAM development, as high-speed, dependable internet is fundamental for effective communication, data management, and coordination among AAM stakeholders.

Exhibit 13: West Virginia's AAM Infrastructure



State-Wide Connectivity Initiatives
Statewide Interoperable Radio Network (SIRN) and the Broadband Equity Access and Deployment (BEAD) efforts plan to expand communication infrastructure and connectivity across the state, essential for safe and efficient AAM operations

Mobile Airspace Monitoring System
Development of a NASA funded, mobile airspace monitoring system for AAM at the Southern West Virginia Regional Airport, featuring advanced surveillance and communication technology, aims to boost safety, efficiency, and educational opportunities in the AAM sector

Strategic Airspace
Within 500-mile radius of 40% of U.S. population, between several population centers, military training routes

34 Public-Use Airports
34 airports for public use, 23 of which are in the FAA NPIAS and recognized as integral to passenger travel and the state's economic vitality. Several airport infrastructure maintenance and expansion efforts

The BEAD program is a culmination of state-level planning and engagement and is poised to not only bridge digital divides but also to underpin the burgeoning AAM ecosystem in West Virginia.

Mobile Airspace Monitoring System
Complementing these digital infrastructure advancements is the development of a mobile airspace monitoring system, intended to provide low altitude airspace management at pilot sites like Southern West Virginia Regional Airport (EBD). This project includes operator stations, telescoping masts for surveillance, and a comprehensive communication suite. Designed for low altitude airspace management, it's vital for AAM

operations. The system's mobility enhances its utility, offering adaptable training and operational support across West Virginia.

Strategic Airspace

In addition to ground-based infrastructure, West Virginia's airspace offers opportunities for the advancement of AAM due to its location within a 500-mile radius of nearly 40% of the U.S. population.[11] This geographic positioning could make the state a central hub for AAM corridors, providing swift connections to major urban centers and extensive coverage across a large portion of the nation's populace. Additionally, the presence of strategic military training areas[65] suggests the region is already accustomed to a certain level of airspace management complexity, which could be advantageous when implementing new systems like AAM.

34 Public-Use Airports

West Virginia's airport infrastructure offers both diversity and growth potential. The state boasts 34 public-use airports, 23 of which are in the FAA NPIAS and recognized as integral to both passenger travel and the state's economic vitality. Key airports in West Virginia are undergoing developments to prepare for aviation advancements and growth by modernizing rural airport infrastructure. Charleston's CRW is extending its runway,[66] while Raleigh County Memorial Airport (BKW) is developing business-ready sites, both reflecting the potential for an AAM-friendly environment. Additionally, a new terminal at CKB and an extra 50 acres for economic development highlight this opportunity.[67]

These advancements present an opportunity for significant industry investment. Stakeholders within the AAM ecosystem are not only expressing a readiness to contribute financially to infrastructure upgrades but are eager to invest in building the initial infrastructure. This investment is particularly focused on areas demonstrating a growing demand for AAM services and within a supportive policy framework. Their willingness to invest upfront indicates a strong belief in the potential of revenue generation from future operations in these high demand areas.

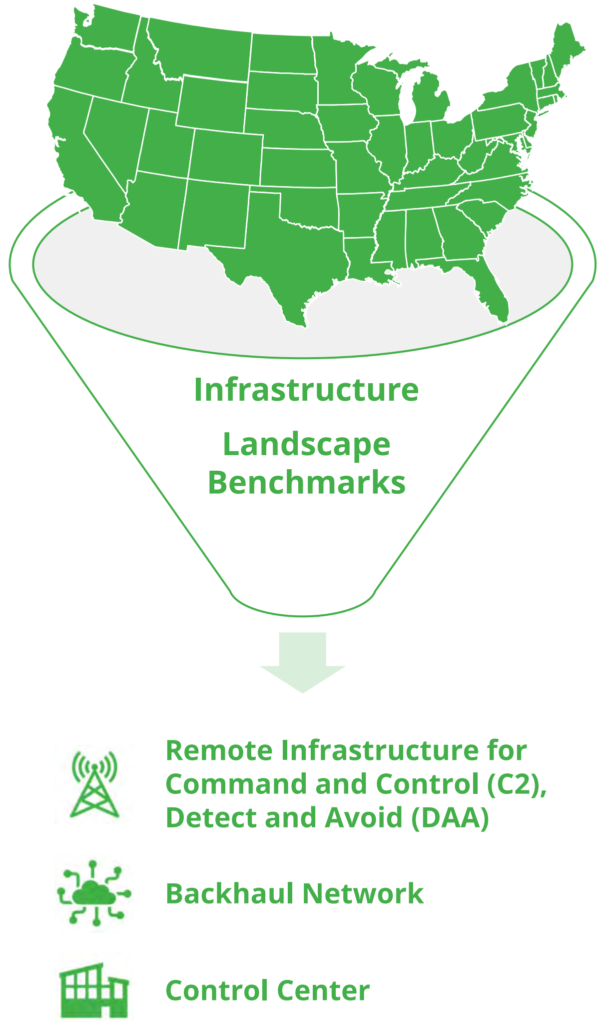
The relationship between public infrastructure development and private sector engagement is symbiotic, and such collaboration could accelerate the modernization of these airports, increasing their value as assets to the state. In recognition of their role in regional economic development, five rural West Virginia airports in Upshur, Braxton, Grant, Mercer, and Logan counties have received a total of $511,427 in Airport Infrastructure Grants from the FAA. This funding, sourced from the bipartisan Infrastructure Investment and Jobs Act, is aimed at developing local airports to meet customer needs, enhance safety, and support state growth.[68] [69] [70]

AAM Infrastructure Benchmarks: Learning from other states

West Virginia has a combination of infrastructure and development efforts that could enable AAM if properly coordinated and supported. A landscape assessment of other states' AAM infrastructure efforts uncovered three primary benchmarks to assess West Virginia's progress towards becoming an early adopter of AAM (Exhibit 14).

AAM requires foundational infrastructure akin to traditional aviation, but with key advancements and integrated technologies to accommodate an increasingly crowded airspace that will include remotely piloted and autonomous aircraft. An example of an AAM infrastructure network under development is Choctaw Nation of Oklahoma's Emerging Aviation Technology Center, which spans over 44,600 acres and will include remote infrastructure such as radar and broadband.[71] North Dakota's Vantis network provides an example of an existing state-wide AAM infrastructure network, comprised of remote infrastructure, a backhaul data network, and a mission and network operations center.[72]

Exhibit 14: Infrastructure Landscape Benchmarks



Remote Infrastructure

Remote infrastructure for aircraft command and control (C2) capabilities as well as airspace surveillance is foundational for safe and efficient AAM operations. C2 enables real-time communication between AAM aircraft, ground systems, and air traffic management, ensuring coordinated and secure operations in shared airspace. Several types of networks are being explored for C2 for AAM applications, including cellular networks, satellite coverage, and dedicated radio frequencies. Each network type serves specific needs based on coverage, reliability, latency, security, and adaptability, catering to the diverse operational requirements of AAM aircraft across different environments and scenarios. Detect and Avoid (DAA) capabilities are critical to prevent aircraft collisions and make sure there is safe separation between aircraft in flight. For traditional aviation, DAA relies on a combination of pilots' visual observations, radar systems, and air traffic control directives to prevent collisions.

However, for AAM, DAA capabilities must be able to accommodate an increasingly crowded airspace that includes uncrewed and/or autonomous aircraft, reducing reliance on pilots' visual observations. Several DAA capabilities for AAM are being explored including onboard aircraft systems, traditional ground-based systems such as radar, and novel ground-based systems such as remote air traffic control tower systems.[73]

Backhaul AAM Data Network

AAM data captured and transmitted across remote infrastructure must be tied together by a backhaul data network. A backhaul data

data network serves as the communication backbone for AAM, transmitting real-time data between aerial aircraft, ground control stations, and traffic management systems. It enables seamless information exchange, facilitating traffic coordination, route planning, and safety measures. This network provides continual situational awareness for operators and automated systems, supporting informed decision-making and timely responses to airspace changes. A robust backhaul data network is essential for AAM for safety, scalability, redundancy, and reliable connectivity, enabling efficient and secure operations in shared airspace.

Remote Control Center

A Remote Control Center (RCC) is the operational heart of AAM, akin to the nerve center that monitors, controls, and facilitates the testing and operational integrity of remote infrastructure. The RCC is responsible for real-time management of a complex ecosystem that includes C2 systems, traffic management, communication networks, and DAA systems.

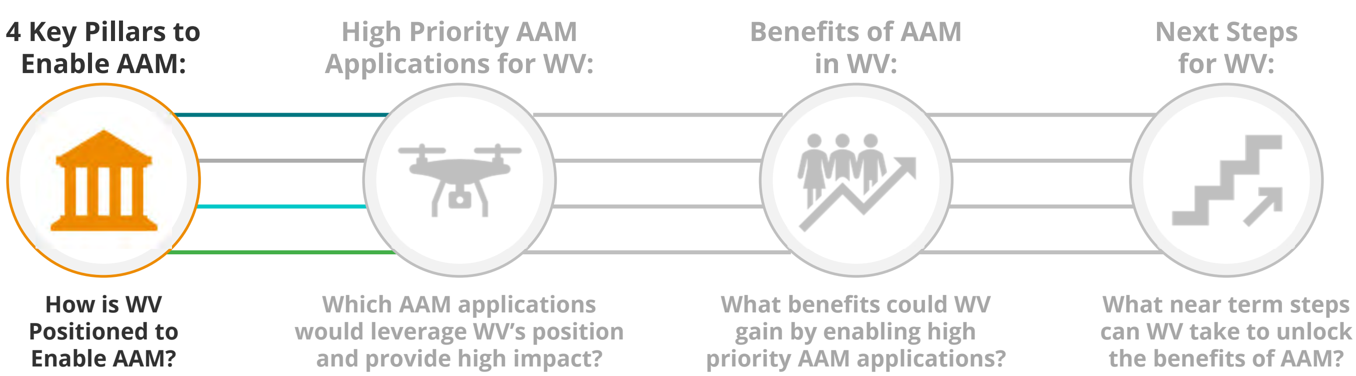
For instance, NASA’s Mobile Operations Facility (MOF), a mobile mission control center on wheels, is a prototype of an RCC that can travel to any flight-testing site to gather critical data and support the integration of air taxis and cargo delivery into the National Airspace System. This facility has been outfitted with sophisticated communication and monitoring equipment that can provide a template for statewide AAM operations. The MOF's capabilities include a portable power generator and satellite data connectivity, enabling real-time monitoring of flight testing and the flexibility to adapt to any test location, thus demonstrating the RCC's potential to oversee a broad variety of AAM use cases across urban, rural, and regional domains.[74]

The development of a Remote Control Center within West Virginia could centralize AAM operations, streamline the testing of advanced aircraft, and make certain the safe and coordinated integration of AAM into existing airspace.

West Virginia Infrastructure Areas for Development

West Virginia offers remote infrastructure that could be leveraged for AAM but lacks an organized approach to coordinate and integrate across these development efforts and networks. Addressing this gap would position West Virginia to enhance its communication and connectivity capabilities, potentially supporting a sophisticated AAM system, optimizing the flow of information and supporting seamless communication between various AAM stakeholders.

This section highlighted and benchmarked West Virginia’s current AAM enablers across four key pillars: Ecosystem, Funding, Policy, and Infrastructure, answering the question **“How is West Virginia currently positioned to enable AAM?”** The following section will explore and prioritize AAM applications for West Virginia to answer the question **“Which AAM applications would best leverage West Virginia’s position and provide maximum impact to the state?”**



High-Priority AAM Applications for West Virginia

Which AAM applications could leverage West Virginia's position and provide maximum impact to the state?

AAM and its three application categories – RAM, LAM, and UAM – encompass a growing range of applications that span several sectors and industries. With current and future AAM applications ranging anywhere from small drones delivering medical supplies to flying taxis transporting people to tourism hubs, it is important for West Virginia to prioritize and strategically enable applications that provide strong benefits to the state while leveraging their current assets and accelerators.

This section explores an initial list of ten AAM applications considered most relevant to West Virginia based on stakeholder interviews and current state analysis. Then, this section states the assumptions made in assessing each application and details the criteria used to rank and down-select the applications. Finally, this section presents the final six down-selected applications (Exhibit 15), considered high priority for West Virginia to strategically enable.

Exhibit 15: High Priority AAM Applications for West Virginia

Utility and Infrastructure
The use of UAS for inspecting and monitoring utilities and infrastructure

Public Operations
The use of UAS by public servants for "dull, dirty or dangerous tasks" e.g. emergency response, law enforcement, surveying

Medevac
The swift transportation of patients between hospitals via aircraft

Cargo Feeder (Hybrid)
Regional air transportation of cargo via hybrid powered aircraft

Medical Logistics
The rapid and efficient transportation of medical materials and supplies within healthcare systems via on-demand UAS flights

Regional Commuter (Hybrid)
Regional air transportation of people via hybrid powered aircraft

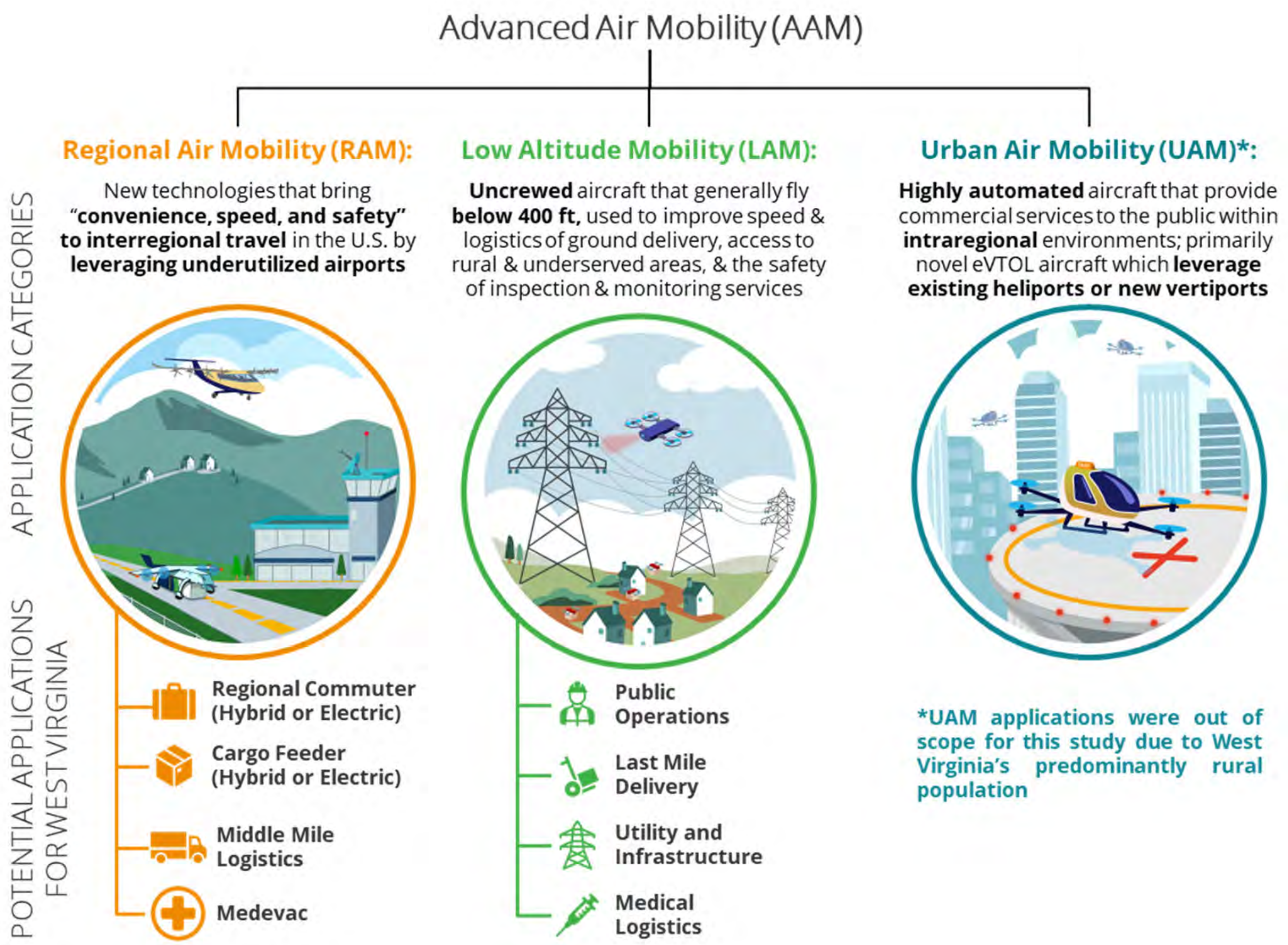
RAM Application *LAM Application*

Initial AAM Applications for Consideration

Ten initial AAM applications emerged as relevant to West Virginia's capabilities and needs based on stakeholder interviews and West Virginia current state analysis (Note: the applications for Regional Commuting and Cargo Feeder each count as two applications based on using hybrid aircraft or electric aircraft).

The AAM applications considered all fall within the application categories of RAM and LAM (Exhibit 16) – UAM applications, given their urban operating environments, were out of scope for this assessment due to West Virginia's predominantly rural population.

Exhibit 16: Initial AAM Applications Identified for Consideration



RAM Applications

RAM applications leverage new technologies and underutilized airports to enhance convenience, speed, and safety of interregional travel. Six RAM application were considered relevant to West Virginia, as defined below (note: the applications for Regional Commuting and Cargo Feeder each count as two applications based on using hybrid aircraft or electric aircraft).

Regional Commuting (Hybrid/Electric) -
Regional commuting flights refer to the transportation of people by air between regional hubs. Post-1978 Airline Deregulation Act, the airline industry largely adopted a hub-and-spoke model where commuter aircraft provide service to regional hubs from smaller regional airports. This shift, while expanding air travel, led to a consolidation of services focused on high-volume markets, often at the expense of rural and smaller communities due to cancelled routes.[75] In West Virginia, this trend has resulted in diminished air connectivity and increased costs. For instance, in Q2 of 2023, the average domestic airfare for West Virginia CRW Airport was $578.37, compared to the national average of $391.79.[76] The EAS program has attempted to address these challenges through subsidies for certain rural routes, but according to air carriers and community officials, the impact has been limited due to the reduction of eligible communities, and wage increases have not kept up with the subsidy caps.[77] RAM presents an opportunity to revitalize these neglected routes with novel aircraft and technologies, offering a potentially more affordable, accessible, and efficient air travel option for West Virginia's dispersed population.

Cargo Feeder (Hybrid or Electric) -
Cargo feeder flights refer to the regional air transportation of cargo. Echoing the challenges faced in regional commuter transport, legacy air cargo carriers also struggle with maintaining service to smaller markets due to aging aircraft fleets and pilot shortages that impact feeder airlines. These challenges have inflated operation costs and, in some cases, led to reduced services levels, particularly impacting rural customers like West Virginians. RAM, with its potential for automated and more cost-effective operations, could serve as an innovative solution to sustain and enhance cargo delivery services to these areas, providing continuous support for local economies.

Middle Mile Logistics -
Middle mile logistics involves the transportation and movement of goods between distribution centers or hubs, connecting the initial source to the final distribution point. Middle-mile logistics is typically reliant on feeder trucks or transport vans, making their efficiency subject to traffic and road conditions. RAM operations for middle mile logistics could provide faster and more direct air connections for various logistical purposes, including inventory restocking and expedited delivery of time-sensitive goods. This pivot from ground-based logistics to RAM operations would enhance the speed and responsiveness of supply chains, particularly in areas like West Virginia where the rugged terrain limits the efficiency of ground transportation.

Medevac: Inter-Hospital -
Inter-hospital Medevac, or medical evacuation, refers to the swift transportation of patients between hospitals. West Virginia currently relies on conventional medevac aircraft and ambulance services for patient transfers between healthcare facilities. However, there's a critical need to improve these services, as evident by the state's longer median Door-In to Door-Out times for patient transfers compared to the national average (the median time for West Virginia was 118 minutes, whereas the median time for all patients nationally was 64 minutes).[78] RAM, with its ability to navigate over challenging terrains swiftly, presents a promising solution to reduce patient transfer times and costs. By integrating RAM into the state's medical emergency infrastructure, West Virginia could enable quicker, more reliable patient transport, particularly vital for those in remote or hard-to-access areas.

LAM Applications

LAM encompasses uncrewed aircraft, or UAS, that generally fly below 400 feet. LAM aircraft are used to improve speed and logistics of ground delivery, access to rural and underserved areas, and the safety of inspection and monitoring services. Four LAM applications were identified as relevant to West Virginia's capabilities and needs and are defined below.

Public Operations -
LAM aircraft, specifically UAS, have a broad range of applications in public operations, aiding in tasks that may be considered "dull, dirty, or dangerous" to provide efficiency and safety to public servants. Examples include emergency response, where UAS can be used for search and rescue missions, assessing disaster areas, and monitoring emergency situations. UAS can also support law enforcement in response times, situational awareness, and accident reconstruction. In West Virginia, the DOT has already realized substantial cost savings and operational efficiencies through its drone program, initially used for measuring material mounds (which translated to over $343,000 in cost savings in just one month).[79] This is just one example of how LAM could benefit various public sector operations.

Last Mile Delivery -
Last mile delivery refers to the final stage of the logistics process, involving the transportation of goods from a distribution center or hub to the end consumer's doorstep or desired location. Last-mile delivery is notably the most expensive and least efficient segment within the delivery chain. The surge in e-commerce has further stressed these existing delivery networks. In West Virginia, where 36% of the population resides more than 10 miles from the nearest grocery store,[80] LAM for last mile delivery can modernize this segment. By deploying LAM solutions, such as UAS for package delivery, the state can enhance the efficiency and reach of last-mile deliveries, thus providing greater accessibility and convenience.

Utility and Infrastructure -
The use of LAM aircraft, specifically UAS, for inspecting utilities and infrastructure is an emerging area with significant potential benefits. For example, rather than using expensive helicopters to fly over transmission lines to inspect them, several energy companies are turning to UAS as a cheaper, safer alternative.[81] Although these operations may not generate direct revenue, they can result in substantial cost-savings and reduced injury risks. In some cases, the money saved by using UAS for inspections and monitoring can be re-invested into hiring more personnel to conduct infrastructure maintenance, thereby promoting a proactive approach to supporting the resiliency and reliability of critical infrastructure.

Medical Logistics: Inter-System -
Inter-system medical logistics refers to the rapid and efficient transportation of medical materials and supplies within healthcare systems. This transportation typically relies on courier services, which can be impacted by batch delivery bottlenecks. The introduction of LAM operations could facilitate the development of an on-demand network, increasing the speed of healthcare logistics, getting critical medical supplies and results delivered more rapidly and reliably.

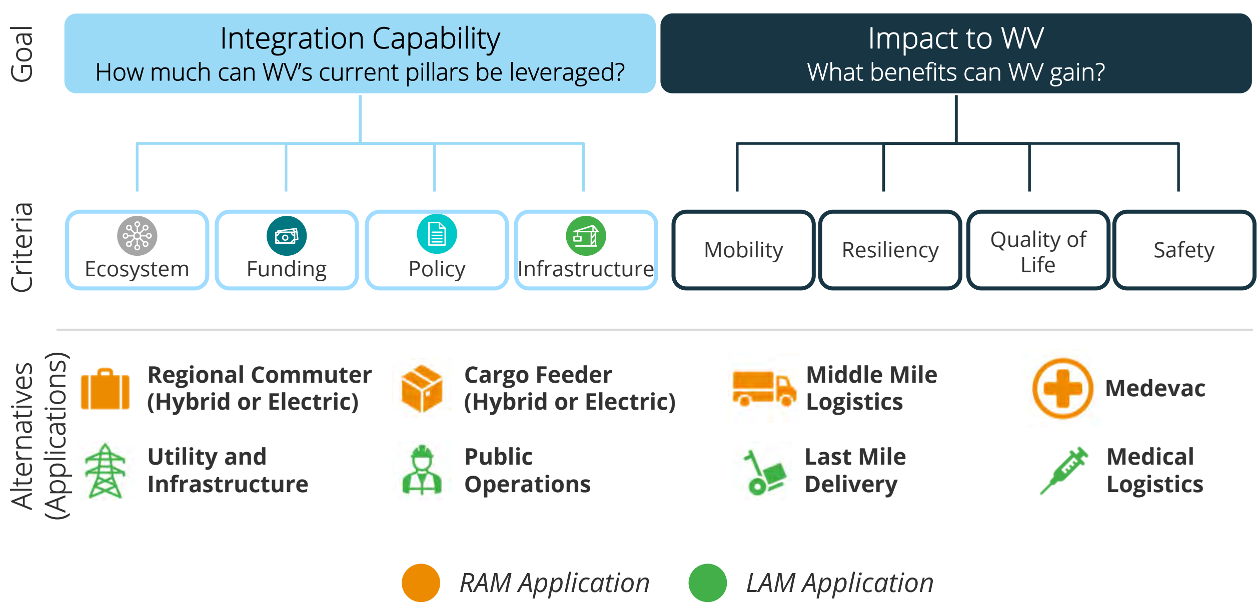
Prioritization Criteria

The RAM and LAM Applications were compared using an Analytical Hierarchy Process (AHP), with the goals, criteria, and alternatives shown in Exhibit 17.

The first goal for each application is integration capability; how much can West Virginia's current pillars be leveraged? Each criterion within this goal was compared and assigned weights for level of importance. Then the applications (alternatives) were measured against the criteria. Overall, applications that already had the most supporting ecosystem, funding, policies, and infrastructure in place were considered the most desirable for this goal, anticipating smoother integration with fewer challenges or barriers to entry.

The second goal for each application is impact to West Virginia; what benefits can West Virginia gain if these applications are operable in the state? Each criterion within this goal was compared and assigned weights for level of importance. Then the applications (alternatives) were measured against the criteria. Applications that offered the most mobility, resiliency, quality of life, and safety were considered the most desirable for this goal, maximizing benefits for West Virginians. Economic benefits were not considered in this step – applications deemed most desirable in this step were scoped and further assessed for their economic impact in the next section, Benefits of AAM in West Virginia.

Exhibit 17: Criteria for Prioritizing RAM and LAM Applications in West Virginia



Assumptions

With the novel nature of many RAM and LAM applications, assumptions were made regarding the current methods and aircraft used for each application, the technology readiness and capabilities of the future RAM and LAM aircraft, and the regulatory environment.

The LAM and RAM applications under consideration will replace or enhance current operations. Where applicable, assumptions were made for the incumbent method and parameters used for each application to establish a baseline against which to measure RAM and LAM impact (Exhibit 18).

RAM and LAM technologies encompass a wide range of aircraft in varying phases of development and maturation, ranging from prototyping, to pursuing Airworthiness Certification, to being fully operational. Current RAM and LAM aircraft in development or operations were used to make assumptions regarding aircraft specifications including range, capacity, speed, and efficiency.

Exhibit 18 shows an example of assumptions made regarding the incumbent method and RAM/LAM method for two applications under consideration.

A robust and supportive regulatory environment is needed to make RAM and LAM operations possible; therefore, this study assumes the necessary regulations will be in place. This includes establishing clear airworthiness criteria and standards, training and certification requirements and ensuring operational rules that balance safety and efficiency. As previously highlighted, these efforts are currently underway including the rulemaking efforts for Airmen Certification and Operating Rules.

Exhibit 18: Example Assumptions for Assessing AAM Applications

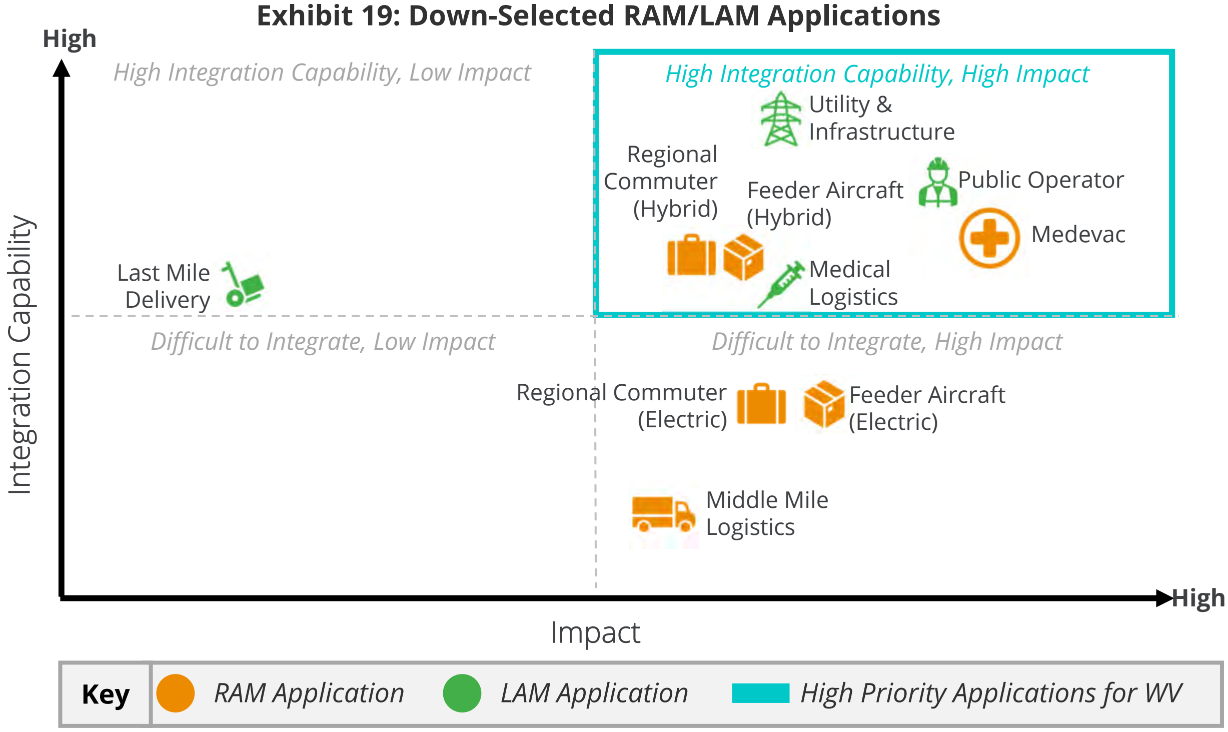
Application	Scope	Incumbent Method	RAM/LAM Method
Regional Commuter	**Airport-to-Airport Schedule air services on routes ranging from 100 to 1,000 miles**	**ERJ-135 aircraft**	**Hybrid: Ampaire Electric: Surf/Eviation**
Utility and Infrastructure	**Inspection of physical assets or risk mitigations related to its operations**	**Bell 407 or Manual**	**Censys Technologies Sentaero**

Down-Selected RAM and LAM Applications Considered High Priority for West Virginia

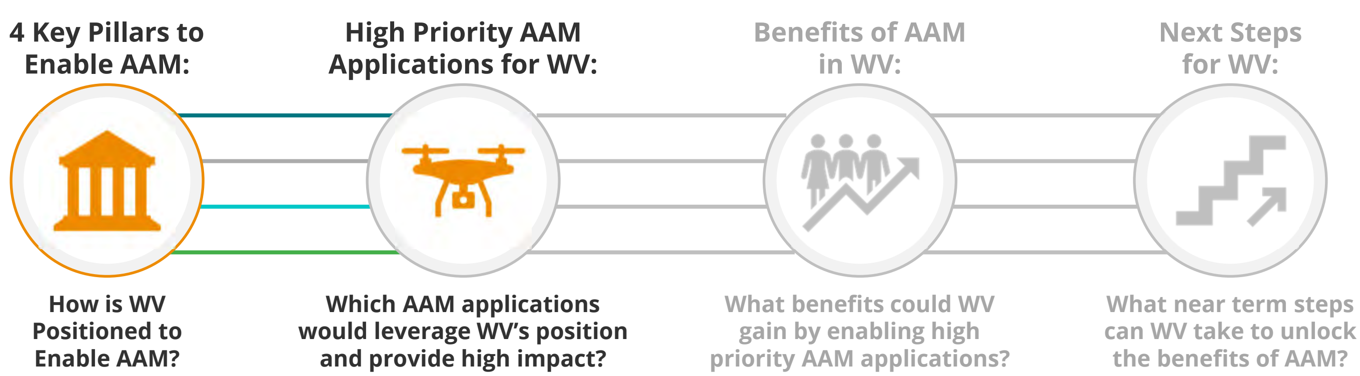
The ten initial RAM and LAM applications identified as relevant to West Virginia's needs and capabilities were assessed using the AHP and assumptions previously explored. Applications scoring high on both impact and integration, positioned in the graph's upper right quadrant, were deemed most desirable.

These top six applications could leverage many of West Virginia's current assets while providing high impact to the state. (Exhibit 19)

Exhibit 19: Down-Selected RAM/LAM Applications



This section prioritized AAM applications for West Virginia to strategically enable, answering the question **"Which AAM applications would best leverage West Virginia's position and provide maximum impact to the state?"** The following section will outline the societal and economic benefits West Virginia could gain by enabling those applications to answer the question **"What benefits could West Virginia gain by enabling high priority AAM applications?"**



Benefits of AAM in West Virginia

What benefits could be realized in West Virginia by enabling high priority AAM applications?

West Virginia, with its rugged terrain and strong community values, is positioned to leverage AAM applications to overcome historical transportation challenges, unlocking benefits for the economy and society. A proprietary economic model was employed to evaluate the potential economic advantages West Virginia could gain by enabling the six RAM and LAM applications considered high priority for the state (Exhibit 20).

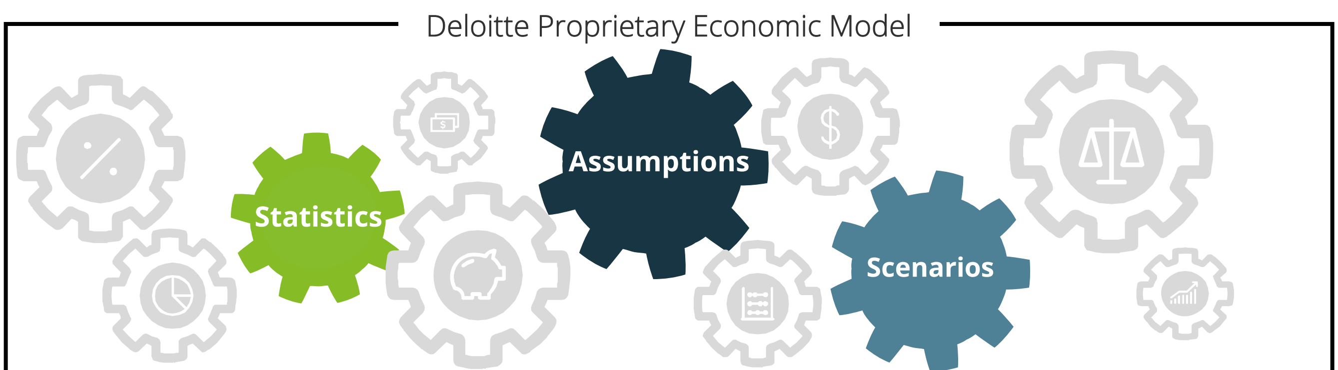
The assessment is not time based, but rather assumes that these applications are fully integrated and operational at scale. This modeling leverages current data and statistics, FAA forecasting for AAM operations,[82] and conservative estimates to calculate impact.

This section details each economic and societal benefit West Virginia could gain by enabling AAM.

Exhibit 20: Methodology for Assessing AAM Benefits in West Virginia

High-Priority AAM Applications for West Virginia

- **Utility and Infrastructure**
- **Medical Logistics**
- **Public Operations**
- **Medevac**
- **Cargo Feeder (Hybrid)**
- **Regional Commuter (Hybrid)**



Economic Benefits of AAM in WV

Create Jobs
5,417 NEW JOBS created in West Virginia by enabling high-priority AAM applications.

Increase Tax Revenue
Over **$29 MILLION IN ANNUAL STATE TAX REVENUE** generated by AAM-related jobs, business revenue, and property.

Reduce Costs for Operators
Over **$40 MILLION IN ANNUAL COST SAVINGS** for operators, including operational savings and hazard savings by leveraging AAM.

Societal Benefits of AAM in WV

Upskill, Retain and Grow Workforce
AAM creates a wealth of **SPECIALIZED, HIGH-PAYING JOBS**, offering an avenue for **UPSKILLING CURRENT WORKFORCE & DRAWING NEW RESIDENTS** to the state.

Improve Access to Transportation, Goods, & Services
AAM enhances **QUALITY OF LIFE FOR RURAL RESIDENTS** by bridging gaps in access to transportation options & delivery of vital goods & services.

Economic Benefits of AAM in West Virginia

West Virginia could create jobs, generate tax revenue, and cut costs by enabling high priority AAM applications in the state.

Creating Jobs
Enabling the operation of high-priority AAM applications would create direct, indirect, induced, and catalytic jobs across West Virginia (Exhibit 21). For example, consider the regional commuter application: a West Virginian booked a RAM flight. An agent checks the passenger in at the front desk and handles their luggage, then three transportation security officers screen the traveler. Concurrently, the RAM operator is coordinating with air traffic control officers to confirm departure time and airspace access. Ground crews and technicians prepare the RAM aircraft. Finally, at the boarding gate, another agent verifies the traveler's boarding passes and guides the passenger to the aircraft, where a pre-flight attendant prepares the traveler for takeoff. In this one example, over a dozen jobs directly support a single regional commuter flight. These roles exemplify the diverse direct job opportunities essential for one operation of one AAM application. In addition to direct jobs, AAM applications would create indirect, induced, and catalytic jobs as well.

As AAM capabilities mature and operations scale, indirect jobs become pivotal in providing essential resources for workforce development. This encompasses tasks like maintaining, repairing, and operating infrastructure, essential for the industry's sustainability and economic success. The growth of the AAM industry will, in turn, boost the development of related businesses and services in the region. The spending of these employees on daily necessities, such as groceries and transportation, spurs growth in these sectors to meet the rising demand. This process, known as induced job growth, generates additional economic benefits for West Virginia.

Equally significant are the catalytic jobs that emerge alongside the industry's growth. These jobs arise in adjacent sectors like tourism, healthcare, and energy, which evolve in response to the regional economic expansion of AAM. The maturation of the AAM industry not only supports its immediate ecosystem, but also propels growth in these interconnected industries.

Exhibit 21: Jobs created by enabling AAM in West Virginia

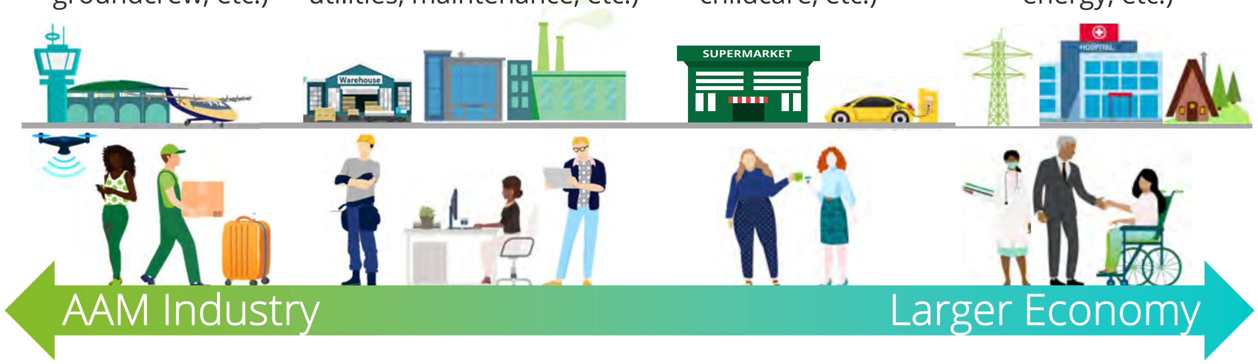
5,417 Jobs Created by AAM Operations

972
Direct Jobs
that enable the operation of an AAM flight (pilot, air traffic controllers, groundcrew, etc.)

1,368
Indirect Jobs
that supply critical components, services, or staffing to support AAM operations (software, utilities, maintenance, etc.)

1,491
Induced Jobs
that create additional revenue through direct/indirect employee consumption (food, childcare, etc.)

1,586
Catalytic Jobs
within tangential industries that benefit from AAM operations (tourism, healthcare, energy, etc.)



Generating State Tax Revenue

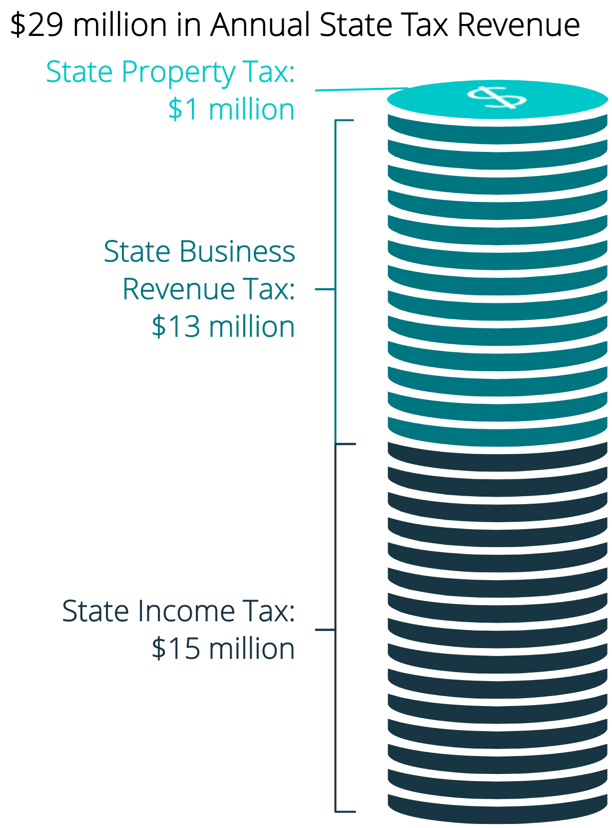
AAM also has the potential to significantly impact the economic landscape of West Virginia by generating $29 million in tax revenue from property, business revenue, and income taxes. (Exhibit 22).

The surge of new employment opportunities created by the AAM industry will stimulate both current and new residents in West Virginia. Based on existing real estate rates, homeownership assumptions, and property values, it is anticipated that enabling AAM operations in West Virginia will generate $1 million in annual state property tax revenue.

AAM operations will attract new industry as well as new customers for West Virginia's current industry, contributing to $13 million in annual state business revenue taxes for the state.

The jobs created by AAM operations – spanning direct, indirect, induced, and catalytic – will contribute to $15 million in annual state income tax revenue for West Virginia. This estimation considers current income taxes, anticipated growth and wages, and is subject to a variety of factors including economic conditions, wage levels, and policy changes.

Exhibit 22: Tax revenue generated by enabling AAM in West Virginia



Cutting Costs for Operators

Operators, including government departments and agencies, would realize significant operational and hazard cost savings by leveraging AAM applications for their operations as a cheaper and safer alternative. Across all six AAM applications considered high-priority for West Virginia, operators could see $29 million in annual operational savings and $11 million in annual hazard cost savings (Exhibit 23).

Operational cost savings by AAM includes money saved by replacing current platforms with AAM aircraft as well as money saved by reducing the number of labor hours per operation. For example, consider the public operations application: a search and rescue squad inspecting a remote area of West Virginia for missing hikers. Instead of sending a crew in a helicopter, the squad can deploy a UAS with sensors right away to search the area, successfully locating the hikers and sharing the coordinates to deploy the helicopter or ground-based personnel for rescue.

In that single operation, a relatively inexpensive UAS – remotely piloted by one person, with a second person reviewing camera feed – can replace a helicopter and a four-person crew during the search process. When compared to the helicopter, the UAS is much cheaper to purchase, power, and maintain, and requires a smaller crew to operate from the safety of the ground. This would free up resources for the squad and allow for a more efficient use of the helicopter for rescue operations.

Hazard cost savings by AAM includes money saved by reducing injuries and fatalities during operations. For example, consider the utility and infrastructure application: a crew inspects transmission lines after a storm. Instead of immediately sending a line worker up a potentially damaged transmission tower, or flying a helicopter in potentially dangerous atmospheric conditions, the crew uses a UAS with cameras and sensors to inspect the transmission lines for damage. By doing this, the crew knows where potential hazards are and pinpoints areas that need repair, reducing the risk of injuries for the crew.

Line workers and pilots are regularly listed in the top twenty-five most dangerous jobs by the Bureau of Labor Statistics in terms of fatality rate.[83] [84] By using UAS for transmission line inspection, the crew reduces their risk of injuries and fatalities, increasing overall employee safety and reducing employer injury and fatality costs.

Exhibit 23: Cost savings generated by enabling AAM in West Virginia

Societal Benefits of AAM in West Virginia

In addition to several economic benefits, AAM has the potential to significantly impact West Virginia's workforce and quality of life.

Workforce Upskilling and Retention
AAM's introduction in West Virginia is projected to significantly boost job creation, especially in high-tech sectors. The aviation sector is already a significant economic contributor to West Virginia's economy, with airports alone contributing more than $1.6 billion to the state's economy and supporting more than 10,770 jobs.[85] AAM would further catalyze that impact, by generating new workforce opportunities through the establishment of AAM facilities and services that will require skilled personnel in scientific, technical, and engineering fields. AAM would also cause growth in supporting industries such as utilities, infrastructure development, and manufacturing. This influx of high-paying jobs is expected to contribute substantially to local economies, elevating average income levels, retaining skilled employees, and fostering economic development.

In addition to providing retention opportunities to current residents, the jobs created by AAM could attract new residents and draw former residents back to West Virginia. According to local stakeholders, many West Virginians have a deep sense of pride in their state and Appalachian culture and wish to stay in West Virginia throughout their lives. Despite this, the scarcity of job opportunities has historically compelled many to leave the state, contributing to a population decline of over 4,000 people since 2022. [86]

To counter this trend, innovative programs have been launched to retain the current workforce and attract new residents. For instance, through a collaborative effort between WVU, Marshall University, and state economic initiatives, recent graduates are being supported in finding rewarding careers within West Virginia.[87] These efforts include providing resources such as co-working spaces, mentorships, and professional development opportunities.

Another innovative program is the ASCEND Program, which offers cash and recreational incentives for remote workers to move to West Virginia. The program is application based, targeting "innovative, bright minds." ASCEND has already seen a 98% retention rate in program participants and is expected to bring over 1,000 remote workers to the state over the next six years.[88]

Initiatives like these are crucial as West Virginia strives to retain its educated workforce, especially in sectors poised for expansion due to AAM's growth. The numerous jobs created by AAM in West Virginia could attract former residents and new residents alike.

Improved Access to Transportation, Goods and Services

AAM stands to transform the quality of life for West Virginians, offering improved access to transportation options, goods, and services for residents.

RAM offers a vital new mode of regional transportation for the 24% of West Virginia's rural residents that currently lack access to intercity transportation[14] due to challenges developing and maintaining ground-based transportation infrastructure across the state's rugged terrain. RAM would offer regional transportation options for West Virginian commuters and travelers, leveraging underutilized airports across the state and flying over the state's rugged terrain. AAM can be an equalizer to democratize the skies, by reducing the average domestic airline itinerary fare due to its lower cost for operations and opportunity to scale operations.

RAM also offers improved movement of cargo, bringing not only necessary resources to West Virginians but also providing a faster level of delivery service for a broader set of goods. A majority of the U.S. population has become accustomed to same-day and one-day delivery options for ecommerce purchases.[89] However, this is not the case for West Virginia, where rural and remote communities face longer delivery times for ecommerce goods and distribution issues for essential goods like food. The state has been experiencing challenges in providing fresh, healthy foods to residents – such as produce, meat and dairy - due to supply chain disruptions and closures of essential distribution centers.[90] This contributes to one in seven West Virginians suffering from hunger.[91] RAM offers efficient movement of time-sensitive cargo to rural areas by leveraging underutilized airports across West Virginia, thereby reducing travel burdens on residents and providing access to essential goods.

RAM and LAM applications, such as medevac, medical logistics, and utility/infrastructure operations offer safe and efficient access to healthcare and reliable utility services for West Virginians.

The state's rugged terrain and isolated communities pose challenges for residents to have adequate access to healthcare facilities and services, as well as challenges to the transportation of medical supplies within healthcare systems.

For instance, West Virginia ranks highest in the nation for the prevalence of heart attacks (7.5%) and coronary heart disease (8%).[92] A West Virginian suffering a heart attack in a rural area may be over an hour's drive from the nearest emergency room and may have to wait up to 50 minutes for an ambulance to respond. A UAS used to fly a defibrillator to the scene could serve as a first line of defense for the patient. Even if the patient had time to get to the ER, they would likely need to be transferred to a major hospital via medevac.

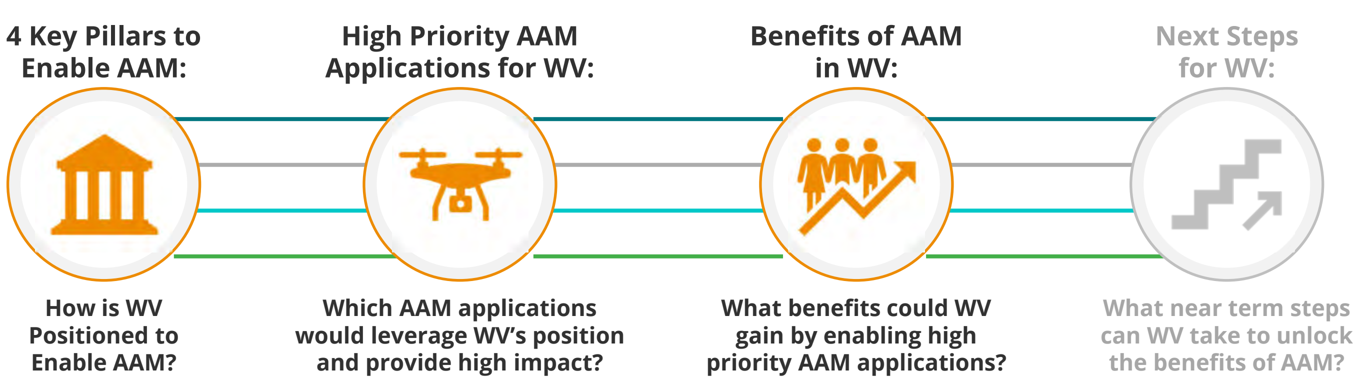
A RAM medevac aircraft could offer swift transportation between healthcare facilities at a faster or cheaper rate than traditional ambulances and helicopters, improving the state's sub-par door-in-door-out time.[78] After the patient received treatment for their heart attack, they would be sent home with several prescriptions to fill. However, the patient may live hours away from a pharmacy that can fulfill those prescriptions. A UAS used to quickly fly the medications to the patient's closest pharmacy/approved healthcare facility would lower time and distance barriers for the

patient, increasing the likelihood of the patient filling their prescription and taking their medicine. A West Virginia healthcare stakeholder expressed interest in UAS prescription delivery operations like previously described. This could be an innovative addition to the "Meds-to-Beds" program, which provides patients with their medication before leaving the hospital. In this example, RAM and LAM applications offer improved access to healthcare and improved patient outcomes, addressing critical healthcare challenges in West Virginia.

The integration of high-priority RAM and LAM applications in West Virginia not only revolutionizes transportation options for rural residents but also serves as a catalyst for democratizing the skies, reducing travel costs, and addressing long-standing challenges in delivering essential goods to remote communities. By efficiently moving both passengers and time-sensitive cargo, these innovations contribute significantly to enhancing the overall quality of life for West Virginians, bridging gaps in healthcare access, and improving the delivery of vital goods and services. As these technologies continue to evolve, the potential for positive impacts on the state's transportation infrastructure, economy, and well-being remains promising.

This section outlined the societal and economic benefits West Virginia could gain by enabling several AAM applications, answering the question **"What benefits could West Virginia gain by enabling high priority AAM applications?"**

The following section outlines next steps West Virginia can take to become an early adopter of AAM, to answer the **question "What near term steps can West Virginia take to unlock the benefits of AAM?"**



Next Steps for West Virginia

What are near term steps West Virginia can take to unlock the benefits of AAM?

West Virginia can unlock several economic and societal benefits for the state if they strategically enable high-priority AAM applications. Below are potential next steps for West Virginia to consider to enable AAM operations and realize the benefits they can bring. Each step is explored further in this section, highlighting a priority area that warrants dedicated, in-depth planning efforts.

Exhibit 24: Next steps for West Virginia to enable AAM

NEXT STEPS FOR WEST VIRGINIA

- Engage with Stakeholder Groups Aligned with High-Priority AAM Applications
- Expand the West Virginia UAS Advisory Council to Include Working Groups
- Establish an AAM Focal Point within State Government
- Scale Mingo County K-16 AAM Curriculum across the State
- Integrate AAM Applications into Government Operations with Standardized Training
- Coordinate with Regional Players in Neighboring States
- Designate State Funding for AAM
- Maintain Harmonization of State AAM Legislation with National Frameworks
- Leverage Mobile AAM Infrastructure while Developing Permanent Infrastructure
- Establish Facilities for AAM Training and Testing

Ecosystem
Funding
Policy
Infrastructure

Ecosystem Steps

Engage with Stakeholder Groups Aligned with High-Priority AAM Applications

The RAM and LAM applications considered high priority for West Virginia touch a broad spectrum of sectors and stakeholders that should be actively engaged throughout strategy development and planning. These stakeholder groups include but are not limited to the general public/community, healthcare providers, utility providers, cargo and logistics companies, commercial aviation companies, and first responders. It is crucial to engage these groups through various methods such as forums, advisory roles, and events to ensure a comprehensive and inclusive strategy.

Expand the West Virginia UAS Advisory Council to Include Focused Working Groups

AAM encompasses a wide range of technologies and applications, requiring focused and collaborative efforts by several diverse experts and stakeholders to inform priorities. The West Virginia UAS Advisory Council has nine appointed members spanning state government, academia, and industry that are responsible for a broad scope of identifying trends, developing strategies, and recommending legislation regarding UAS. Initial findings and recommendations from the UAS Advisory Council will need to be reviewed further and developed into tactical, actionable plans, requiring more personnel and focused efforts on individual topic areas. Enabling the UAS Advisory Council to convene Working Groups can drive specialized efforts on specific areas of interest or challenges, promoting a more comprehensive and detailed approach to addressing complex issues and providing valuable insights and recommendations for West Virginia.

Establish an AAM Focal Point within State Government

Enabling AAM requires close coordination across state government departments and agencies. A designated, full time AAM Focal Point within West Virginia's government is needed to maximize the impact of the West Virginia UAS Advisory Council's recommendations by leading the coordination and execution of those recommendations across state government. The AAM Focal Point should be positioned within a department or authority tied to transportation, economic development, or technology innovation to coordinate and advocate for AAM regulations, funding, infrastructure development, and integration into relevant state plans and strategies. The creation of such a Focal Point would improve resource management and enhance the effectiveness of implementation efforts. Moreover, it would provide a clear direction and accountability, fostering a more efficient and responsive approach to addressing a complex intermodal integration of AAM.

Scale Mingo County K-16 AAM Curriculum across the State

Developing and maintaining a skilled, resilient AAM workforce starts at the primary education level. Mingo County is developing and will pilot a K-16 AAM curriculum that incorporates learning opportunities for the design, manufacturing, flight operations, airspace management, and sustainment of AAM assets. When ready, this curriculum should be scaled across the state to promote an AAM talent pipeline and proactively prepare West Virginia's workforce for an industry projected to grow seven-fold in the coming decade. [1]

Integrate LAM Applications into Government Operations with Standardized Training

LAM applications across public operations – such as emergency response - offer potential cost-saving and even life-saving benefits if performed with proper technique and coordination across government agencies. Training, certifying, and credentialing government personnel in the use of LAM technologies – such as UAS – would enable the safe and efficient integration of LAM applications into government operations. While there is currently no nationally established credentialing authority to provide UAS education and training for first responders, West Virginia's ecosystem member, ASSUREd Safe, is developing education materials, training courses, and standards to address this.

Coordinate with Regional Players in Neighboring States

Successful development of AAM, particularly for regional travel beyond state lines (such as RAM), requires strong coordination across state governments extending beyond individual state lines. To unlock the full potential of AAM at a national level, states must not only harmonize their efforts in areas including policy, funding, and infrastructure development, but also actively collaborate to establish a regional route network across bordering states. This network could boost return on investment, by expanding the scope and scale of AAM operations.

West Virginia already collaborates across the Appalachian Region to foster economic development and innovation, making AAM a natural next step in coordination efforts and priorities. AAM coordination across state lines should be done through methods such as joining or establishing AAM coalitions, attending roundtables and events, or participating in national programs. These activities will amplify diverse perspectives, fostering a comprehensive approach for integration as well as providing a forum for an exchange of innovative ideas and best practices.

Funding Steps

Designate State Funding for AAM

Allocating state funding for AAM efforts signals state support and leadership in developing and fostering an AAM industry. By funding initial AAM efforts such as planning and strategy development, education initiatives, and infrastructure development, the state would be "shovel-ready" to attract industry investments and unlock the societal and economic benefits of AAM. A key next step for West Virginia is to dedicate funding for the development of a comprehensive planning document to integrate AAM within an intermodal system, while leveraging existing infrastructure. This document would serve as the pivotal blueprint, setting the stage for the identification of key additional investments to propel the state into a new era of innovation and growth.

Policy Steps

Maintain Harmonization of State AAM Legislation with National Frameworks

Strategic alignment with national AAM strategies, plans, and frameworks not only situates a state as a pivotal player in a harmonized and competitive national ecosystem, but also positions it as an early adopter of AAM technology. West Virginia should proactively inform its legislation by drawing on valuable and timely resources such as the FAA's Innovate28 Plan and the forthcoming AAM National Strategy from the AAM Interagency Working Group (scheduled for publication in 2024).[94] This approach not only demonstrates forward-thinking but also contributes to fostering seamless alignment and compatibility across state borders, aligning with the overarching national vision for the future of AAM.

Infrastructure Steps

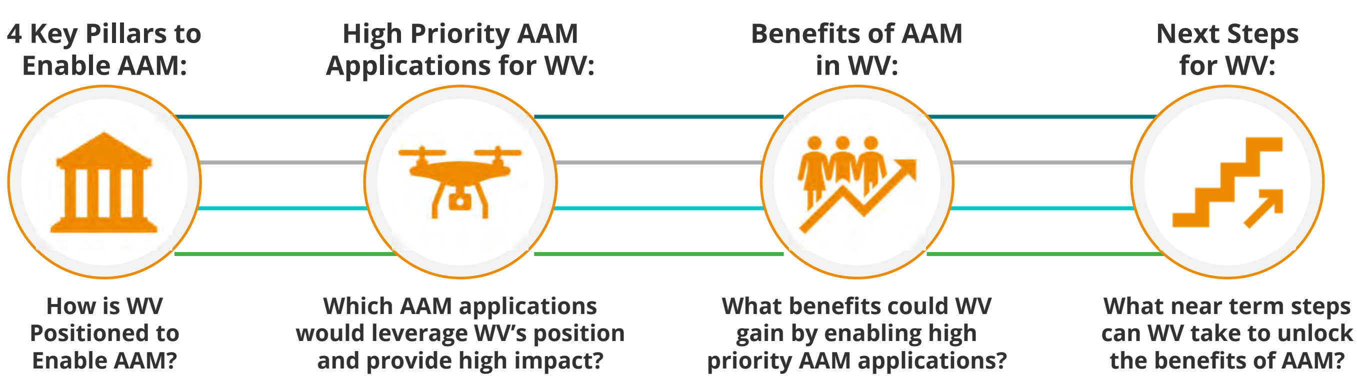
Leverage Mobile AAM Infrastructure While Developing Permanent Infrastructure

Leveraging and expanding West Virginia's unique mobile AAM infrastructure - while developing permanent AAM infrastructure – enables near-term AAM research and operations while preparing for operations at scale in the long term. The Mingo County Redevelopment Authority is in the process of procuring a low-cost, mobile airspace monitoring system for AAM airspace surveillance and communication that could cover a 2.5-mile operational radius.[20] Procuring and deploying multiple mobile airspace monitoring systems would support a versatile and transportable AAM test environment for research and development efforts. In parallel, developing permanent infrastructure to support state-wide C2 and DAA capabilities, backhaul networks, and a command-center would proactively prepare West Virginia for state-wide AAM operations, and an industry projected to reach $115 billion annually in the next decade.[1]

Establish Facilities for AAM Training and Testing

West Virginia's remote areas offer the space, privacy and diverse environment conducive for AAM training and testing for government agencies, academia and private industry. The establishment of an AAM training facility, such as an ASSUREd Safe Training Center, would foster research and development of AAM to meet emergency response mission requirements while also providing protocols and training for various federal, state, and local public safety agencies across the region. The establishment of an AAM proving ground for research, development, testing and evaluation of AAM technologies would attract industry and academia, fostering innovation in the region.

This section outlined next steps West Virginia can take to become an early adopter of AAM, to answer the **question "What near term steps can West Virginia take to unlock the benefits of AAM?"**



Shaping the Future of Transportation

West Virginia's Opportunity

West Virginia is poised to become a key player in the AAM arena by leveraging its diverse ecosystem, unique assets, existing infrastructure, and demand for innovative transportation solutions. While AAM offers numerous benefits for the state, West Virginia must act swiftly to harness the rapidly emerging AAM industry. A failure to act quickly and decisively may result in a lost opportunity as other states make significant investments in AAM development and infrastructure. By taking strategic next steps, West Virginia could enable AAM operations that results in significant societal and economic impact for the state.

Vertx Partners connects small businesses, innovators, and researchers with a spectrum of other Appalachian entities and larger organizations, such as the Air Force and the Department of Defense. Vertx consolidates these disconnected entities through innovative ecosystem integration, fortifying connections, and unlocking collaborative opportunities.

While navigating the unintuitive and complex federal contracting landscape can be a challenge, Vertx's team of industry veterans lends their expertise, guiding businesses through the intricacies of the process. By connecting the dots for businesses and academia alike, Vertx Partners has developed a network of dynamic Appalachian innovators dedicated to breathing new life into the area's economic landscape.

As part of its mission to revitalize Appalachia, Vertx Partners plays a key role in positioning West Virginia at the forefront of the emerging field of Advanced Air Mobility (AAM). Recognizing AAM's economic and societal potential in West Virginia and the state's preestablished aerospace network, Vertx fosters a statewide AAM ecosystem. The inaugural meeting of the "Coalition of the Willing" in December 2021 brought together state and local leaders, marking the commencement of efforts to shape West Virginia's place in the national AAM movement. These efforts have gained momentum, and Vertx continues to make significant headway.

To further promote West Virginian AAM, Vertx engages in regional educational and political efforts. By serving as a thought leader and initiating conversations through think pieces, Vertx offers free resources to educate newcomers to the AAM landscape. Against this backdrop, the state took a crucial step forward when Vertx petitioned the West Virginia State Legislature to create the WV UAS Advisory Council, essential to legitimizing AAM's presence in the region. Vertx President and Founder Sean Frisbee's seat on the Council further underscores the company's commitment to shaping the future of AAM in West Virginia.

Vertx's latest AAM efforts saw the company play a pivotal role in helping the Mingo County Redevelopment Authority (MCRA) secure $2.9 million in Congressionally Directed Spending (CDS). The MCRA's K-16 UAS education initiative, cited in the study for its potential to bring quality AAM education to students throughout the state, is funded through the earmarked CDS that Vertx helped secure. This study is another steppingstone in bringing AAM to West Virginia and reinvigorate Appalachia, an effort that Vertx Partners will see to fruition.

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In addition, we extend a special acknowledgment to the **Deloitte Team**. Their exceptional work in providing a national perspective to this study has been invaluable. The team's insights have been crucial in exploring how West Virginia can contribute to the nationwide effort of bringing advanced air mobility to the public, especially in rural America. Their expertise and perspective have greatly enhanced our understanding of the potential impact and opportunities of advanced air mobility in a broader context.

Additionally, we extend our gratitude to several individuals who devoted significant time and effort in supporting this study. Their contributions, encompassing a range of ideas, perspectives, experiences, and visions, have been invaluable. We sincerely thank each of you for your support.

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NARTP
NATIONAL AEROSPACE
RESEARCH & TECHNOLOGY PARK

A Strategic Roadmap for the Development of Advanced Air Mobility

June 2022

MAKING AN IMPACT THAT MATTERS since 1845

Contents

Acronym Definitions

AAM	Advanced Air Mobility
ACEA	Atlantic County Economic Alliance
ACY	Atlantic City International Airport
ATC	Air Traffic Control
ATM	Air Traffic Management
BVLOS	Beyond Visual Line of Sight
CAGR	Compound Annual Growth Rate
eVTOL	Electric Vertical Take-off and Landing
FAA	Federal Aviation Administration
GDP	Gross Domestic Product
hVTOL	Hybrid Vertical Take-off and Landing
NARTP	National Aerospace Research and Technology Park
NAS	National Airspace System
NJDOT	New Jersey Department of Transportation
NJEDA	New Jersey Economic Development Authority
NUAIR	Northeast UAS Airspace Integration Research Alliance
OEM	Original Equipment Manufacturer
O&M	Operation and Maintenance
PMO	Program Management Organization
PPP	Public-Private Partnership
R&D	Research and Development
RAM	Regional Air Mobility
RFP	Request for Proposal
ROI	Return on Investment
SJTA	South Jersey Transportation Authority
UAS	Uncrewed Aircraft Systems
UAV	Uncrewed Aircraft Vehicle
UTM	Uncrewed Aircraft System Traffic Management
VLOS	Visual Line of Sight
VTOL	Vertical Take-off and Landing

Executive Summary

Advanced Air Mobility (AAM) is a step-change in aviation technology and innovation that can revolutionize the way people and cargo move throughout the United States, while transforming the global economy. In the U.S. alone, the AAM market is estimated to reach $115 billion annually by 2035, employing more than 280,000 high-paying jobs.[1]

Today, many state and local governments are recognizing the benefits AAM can provide to their communities and economies. States that enable safe, sustainable, and scalable AAM deployment can become national leaders within the U.S. market. One such state that is currently positioned to become a leader in AAM is New Jersey.

New Jersey's proximity to major cities, such as New York City and Philadelphia, makes it an economically viable location for the early adoption of AAM. New Jersey also has a unique combination of aviation assets and accelerators, such as the FAA William J. Hughes Technical Center, a designated Smart Airport Test Bed Facility at Atlantic City International Airport (ACY), as well as the National Aerospace Research & Technology Park (NARTP). Collectively, these assets, as well as the surrounding one-mile area, constitute New Jersey's first and only officially recognized Aviation District, located in Atlantic County.[2] This Aviation District and partnerships with organizations, such as NASA and the U.S. Air Force Air Mobility Command, bring strong expertise to key AAM-related research fields such as safety, energy storage, electric propulsion, sensors, and smart infrastructure. NARTP is well positioned to facilitate strategic alignment of interests between the Aviation District, partnerships, and private industry. AAM will provide New Jersey with a unique opportunity to develop an Aviation Innovation Hub in Atlantic County that builds on unique institutional assets found nowhere else in the world. By leveraging those assets in a region with a relatively lower barrier to entry, New Jersey can launch and accelerate AAM industry development in Atlantic County that would expand across the state. The advancement of AAM offers a once in a generation opportunity to build and strengthen the state's research and development capabilities, which is consistent with Governor Murphy's economic development strategy to reestablish New Jersey as a leader in technology and innovation.[3]

Enabling AAM in New Jersey would unlock several economic, environmental, and societal benefits for the state. Establishing and growing an AAM industry in the state is projected to create almost 26,000 jobs in New Jersey over 15 years, which would generate an additional $152 million in annual state tax revenue.[4] AAM also has the potential to reduce carbon emissions and noise pollution in New Jersey; AAM aircraft will likely be electric, or hybrid powered, and some prototypes are already almost 100 times quieter than helicopters during take-off and landing.[5] Lastly, AAM would improve the quality of life for New Jersey residents by providing a safe, affordable, accessible, and equitable form of transportation for cargo and passengers, connecting historically underserved communities with essential goods and services.

Economic Benefits of AAM

Create Jobs

25,679 NEW JOBS created **IN NEW JERSEY** over 15 years by enabling the AAM industry.

Increase Tax Revenue

OVER $150M ANNUAL STATE TAX REVENUE generated by AAM-related jobs at the end of 15 years.

Environmental Benefits of AAM

Reduce Emissions

by **6,000KG of CO_2 DAILY FOR EVERY 1,000 PASSENGERS** that use AAM transportation.

Reduce Noise

AAM aircraft are estimated to be **100 TIMES QUIETER** during take-off and landing compared to traditional aircraft.[1]

Societal Benefits of AAM

Efficient Transportation

for over **22 THOUSAND DAILY COMMUTERS** & **27 MILLION ANNUAL VISITORS** to Atlantic City.

Increase Access & Equity

AAM provides **THREE TIMES GREATER ACCESS** to jobs, food, and healthcare than conventional public transportation.

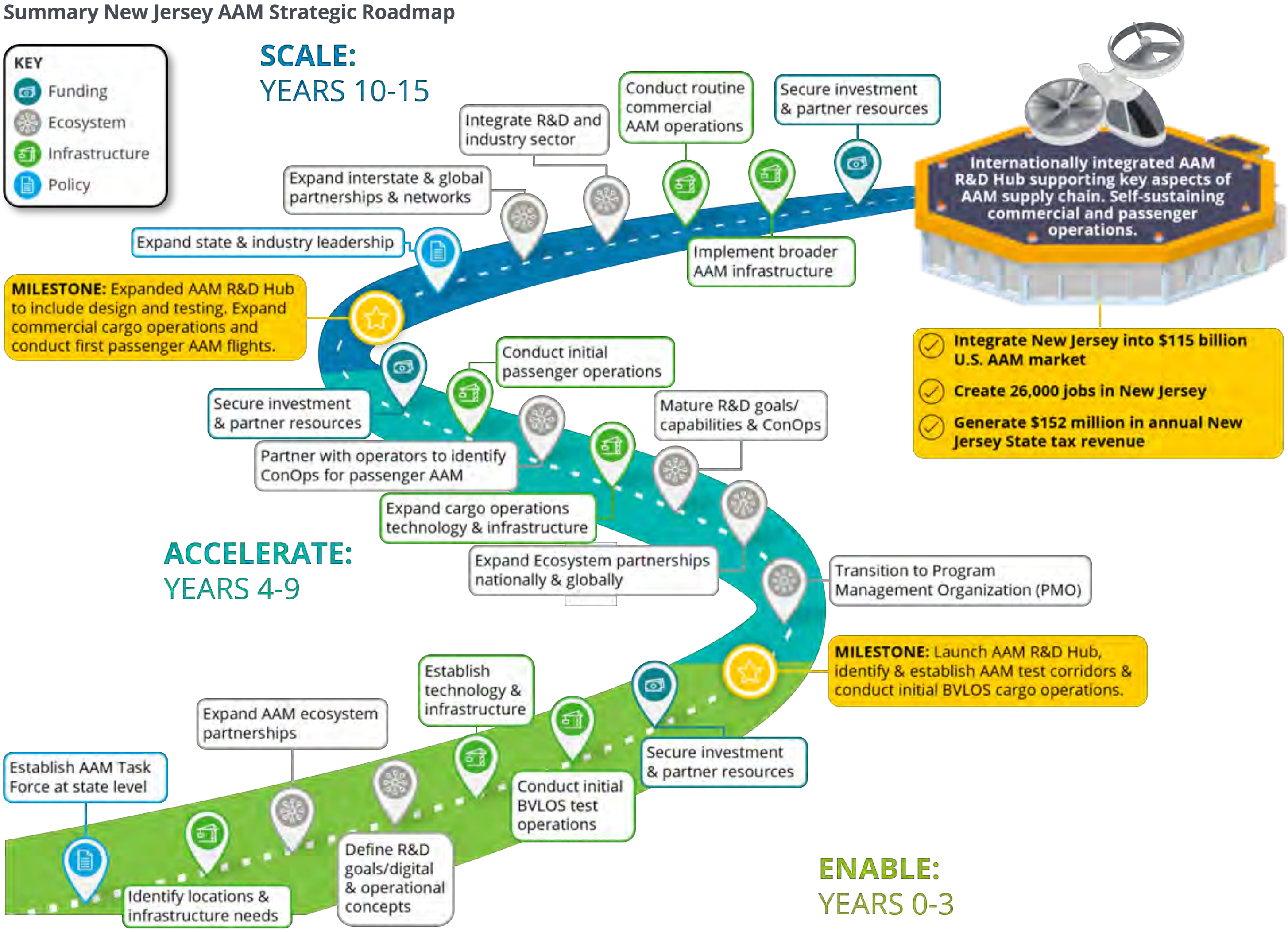
To realize the benefits that AAM would bring across the state, New Jersey needs an executable strategy to develop and mature the AAM industry and market. As such, NARTP retained Deloitte Consulting to develop a Strategic Roadmap that introduces AAM capabilities, highlights AAM market opportunities for New Jersey, identifies key drivers for developing a successful AAM state-wide program, and provides an integrated strategy and recommendations in a multi-phased approach to enable AAM in New Jersey.

The strategy focuses on the current needs of the emerging AAM market, such as research, development, and testing, while creating the conditions to support a more mature market through increasing levels of operational complexity.

The Strategic Roadmap provides recommendations, summarized below, for NARTP to serve as a catalyst for AAM innovation in New Jersey, building on the state's unique assets and location. The recommendations are separated into three phases – Enable, Accelerate, and Scale. These phases support increasing levels of research and operational complexity consistent with FAA's "crawl, walk, run" framework. The recommendations address the infrastructure, policy, funding, and ecosystem that are necessary for New Jersey to develop a robust and sustainable AAM market along the three phases. An example of this would be creating positions and units dedicated to developing aviation innovation and R&D within the New Jersey Department of Transportation, New Jersey Economic Development Authority, and the South Jersey Transportation Authority.

While the AAM industry is still emerging, New Jersey should act swiftly to build momentum toward the development of AAM to position itself as a national leader. A failure to act quickly and decisively may result in a lost opportunity as other states make significant investments in AAM development and infrastructure.

Summary New Jersey AAM Strategic Roadmap



Introduction

Advanced Air Mobility: The next big inflection in the aerospace industry's ongoing evolution.

Advanced Air Mobility (AAM) encompasses a range of cutting-edge technologies that offer the potential for safe, sustainable, affordable, and accessible mobility. AAM aircraft leverage hardware and software for communications, surveillance, ground controls, and other support equipment to enable a new dimension of flexibility, accessibility, and autonomy that traditional crewed aircraft cannot perform.

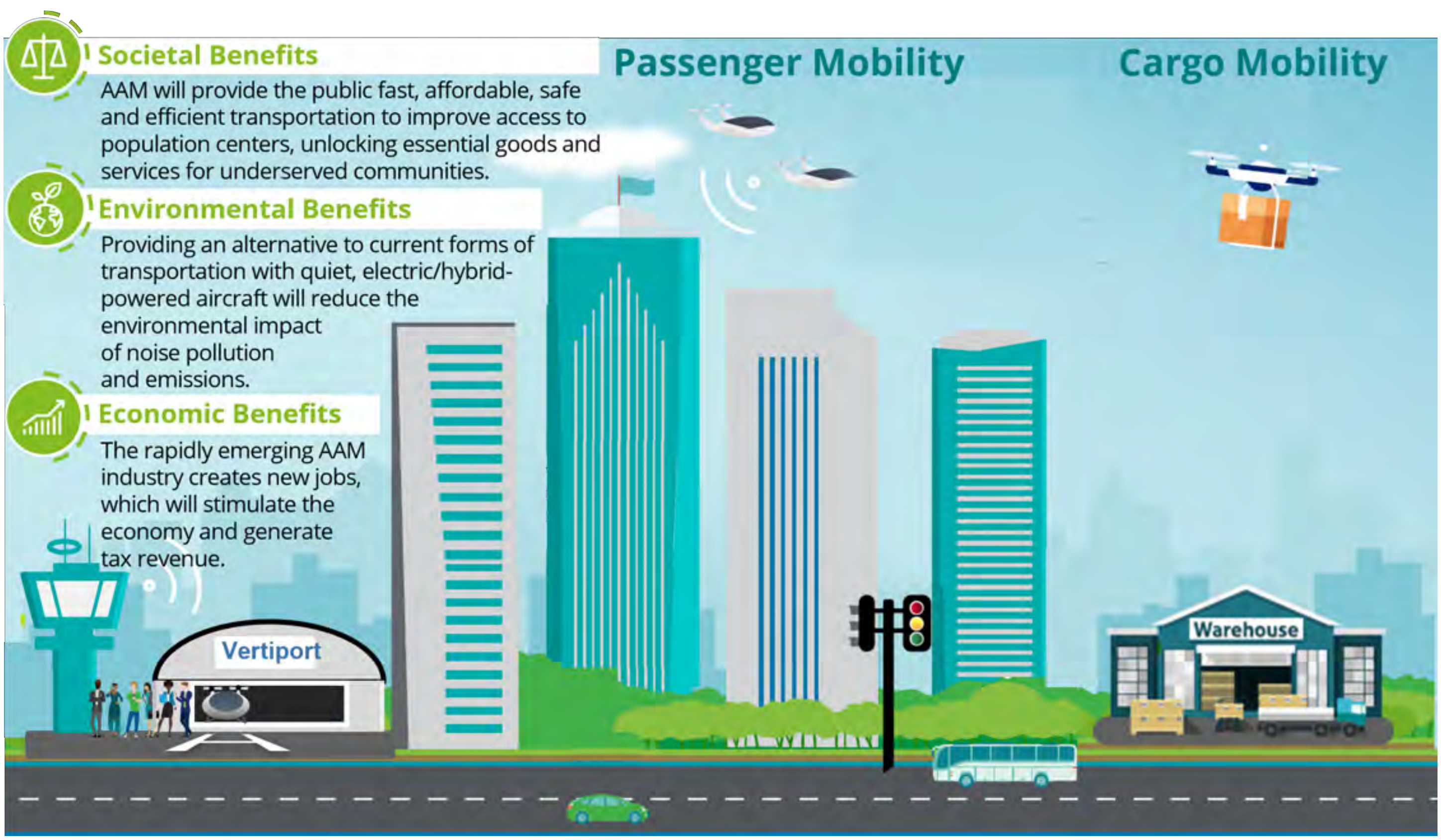
AAM will integrate air travel as part of day-to-day transportation, whether through delivery of goods in urban environments, linking rural areas to population centers through passenger and cargo mobility, or a new mode of passenger travel within cities and regions. AAM aircraft are being developed to be quieter than current aircraft and run on electric or hybrid-electric power, offering a "green" alternative to traditional transportation methods, and reducing the impact of noise pollution and emissions on the environment.

AAM technologies are rapidly evolving, offering new capabilities yet to be implemented. The limitless potential and many benefits of AAM (Exhibit 1) have piqued the interest of governments around the world; a recent Deloitte study found that achieving AAM leadership and market share seems to be a priority among the United States, China, Germany, and South Korea.[1] As these countries race to become the global leader in AAM, the AAM market will continue to grow and mature swiftly.

Passenger mobility applications:
Passenger transportation from point A to point B within the city, from one city to another, either on-demand or as a scheduled service.

Cargo mobility applications:
Logistics and cargo transportation, B2B (business-to-business), services from one city to another, and from point A to point B within the city as well as B2C (business-to-consumer) last-mile package delivery.

Exhibit 1: AAM Benefits for Passenger and Cargo Mobility Applications



A booming market: the AAM market in the United States is poised to grow sevenfold, reaching approximately U.S. $115 billion by 2035.

Globally, AAM vendors from the aviation industry and non-traditional startups are delivering innovative and disruptive capabilities at a significant rate. AAM technologies represent new and extended business opportunities for companies operating across the aircraft manufacturing, infrastructure, supply chain, fleet management, and software spaces. In addition to the commercial utility these technologies provide, many aspects of AAM may have a dual use with military applications as well, driving the demand for AAM even further.

2021 was a milestone year for the AAM market as electric vertical takeoff and landing (eVTOL) aircraft companies witnessed almost $6 billion in investments, an increase of $1.5 billion compared to the total $4.5 billion in investments between 2010 and 2020. According to Vertical Flight Society, approximately 600 eVTOL aircraft concepts and designs are being developed by about 350 companies worldwide.[6]

Within the AAM market, two applications are leading the way: cargo mobility and passenger mobility. While the cargo mobility market will likely be the first to grow and achieve scale, the passenger mobility market is expected to start slowly but catch up and exceed the former beyond 2035.

In the U.S., the AAM market for passenger and cargo mobility is projected to reach $115 billion by 2035 (Exhibit 2). The need for AAM jobs will grow with the demand for these markets.

In the U.S. alone, the AAM market is estimated to create more than 280,000 high-paying jobs by 2035, generating $8 billion in tax revenue.[1]

Exhibit 2: Projected US AAM Cargo & Passenger Market (in billions of USD)

The tax revenue from AAM related jobs will continue to increase over time for state and local governments. In fact, several states are taking notice of the economic benefits that come with participating in this projected $115 billion market. However, to unlock the economic benefits of AAM, states will need to work strategically to attract and mature the AAM industry.

Enabling AAM technologies and maturing the industry will occur faster in states that offer incentives, lower barriers of entry, and supporting assets that are already in place. One such state that is currently positioned to become a leader in AAM is New Jersey.

States that enable safe, sustainable, and scalable AAM deployment will become national leaders within the U.S. market.

New Jersey: A Future Leader in AAM

Uniquely positioned to drive AAM growth and innovation nationally, starting in Atlantic County

New Jersey's proximity to major cities, such as New York City and Philadelphia, make it an economically viable location for the early adoption of AAM. This viability lies in the demand from workers commuting daily from New Jersey to surrounding major cities. A Census report determined that New Jersey has more residents traveling out of state for work than any other state in America.[7] While this demand provides the need for New Jersey to become an early adopter of AAM to improve regional transportation and alleviate traffic congestion, the state has many assets that can be leveraged to accelerate the development of the AAM industry.

New Jersey has long been known for strong academics, ranking second in the U.S. in public education and creating an environment that has more scientists and engineers per square mile than any other location in the U.S.[8] In 2019, the state's economy employed 4.33 million people, the largest of the industries being elementary and secondary schools. This foundation has created a strong cast of academic institutions across New Jersey to support the AAM industry, both through research partnerships and workforce development programs. An example of this would be an institution in New Jersey that is researching and assessing the operational capabilities of communications and mapping sensors aboard Uncrewed Aircraft Systems (UAS) aircraft.[9]

New Jersey also has a supportive government eager to set the state on a path towards a stronger future, with innovation at the forefront. Governor Murphy's economic development strategy seeks to reestablish New Jersey as a leader in technology and innovation by creating a diverse innovation ecosystem, while doubling venture capital investment in the state.[3] The advancement of AAM offers an unparalleled opportunity to build and strengthen the state's innovation capabilities and ecosystem to become a national leader in the next generation of mobility.

> There are many assets across New Jersey that position the state to play a lead role in AAM. Leveraging those capabilities in a location with a lower barrier-to-entry, such as Atlantic County, can help accelerate AAM industry development for the state.

With several nationally recognized assets and an airspace that supports an increase of AAM operations (Exhibit 3), Atlantic County holds tremendous potential to accelerate New Jersey's AAM capability and industry.

Opportunity for Atlantic County

Atlantic County is home to New Jersey's only officially recognized Aviation District,[2] which has potential to become a leading destination for research and development of AAM technology. The Aviation District is comprised of aviation assets, such as the FAA William J. Hughes Technical Center, ACY, a designated Smart Airport Test Bed Facility, and NARTP.

The FAA's William J. Hughes Technical Center is a research facility known for advancing the United States National Airspace System (NAS) and sustaining its continued safe and efficient operations. Advancing the NAS includes facilitating the introduction of new technologies into the airspace, which will be key to developing the regulatory framework of AAM through certification requirements for safe, secure, and reliable integration into the NAS, as well as the development and assessment of future detailed concepts of operations and procedures. The FAA's William J. Hughes Technical Center also has strong partnerships with both public and private entities to accelerate AAM-related testing and research, such as NASA to develop energy storage, electric propulsion and sensors and the U.S. Air Force Air Mobility Command located at Joint Base McGuire Dix Lakehurst to jointly establish pathfinders for smart airports.[4]

ACY provides New Jersey a proving ground for AAM testing in an operational environment. The airport offers Class C airspace, meaning operators can avoid holding patterns, ground stops, and many air traffic control delays that come with Class B airspace in nearby Philadelphia or New York City. ACY is currently operating at only 23% capacity, providing potential to expand operations to include thousands of additional take-offs and landings each year to support AAM development.[10]

At the center of Atlantic County's aviation assets is NARTP, a research center right next to ACY that brings together an ecosystem of industry, academia, and governmental partnerships. NARTP is positioned to be the catalyst of AAM advancement in New Jersey by forming strategic partnerships to develop a thriving AAM-focused ecosystem. NARTP's leadership will facilitate alignment across the key stakeholders that comprise the New Jersey and Atlantic County AAM ecosystem, providing a focal point in the state to advocate for the development of AAM.

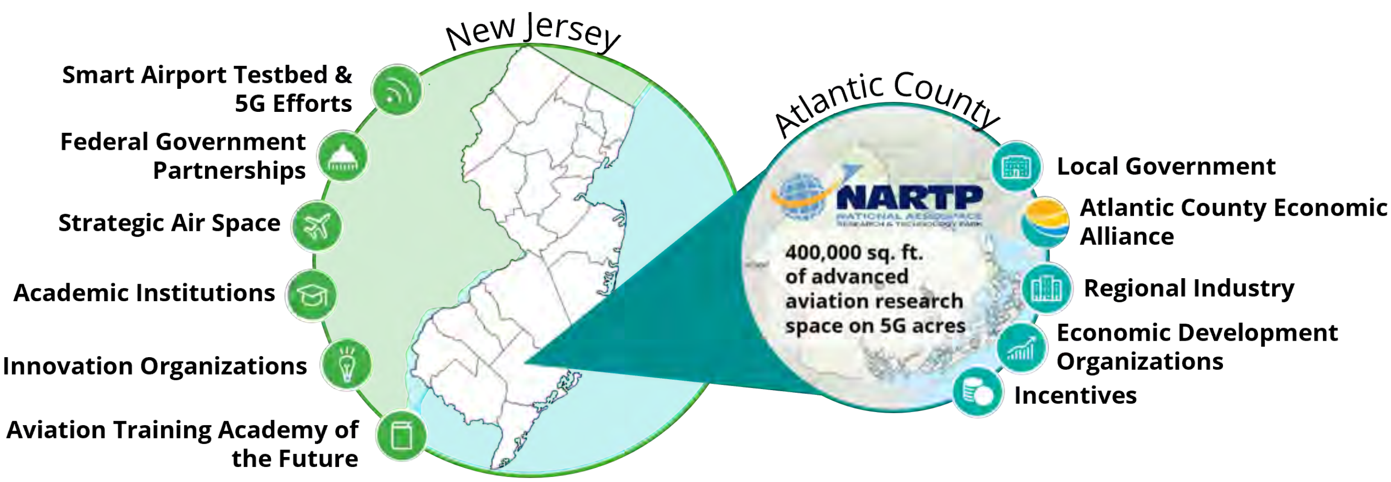
Economic development groups will foster growth of this ecosystem. The Atlantic County Economic Alliance (ACEA) and New Jersey Economic Development Authority (NJEDA) attract commercial opportunities, businesses and technology innovators that keep New Jersey and Atlantic County at the forefront. The ACEA is exploring the development of an Aviation Training Academy in collaboration with the U.S. Air Force Air Mobility Command and Embry-Riddle Aeronautical University. The Academy would implement virtual and augmented reality training and the maintenance and repair of UAS and AAM vehicles, which would help develop a workforce to facilitate AAM research and development in Atlantic County.

Surrounding academic institutions, such as Atlantic Cape Community College, will also provide workforce development and training programs needed to support demand over time.

Collectively, these assets provide a foundation for New Jersey to become a leader in AAM.

New Jersey is positioned to be a leader in the development and growth of the projected $115 billion US AAM market if it leverages its unique research ecosystem, assets, and geographic location.[4]

Exhibit 3: AAM Assets Within New Jersey & Atlantic County's Ecosystem



Smart Airport Testbed & 5G Efforts
ACY, Designated Smart Airport Testbed; Private 5G Network Testing

Federal Government Partnerships
FAA, TSA, Air Marshalls, Access to NJ Congressional Delegation

Strategic Air Space
Proximity to NYC, Philadelphia, "Air Jitney" Route to Atlantic City
Opportunity for test flights over water and unpopulated areas

Academic Institutions
Embry-Riddle Aeronautical University, Stockton University, Rowan University, Atlantic Cape Community College, Atlantic County Institute of Technology

Innovation Organizations
National Institute of Aerospace, Smart Airport and Aviation Partnership, FlightPlan Aviation Business Accelerator

Aviation Training Academy Of The Future
Development in consultation with Embry-Riddle, U.S. Air Force, and FAA for Part 147 and UAS and AAM

Local Government
Atlantic County and NJ's only "Aviation District"

Atlantic County Economic Alliance
Access to federal, state, and local incentives, workforce development and recruiting, permitting and regulatory assistance, project facilitation, full economic development concierge

Regional Industry
Casino/Hospitality Industry, eCommerce/Air Cargo Opportunities

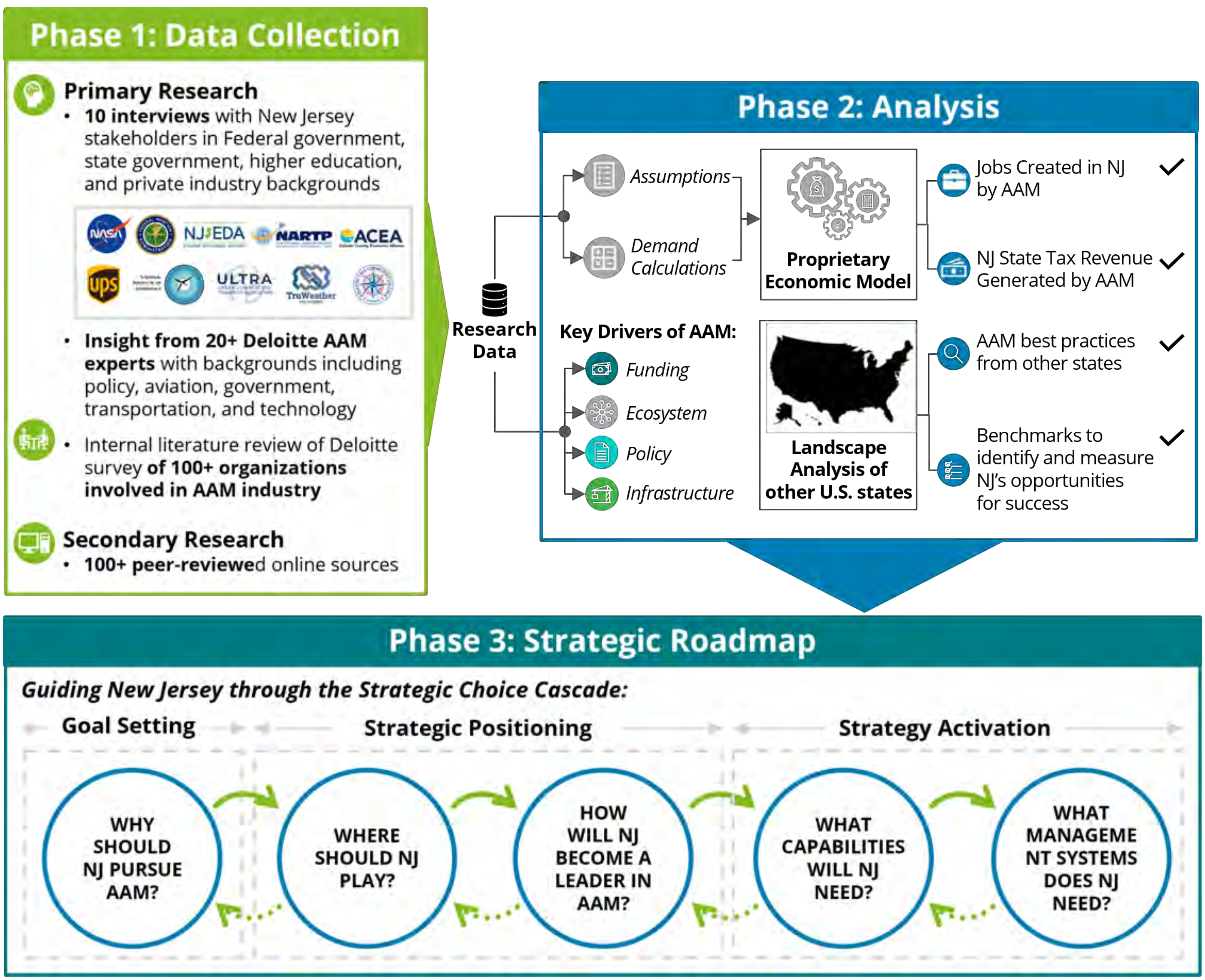
Economic Development Organizations
ACEA, NJ Economic Development Authority, U.S. Department of Commerce, U.S. EDA

Incentives
Federal Opportunity Zone designation, "Aviation District" tax credits for creating jobs

Project Methodology

A three-phased approach was conducted to gain a holistic understanding of New Jersey's capabilities, needs, and advantages regarding AAM, as outlined below (Exhibit 4). In Phase 1, data was collected through interviews with New Jersey stakeholders and AAM industry experts, an internal literature review of an AAM industry survey, and secondary research of peer-reviewed sources. The qualitative and quantitative data collected in Phase 1 was organized and analyzed in Phase 2 to understand AAM market opportunities, the economic impact of AAM in New Jersey, and best practices and benchmarks from other states that are exploring AAM. The results from Phase 2 were used to inform a Strategic Roadmap in Phase 3, which guides New Jersey through the strategic choice cascade and outlines the steps New Jersey should take to become a national leader in the AAM market. The remainder of this report walks through the Strategic Roadmap.

Exhibit 4: High-Level Methodology Outline of AAM Strategic Plan



AAM Benefits for New Jersey

Economic, environmental, and societal benefits

Advanced Air Mobility (AAM) is a step-change in aviation technology and innovation that could revolutionize the way people and cargo move throughout the United States. Today, many state and local governments are recognizing the benefits AAM can provide to their communities and economies. States that enable safe, sustainable, and scalable AAM technologies will become national leaders within the U.S. market and unlock benefits for the economy, environment, and society.

Economic Benefits of AAM

Creating Jobs

Imagine a scenario where a person requests an AAM flight as a part of their commute. To enable this trip, software and supporting ride-hailing applications are needed to be developed and managed to receive the trip request. An operator would receive the request through a scheduler who would review fleet availability and finalize the itinerary. Once the trip itinerary is final, the operator would coordinate with the air traffic authority and controller to ensure appropriate communication to enter the airspace at the designated time. In parallel, groundcrews and technicians prepare the vehicle for departure. Once vehicle preparation is complete, a pre-flight attendant loads any belongings onto the aircraft and addresses customer needs before take-off. These are some examples of the numerous direct jobs that will be needed to enable a single AAM flight. To support AAM demand at scale for long-term sustainability, a range of direct, indirect, induced, and catalytic jobs will be required (Exhibit 5).

As AAM capabilities mature and operations scale, indirect jobs will play a pivotal role in supporting the industry by supplying critical resources in the development of the workforce. This includes maintaining, repairing, and operating the necessary infrastructure to facilitate sustainability and economic viability.

While the AAM industry continues to grow, it will stimulate the growth and development of supporting businesses and services in the region. The employees in these jobs will contribute to the local economy through consumption, such as groceries and transportation expenses, driving the need for those industries to increase capacity to meet new demand. This mechanism, defined as induced job growth, creates further economic impact and benefits for New Jersey.

The final, and potentially most impactful category of jobs that will be created, is catalytic; the growth by tangential industries to support the AAM industry. As the industry matures, the surrounding ecosystem and tangential industries, such as tourism, insurance, legal firms, and real estate will respond to the economic growth observed regionally.

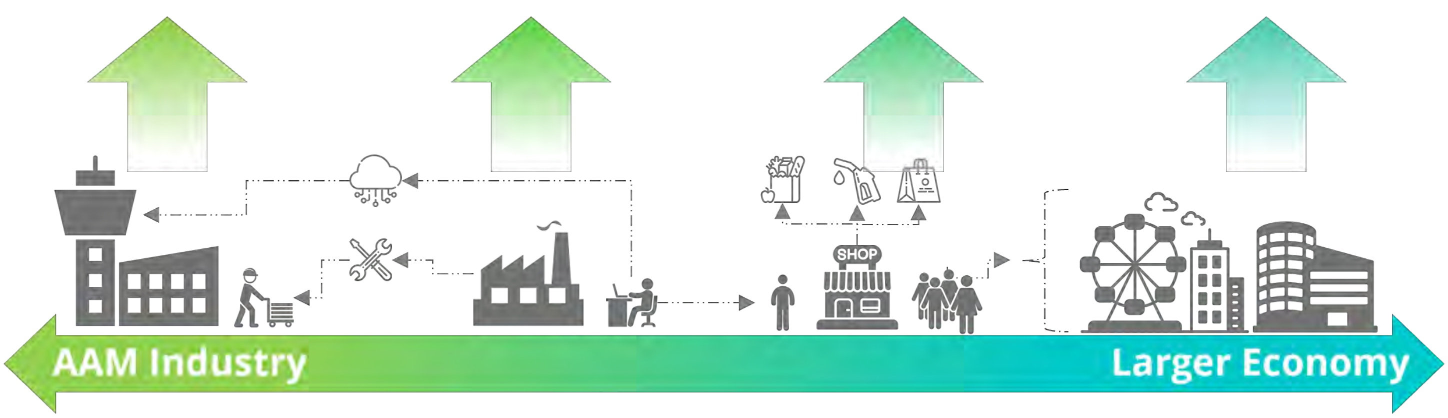
Exhibit 5: Types of Jobs Created to Support AAM

Direct Jobs:
Enable the operation of an AAM flight (air traffic controllers, groundcrew, gate agents, security, etc.)

Indirect Jobs:
Supply critical components, services, or staffing to support the operation of an AAM flight (software, utility companies, maintenance, etc.)

Induced Jobs:
Create additional revenue through direct/indirect employee consumption (gasoline, groceries, utilities, childcare, etc.)

Catalytic Jobs:
Exist within tangential industries that benefit from AAM operations (Tourism, insurance and legal firms, real estate, etc.)



When analyzing the economic impact of developing a new and innovative mode of transportation, it is clear that AAM has the potential to alter states' economic landscapes through job creation. A proprietary economic modeling tool was used to develop an analysis of economic impact and the total jobs across all four categories that are required to enable and support the AAM operations in New Jersey over a 15-year progression (Exhibit 6). In total, the AAM industry would create over 25,000 jobs in New Jersey over 15 years.[4]

Taxes from Jobs

AAM also has the potential to significantly impact the economic landscape of New Jersey through tax revenue generated from newly established jobs. The proprietary economic modeling tool estimated the cumulative tax revenue generated from income, property, and sales tax.

This cumulative tax revenue is a projection for New Jersey but has been demonstrated

New Jersey could see almost $152 million earned annually in additional tax revenue from AAM-related jobs at the end of the 15-year projection.[4]

in other states developing an AAM market. For example, North Dakota employs 175 people directly and 167 people indirectly, and the state has already seen $19.3 million in tax revenue.[11] This resulted from induced businesses attracted to their UAS test site. New Jersey has the potential to see a similar economic impact through the development of the AAM industry.

Environmental Benefits of AAM

Reduce Emissions

AAM has the potential to reduce reliance on fossil fuels by serving as an electric or hybrid electric alternative to current transportation methods. This benefit is very relevant and timely, as regions all over the world have set long-term goals to reduce carbon emissions to zero in an effort to combat climate change.

In 2020, transportation made up 27% of all U.S. greenhouse gas emissions, more than half of this percentage was comprised of light-duty vehicles, such as cars, trucks, and buses.[12] Consider an average commute from Northern New Jersey to New York City, a duration of about 30 minutes. Each gasoline vehicle will produce around 6kg of CO_2 emissions per trip, compared to an eVTOL which produces zero emissions.

A group of 1,000 AAM passengers (less than 1% of Newark's population) could reduce the total daily CO_2 emission output by 6,000kg, which is the average output that a single vehicle produces annually.[13]

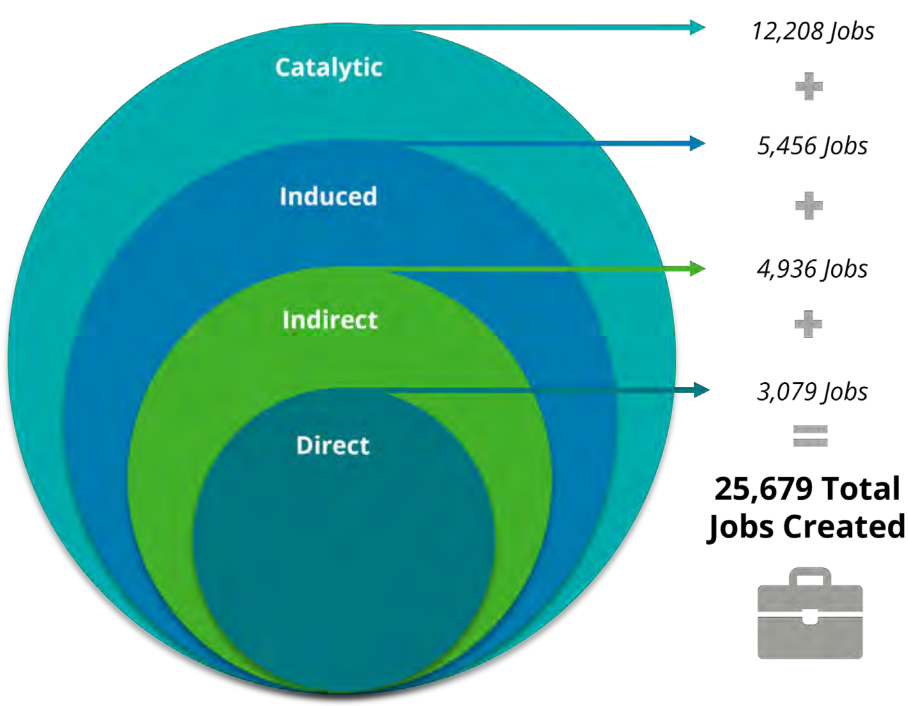
In addition to passenger vehicle impact, AAM also provides a more environmentally friendly alternative to traditional cargo transportation methods such as airplanes and delivery trucks. The demand for fast, efficient cargo delivery is rapidly increasing, as the World Economic Forum forecasts that e-commerce distribution volumes will continue to rise.[14]

AAM usage of electric and hybrid VTOL aircraft would reduce the number of ground-based passenger and cargo delivery vehicles in operation, improving air quality and decreasing reliance on fossil fuels.

Reduce Aircraft Noise Pollution

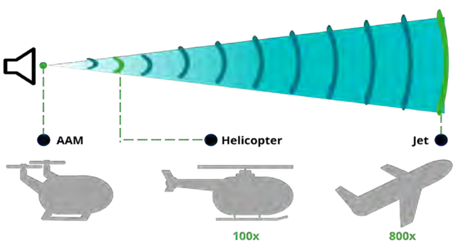
Another less commonly discussed environmental issue is noise pollution caused by airplanes and helicopters, which AAM aircraft manufacturers have highlighted, placing significant emphasis on the reduced noise of their aircraft. For example, one claim has been made that an eVTOL can be 100 times quieter than a helicopter during take-off and landing and audibly unnoticeable

Exhibit 6: Breakdown of Total AAM Jobs Required over 15 years per Category



while cruising at max elevation,[5] as shown in Exhibit 7 below.

Exhibit 7: Comparison of noise generation per aircraft during take-off and landing



This feature aims to lessen the disturbance caused to residential areas situated closely to airports and helipads. Atlantic City residents near the regional airport have voiced their concerns about this problem numerous times in recent history. In one situation, a mother complained that her son would be regularly frightened by the loud planes taking off and landing over their house.[15]

AAM has the potential to deliver many benefits to states, cities, and communities where traditional crewed aviation cannot through the implementation of innovative technology that has less impact on the environment.

Societal Benefits of AAM

Efficient Transportation

While AAM has been touted as positively impacting our economy and environment, the technology has the potential to significantly impact the quality of life of entire communities. One ever-growing issue that could be improved by AAM is traffic congestion.

> In 2020, each driver in the Mid-Atlantic (specifically South New Jersey, Philadelphia, Delaware, & Maryland) wasted an average of 37 hours sitting in traffic (37% higher than the national average of 27 hours).[16]

Atlantic County specifically suffers from this problem due to its heavy commuting presence. The current number of people who commute and live outside of Atlantic City (22,000) is double the number of non-commuters who both live and work in the city (11,000).[8] This means there is already a heavy reliance on daily long-distance commutes translating to a larger loss of time for those involved.

> At an average cruise speed of 150mph,[17] a trip from Philadelphia to Atlantic City with AAM could take as little as 25 minutes compared to the typical 1.5-hour car commute.

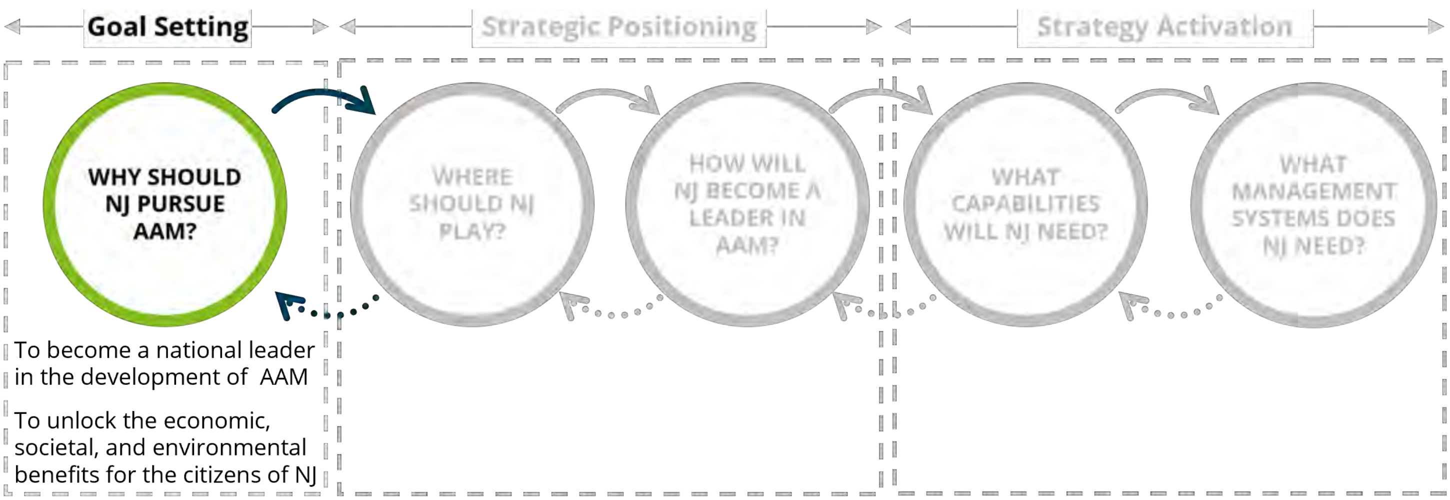
AAM has the potential to alter the way our population travels daily, providing more useable time and reducing costs associated with its impact.

Access and Equity

The success of AAM will not only be predicated on how quickly people move from point A to point B, but also on how accessible and affordable it is for all citizens in the region rather than an exclusive, luxury option. For residents and families who live in disadvantaged communities and impoverished areas, this new form of transportation could unlock a world of accessibility that previously seemed impossible. The Atlantic City Stakeholder Report identified limited public transportation as one of the city's weaknesses.[18] This lack of transportation restricts access to employment opportunities, contributing to unemployment rates and societal dissatisfaction. An AAM program would give people in the community access to the same resources or opportunities through a new mode of travel, while recognizing individual circumstances to create equitable solutions for those resources and opportunities to be reached. Opportunities such as access to new areas to work, shop, and live, stimulating the local economy and leading to improved growth. Exhibit 8 depicts the three-times-greater access that is possible through AAM compared to traditional ground-based vehicle travel.

Exhibit 8: Comparison of Accessibility with AAM versus Traditional Transportation

This section highlighted the potential economic, environmental, and societal benefits through developing the AAM market within the state to answer the question, “Why should New Jersey pursue AAM?” The following section will develop key themes to strategically position New Jersey in the AAM market to answer the question, “Where should New Jersey play?”



Where to Play

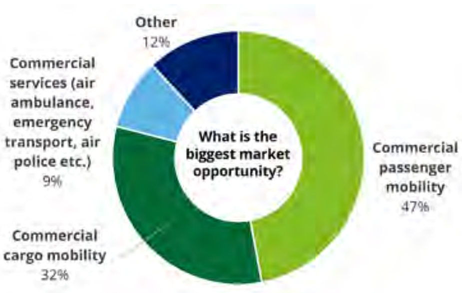
AAM market opportunities for New Jersey and where to start

A survey of 100+ industry, government, and academic organizations in the AAM industry[1] along with 30+ targeted interviews of subject matter experts and New Jersey stakeholders[4] were analyzed to identify trends, challenges, and priorities for AAM. These trends will help inform New Jersey on which AAM applications and capabilities the state should target to participate in the growth and maturation of the projected $115 billion AAM market.

AAM Market Opportunities

Exhibit 9 shows which AAM market opportunities survey respondents believe are the most significant.

Exhibit 9: Breakdown of Biggest AAM Market Opportunity by Survey Response



According to AAM industry players, commercial cargo mobility and passenger mobility are expected to be the biggest near-term market opportunities in AAM.[1]

However, adoption curves are expected to differ due to safety, societal, and operational considerations. Cargo mobility is expected to have greater near-term adoption than passenger mobility due to the lower psychological barriers and fewer regulatory challenges.

Passenger mobility could build on capabilities developed and proven through success of transporting cargo including advances in autonomy, remote piloting, secure communications, detect and avoid capabilities, and ground infrastructure.

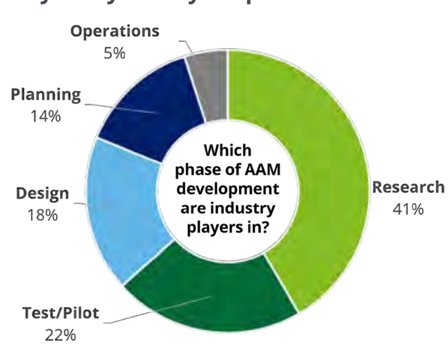
Where to Start

AAM capabilities for cargo and passenger mobility applications are being developed using a crawl-walk-run approach to ensure they are demonstrated safely at increasingly levels of complexity.

R&D is expected to remain a priority for the AAM sector as it matures from initial operations to scaled operations that are a routine part of transportation and logistics networks.

The ultimate objective of safe, scaled commercial operations that are fully integrated into air and ground transportation systems relies on extensive R&D. As shown in Exhibit 10, the majority of survey respondents are still in various phases of research and development, while only 5% of respondents are working in operations.[1]

Exhibit 10: Breakdown of AAM Industry Players by Survey Response



Prioritizing Safety and Reliability

As the AAM industry increases technology and operational complexity through R&D, the regulatory environment is also evolving quickly to ensure that safety and reliability remain the top priorities. As shown in Exhibit 11, the majority of survey respondents identified regulation and certification, and safety and reliability as the biggest challenges for passenger and cargo mobility.[1]

Exhibit 11: Biggest AAM Challenges by Survey Response

Entities that continuously meet evolving AAM regulatory standards to ensure safety and reliability will emerge as leaders in the industry.

To do so, advanced R&D facilities and technological capabilities will be needed.

Key Technology and Capabilities

In targeted interviews with New Jersey stakeholders and AAM industry experts, several technologies and capabilities were identified as priorities to enable AAM in a safe and reliable manner and meet regulatory standards, such as Beyond-Visual-Line-of-Sight (BVLOS) flight, AAM Test Beds and Corridors, and a Digital Twin.[4]

BVLOS

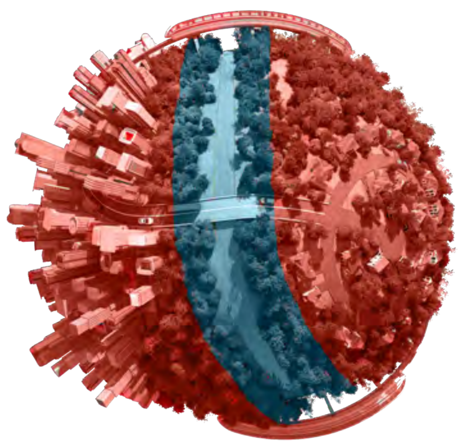
AAM encompasses crewed, uncrewed, and/or autonomous flight. One of the first steps towards commercial uncrewed flight operations is establishing remotely-piloted flights.[19] Currently, remotely-piloted flights are restricted to within visual-line-of-sight (VLOS), with the exception of obtaining a waiver from the FAA. This means the pilot on the ground must be able to see the aircraft at all times, which restricts flights to a very small radius. A current priority across industry and the FAA is to enable beyond-visual-line-of-sight (BVLOS) flights, meaning the pilot on the ground does not need to see the aircraft during flight (Exhibit 12).[20] BVLOS unlocks a variety of benefits and uses, while also introducing more operational complexity that builds toward increased capability and maturity.

Exhibit 12: BVLOS Flight

AAM Test Beds and Test Corridors

Early phases of AAM R&D focus on small-scale operations, often in environments with minimal physical obstacles and ideal conditions. As AAM technological capabilities mature, testing will need to be conducted in environments that simulate real-world conditions and larger-scale operations. To enable this, test beds all over the U.S. are being stood up in coordination with the FAA.[21] Leading test locations have facilities that support advanced testing such as BVLOS and autonomous operations and offer environments that can simulate a range of weather conditions, geographies, and population densities.[22] For larger-scale and longer-range testing, AAM corridors are also being established, which are sections of airspace approved by the FAA for BVLOS testing and uncrewed aircraft operations (Exhibit 13).

Exhibit 13: AAM Test Corridor

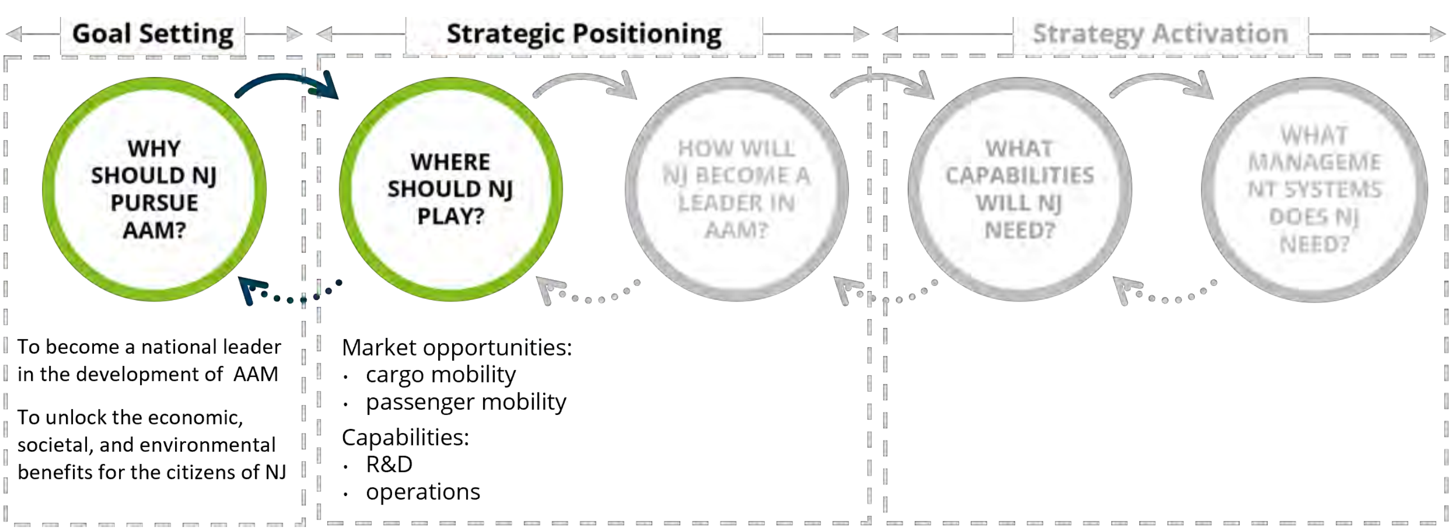


Digital Twin

One way to minimize risk and cost of AAM testing is with digital tools to simulate and test AAM in a virtual environment (Exhibit 14). This virtual environment is designed to be identical to a real environment through the use of extensive data, creating a ”digital twin” of the real environment. A digital twin can generate an operational environment that offers endless capabilities such as performing AAM simulations, assessing risk, and evaluating impact of AAM on the environment.

Exhibit 14.: Digital Twin

This section highlighted market opportunities, where to start, and key technologies and capabilities to consider, which answers the question, “Where should New Jersey Play?” The following section will develop key themes to strategically position New Jersey in the AAM market and answer the question, “How will New Jersey become a leader in AAM?”



How New Jersey can become a Leader in AAM

Preparing New Jersey for the Future

New Jersey and Atlantic County have an opportunity to develop and grow the emerging AAM market through the advancement of R&D and operational capabilities for commercial passenger and cargo operations. While this opportunity has the potential to transform New Jersey's role in the next generation of mobility, the path to success will be shaped by the state's priorities and direction.

Four Key Drivers for AAM Success

20+ targeted interviews of AAM leaders, subject matter experts, and New Jersey stakeholders were conducted and analyzed to understand New Jersey's current standing and identify key drivers towards the successful development of an AAM R&D environment and commercial operations capability.[4] From these interviews, the following pillars shown in Exhibit 15 emerged as key drivers to enable the AAM market in New Jersey:

Funding

80% of interviewees communicated a need for dedicated funding either through financial support, incentives, or grants from federal, state, and local governments for AAM related activities and endeavors to create a successful AAM industry. While the AAM industry is still emerging, funding has played a vital role in maturing AAM aircraft technology to the current state, and this will be similar for states' capabilities to enable AAM.

*"For New Jersey to become a **leader in AAM**, the **state and local governments** need to make an investment in this space and not just rely on industry. There is a lot of opportunity here for **economic development**, so an investment in AAM would have a **large impact and a substantial ROI.**"*

Ecosystem

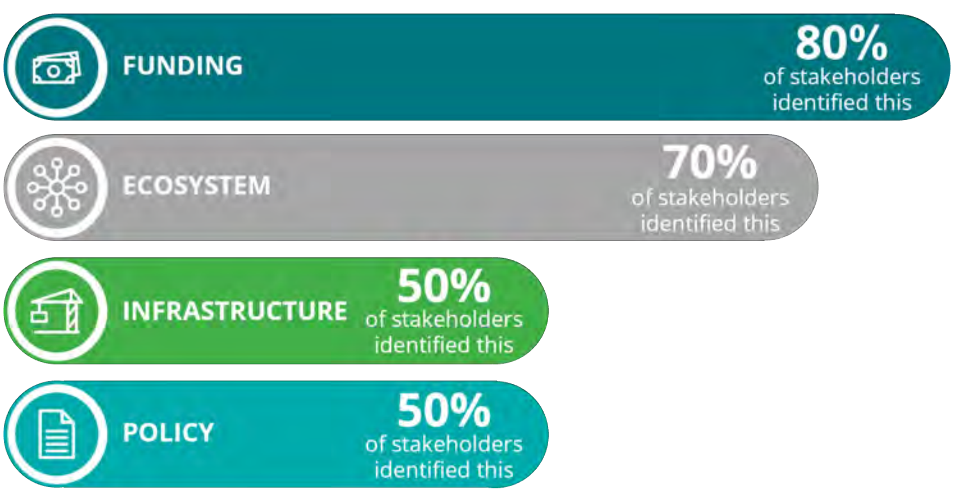
70% of interviewees highlighted the need for a diverse and collaborative ecosystem across the region and state to enable AAM. As the AAM industry continues to mature, the ecosystem required to enable, accelerate, and sustain AAM capability will also expand. This network of organizations within the state across academia, private industry, federal and state government will collaborate and play a unique role in the development of AAM capability that generates distinct benefits for each stakeholder.

*"Economic development is an **ecosystem** play. New Jersey is more likely to **attract companies** if there are other **pieces of their ecosystem puzzle** close by."*

Infrastructure

50% of interviewees identified infrastructure as a key driver towards the successful development of an AAM R&D environment and commercial operations capability. A network of technologies (e.g., hardware, software, aircraft), systems (e.g., cybersecurity, communication, command and control networks, data sharing platforms) and supporting structures/facilities (e.g., radars, weather sensors, vertiports, maintenance centers) are needed to enable safe AAM R&D and operations. Many interviewees emphasized the need to first identify and leverage current infrastructure within the state that can support AAM R&D and operations. As AAM technologies and capabilities continue to develop and mature, the state will need to build the proper infrastructure to support them.

Exhibit 15: Drivers for AAM Success from Targeted Interviews



*"New Jersey already has many **aviation assets and infrastructure** to serve as **a foundation for AAM**, but we need to connect the dots and build upon that to **support safe BVLOS flight, R&D efforts, and future passenger/cargo operations.**"*

Policy

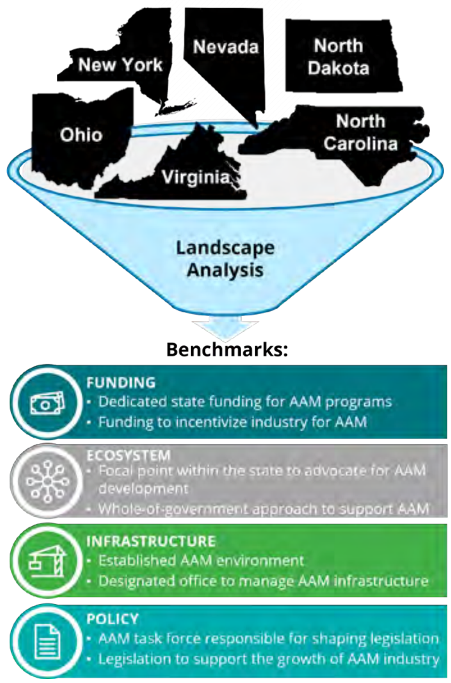
50% of interviewees pointed to policy as a key driver towards the successful development of an AAM R&D environment and commercial operations capability. Many leaders in the AAM sector believe the industry's maturation is predicated on the development of policy and regulations that clearly define how this technology will be certified and integrated into our current transportation system. Several interviewees expressed that there are current policies in place that inhibit AAM either because they are outdated or implemented out of fear or misinformation. Interviewees also stated that policies and regulations have been moving slower than AAM technologies have been advancing, which hinders innovation and maturation of the AAM industry.

*"There is legislation in New Jersey coming out that **may inhibit AAM and scare off potential industry players** from coming here. We need to work with our policy makers to **inform and educate the public about AAM and the benefits** it would bring to everyone, and we need a **dedicated group to help shape policy to enable safe AAM operations.**"*

Learning from other States

Several states across the U.S. are considering and pursuing AAM. For New Jersey to become a leader in the AAM space, it is important to identify and evaluate best practices from other states to leverage and build upon. The four pillars of funding, ecosystem, infrastructure, and policy served as assessment criteria in a landscape analysis of other states. The resulting insights from this analysis provide benchmarks for New Jersey to understand how the state compares to others and where to focus its efforts to maximize impact. A summary of the landscape analysis and resulting benchmarks is shown in Exhibit 16 below, highlighting six states that represent a variety of geographic locations, sizes, demographics and AAM maturity levels:

Exhibit 16: AAM Landscape Analysis & Benchmarks with Example States



How can New Jersey get ahead?

The key drivers, best practices, and benchmarks identified for AAM success at the state level provide a framework for New Jersey to become a leader in AAM.

Those key drivers and best practices focus on four pillars: funding, ecosystem, infrastructure, and policy, which drive the successful development of an AAM R&D environment and commercial operations capability.

New Jersey has many unique assets across these areas that should be leveraged to accelerate the maturity of the AAM market across the state and each will play critical roles in the key drivers of funding, ecosystem, infrastructure, and policy, as mapped in Exhibit 18.

New Jersey's Funding Enablers

To seed the growth of emerging markets in New Jersey, economic development groups such as NJEDA and ACEA are actively assisting projects and companies through financial resources, incentives, or programs.

For example, the ACEA received a $1 million federal economic development grant for projects that focus on planning and feasibility studies regarding AAM to accelerate the development of the industry in Atlantic County and across the state.[23] One example of this is through the exploration of a regional air-cargo and logistics center that leverages AAM to support middle-mile and last mile delivery.

New Jersey's Ecosystem

Ecosystems will play a vital role in supporting and maturing the AAM market near- and long- term to create sustainable mobility options for New Jersey.

Groups within the state, such as NARTP in Atlantic County, are providing leadership in the advancement of AAM by creating an ecosystem of industry, academic, and governmental partnerships to foster innovation, collaboration, and sustainable economic growth. Examples of such partnerships are shown in Exhibit 17.

Exhibit 17: Current State of AAM Partnership Ecosystem within New Jersey

New Jersey's Infrastructure

A primary challenge to enabling AAM in New Jersey will be the development and installation of the necessary infrastructure. New Jersey has already started a crucial first step by identifying and leveraging current infrastructure within the state that can support and accelerate AAM capabilities; New Jersey has designated an Aviation District in Atlantic County, which is comprised of ACY, a designated Smart Airport Testbed, the FAA's William J. Hughes Technical Center, and NARTP. ACY is currently operating at 23% capacity, offering the potential for expansion and construction of AAM-enabling infrastructure.[10]

New Jersey's Policy-Shapers

Two types of policy are critical for AAM:

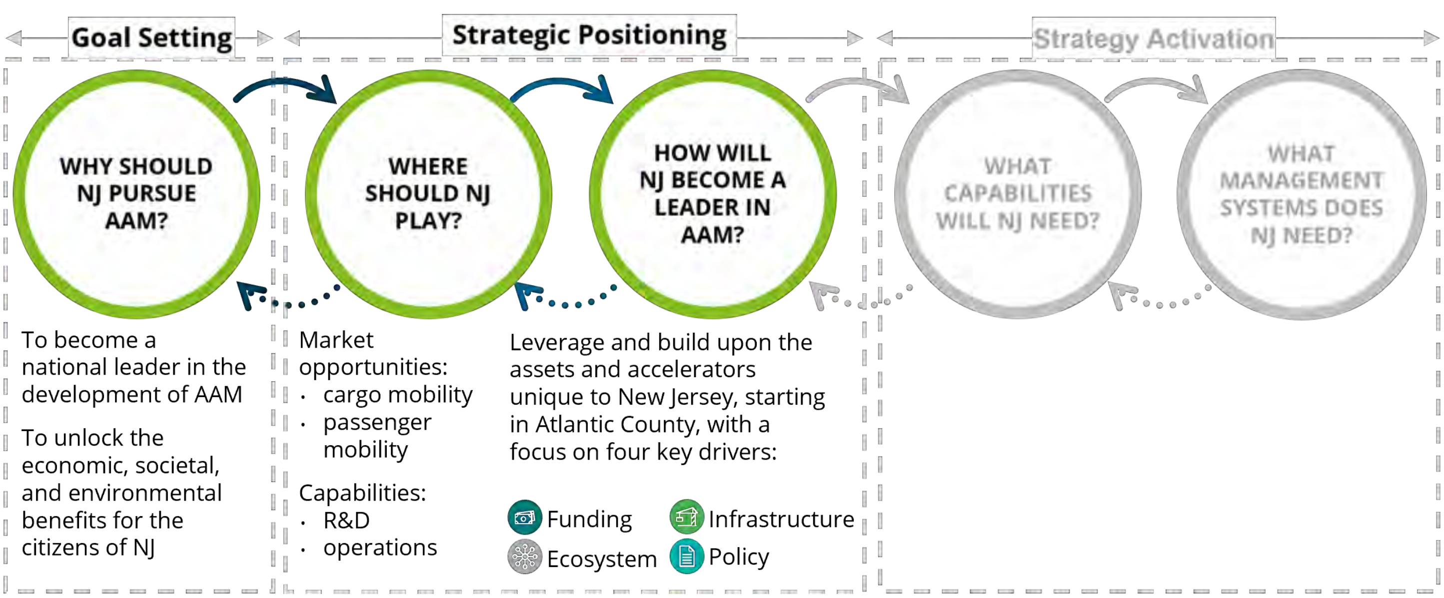
1. Legislation to prioritize, develop, and fund AAM-related activities
2. Regulations to clearly define requirements for certification and operations

The development of these policies will be the turning point that accelerates the industry toward commercial operations and scalability. While this will take time, New Jersey has a unique asset in the FAA William J. Hughes Technical Center that can be leveraged to develop key insight around certification requirements for safe, secure, and reliable AAM operations and integration into the NAS.

Exhibit 18: New Jersey's Assets and Accelerators Mapped to AAM Key Drivers

	Key Drivers:			
ASSET	FUNDING	ECOSYSTEM	INFRASTRUCTURE	POLICY
SMART AIRPORT TESTBED & 5G EFFORTS			✓	
FEDERAL GOVERNMENT PARTNERSHIPS	✓	✓	✓	✓
STRATEGIC AIR SPACE			✓	
ACADEMIC INSTITUTIONS		✓		
INNOVATION ORGANIZATIONS		✓		
AVIATION TRAINING ACADEMY OF THE FUTURE		✓	✓	
LOCAL GOVERNMENT	✓	✓	✓	✓
ATLANTIC COUNTY ECONOMIC ALLIANCE	✓			
REGIONAL INDUSTRY		✓	✓	
INCENTIVES	✓			
FAA WILLIAM J HUGHES TECHNICAL CENTER		✓		✓
ECONOMIC DEVELOPMENT ORGANIZATIONS	✓			

This section highlighted key drivers for AAM success, best practices and benchmarks from other states, and a framework for New Jersey, answering the question "How will New Jersey become a leader in AAM?" The following section will provide the steps New Jersey will need to take to realize the state's potential, answering the questions that make up Strategy Activation.



The Road Ahead

Realizing the opportunity and benefits of AAM in New Jersey

This section defines an integrated strategy and recommendations to guide New Jersey through the development of AAM, positioning the state to be a leader in the industry.

Strategy

The strategy focuses on the needs of the nascent AAM sector today (research, develop, test) while creating the conditions to support a more mature market (operate at increasing levels of complexity), which were identified through Deloitte's research (Exhibit 19). It aims to create synergies between research and commercial use (research informs commercial applications while information and data from commercial applications drives research), while being anchored on the principle of generating returns for the citizens and economy of Atlantic County and New Jersey during the process of maturing a new technology from initial viability to scaled operations.

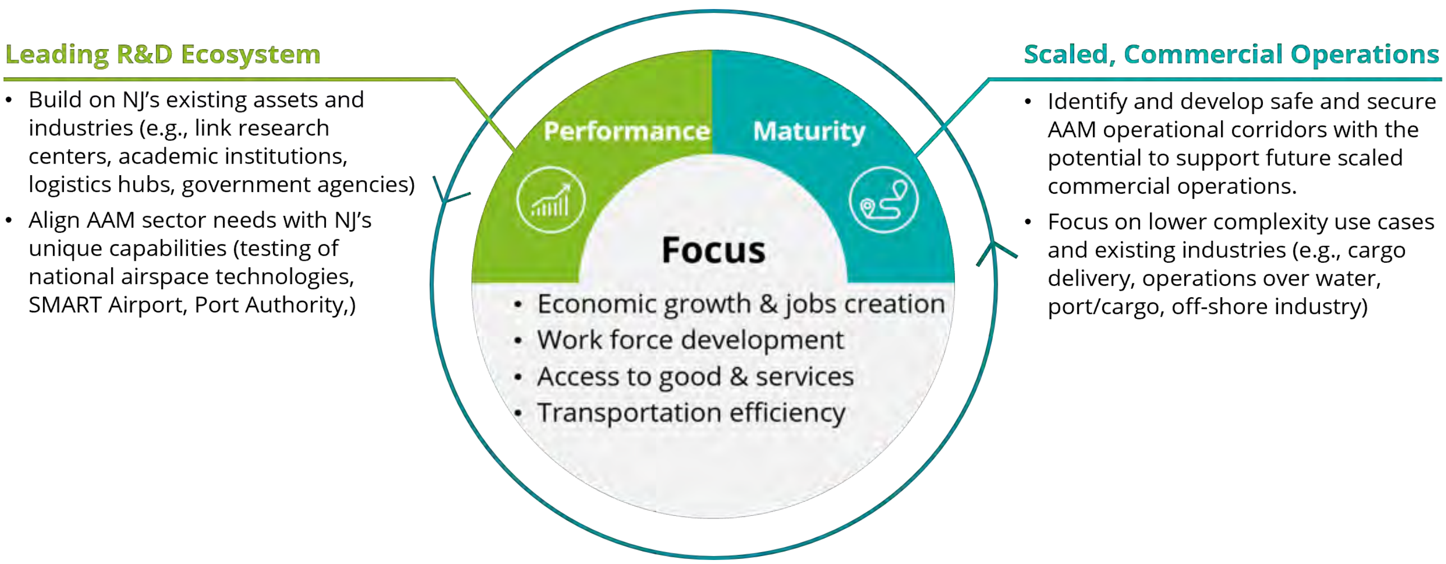
Recommendations

The Strategic Roadmap provides a series of recommendations and potential approaches for NARTP to serve as a catalyst for AAM innovation in the state, building on its unique assets and location. These recommendations can serve as a guide for more detailed implementation plans, investment decisions, and partnership discussions. The recommendations are broken into three phases – Enable, Accelerate, and Scale. These

Establish NARTP as the Catalyst for New Jersey to Develop a Leading Advanced Air Mobility R&D Ecosystem

phases support increasing levels of research and operational complexity consistent with the FAA's "crawl, walk, run" framework. Each phase includes a target outcome that serves as a north star for that phase (Exhibit 20). Through these phases, NARTP can mature the New Jersey AAM research and development ecosystem and build the conditions for thriving commercial AAM operations that are integrated into the state's broader transportation and logistics networks.

Exhibit 19: Strategic Focus on Both Current and Future AAM Markets



- The early "Enable" phase focuses on establishing the foundational AAM R&D Hub by formally linking existing stakeholders, state assets and expanding partnerships, while at the same time developing corridors with the infrastructure to support initial BVLOS operations with an initial focus around cargo operations.
- As these mature through the "Accelerate" phase, additional partners are added to the research ecosystem, including both national and international partners along with investment toward advanced AAM capabilities (automation, communications, etc.) to support more complex operations. This is accompanied by the development of initial passenger routes in locations that are safe and economically viable.
- These phases and outcomes build to a mature "Scale" phase that supports a thriving commercial ecosystem of AAM innovation in the next generation of technology, as well as AAM operations integrated into local and regional transportation and logistics networks. **A summary of this roadmap is provided below with more detailed recommendations for each phase in the following sections.*

Exhibit 20: AAM Roadmap Phases and Target Outcomes

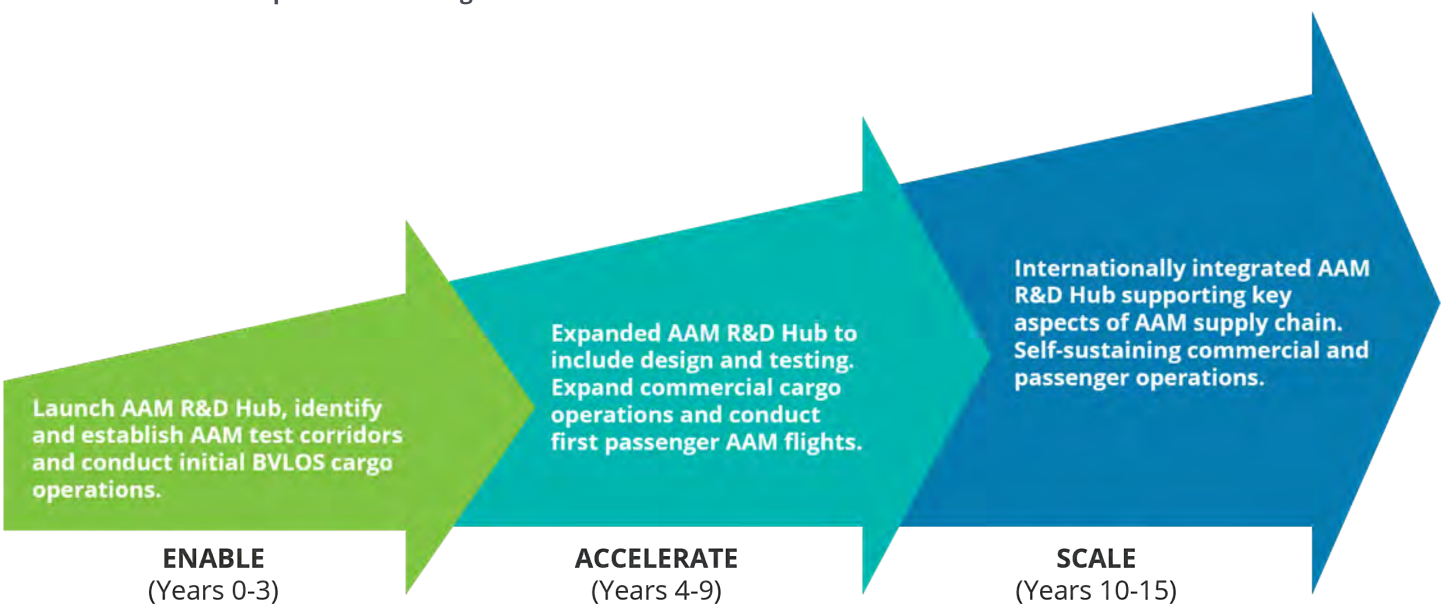
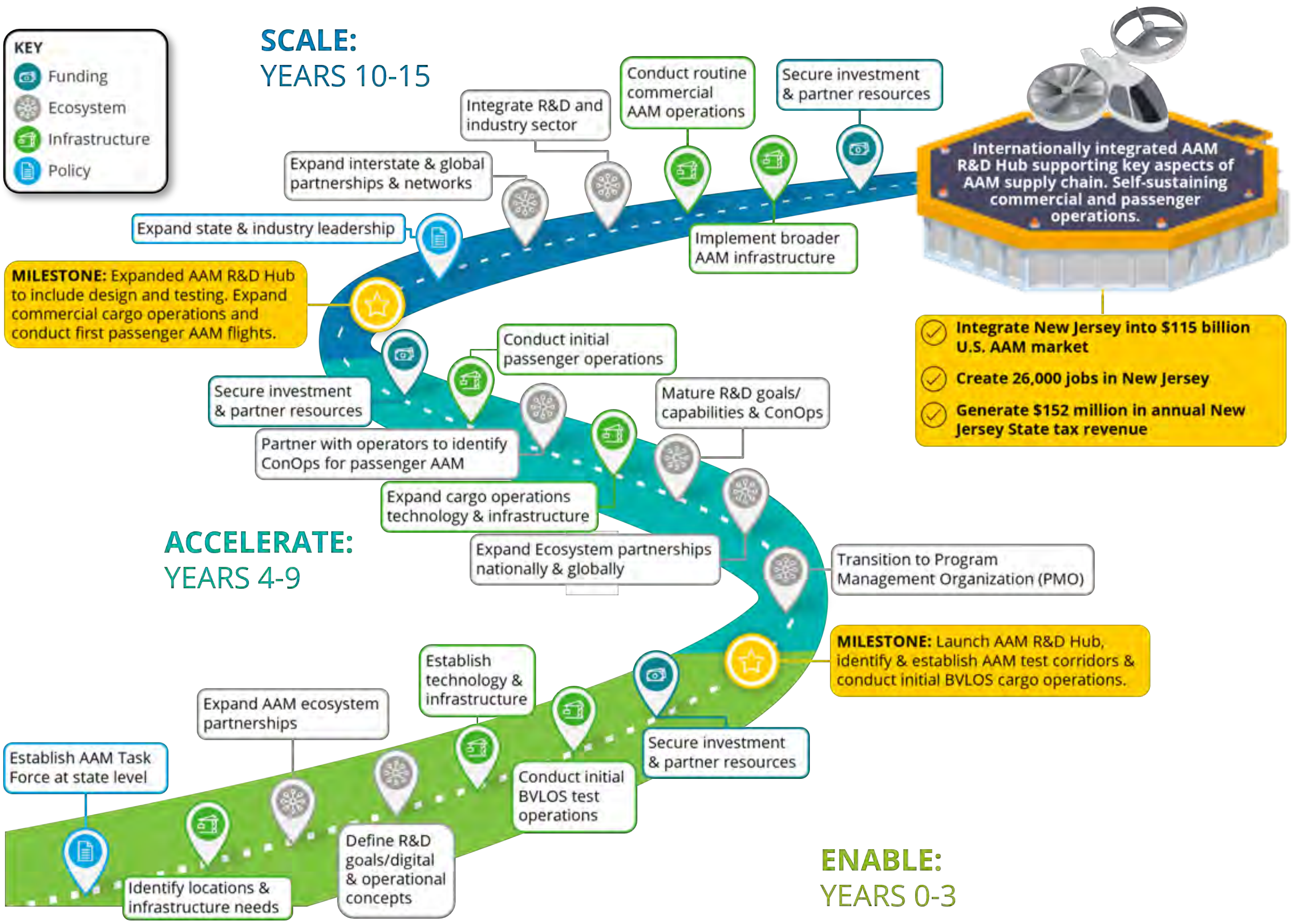


Exhibit 21: Summary New Jersey AAM Strategic Roadmap



ENABLE
0 – 3 YEARS

Launch AAM R&D Hub, identify and establish AAM test corridors and conduct initial BVLOS cargo operations.

Leverage and build regional infrastructure for AAM and BVLOS research and testing: the creation of an AAM task force at the state level will be vital in making sure the correct legislation is in place to begin construction of the infrastructure. Additionally, establishing public-private partnerships, setting up training programs, and identifying AAM technology vendors to grow the industry and workforce will lay the foundation for an ecosystem that can grow over time.

Exhibit 20: AAM Roadmap Phases and Target Outcomes

Recommendation	Potential Methods	Value
Establish State Task Force for AAM	• Establish NARTP as lead organization for an AAM task force including representative stakeholders (e.g., state, federal, industry academia). • Provide a dedicated team to implement state AAM development / growth. • Designate or create state units and positions dedicated to developing AAM innovation (e.g., division or formally designated group within NJDOT, NJEDA, SJTA).	• Research shows that states with a focal point to advocated for policy and promote AAM nationally and globally has more favorable legislation and better alignment across the ecosystem.
Identify Locations and Infrastructure Needs	• Formalize partnership agreements between existing aerospace R&D facilities, organizations, and locations with roles and AAM commitments. • Identify shortlist of potential AAM test corridors with capability to scale for commercially viable operations that link cargo or transit hubs. • Inventory current R&D and aviation operations infrastructure across locations.	• A network of research and operational assets across New Jersey will establish the initial of AAM Innovation Ecosystem (test beds, research centers/ institutions, commercially viable flight corridors) that supports the AAM industry.
Expand AAM Ecosystem Partnerships	• Establish formal partnerships and roles across stakeholders in NJ AAM Ecosystem. • Establish new partnerships (industry, states, federal, global) based on AAM research synergies connecting NJ to the national/global AAM sector growth. • Establish educational and workforce development partnerships integrated with AAM ecosystem.	• Formal partnerships between state AAM Ecosystem stakeholders (R&D centers, test beds, logistics hubs, etc.) and industry will enhance research, operational and workforce development capability.

Recommendation	Potential Methods	Value
Develop R&D Goals / Digital & Operational Concepts	• Develop key roles and objectives for each partner (e.g., advancing air traffic management concepts, testing ground infrastructure, implementing communication and data security, supporting cargo delivery demonstration/test operations). • Develop a Concepts of Operation and Digital Twin for each potential test corridor to support initial testing and demonstration of flight along with pathway to commercial operations. • Identify safe and secure technology/infrastructure needs to support research or operational concepts/goals.	• Goals from stakeholders in the NJ AAM Ecosystem will leverage their unique potential within the national AAM sector. • Baseline Operational Concepts for proposed test corridors (i.e., logistics, passenger operations, BLVLOS) will provide the basis for future technology and infrastructure investments.
Establish Technology and Infrastructure	• Conduct a gap analysis between existing technology and infrastructure and requirements of research goals and operational concepts. • Prioritize investment to support priority research topics and support initial BVLOS test operations. • Identify and secure vendors to acquire and install technology focusing on selected test corridors. • Develop a data repository to collect and share AAM related digital, operational and test data. • Validate communication, navigation, surveillance, and information security concepts.	• Installed infrastructure will support AAM research and enable New Jersey to conduct initial AAM test operations with a pathway to commercial operations.
Conduct Initial BVLOS Test Operations	• Develop a safety case and work with the FAA to gain approval for flight operations. • Identify and secure teams to conduct flight operations. • Conduct test flights with increasing complexity (shorter flights, visual observers, etc.). • Conduct BVLOS demonstration flights.	• BVLOS test operations willthat demonstrate viability by linking key logistics/cargo hubs.
Secure Investment and Partner Resources	• Identify initial state level investment to support critical infrastructure for BVLOS corridor. • Identity state agencies to support/participate in AAM ecosystem development. • Identify industry organizations to participate in the task force and support initial operations. • Identify individuals to serve as lead for the NJ AAM ecosystem.	• State and federal investment will be supplemented by key anchor partners in AAM R&D Hub. • Partner resources will support initial R&D efforts and operations, where practical.

ACCELERATE
4 – 9 YEARS

Expand AAM R&D Hub to include design and testing. Expand commercial cargo operations and conduct first passenger AAM flights.

Begin installing and expanding infrastructure to support cargo and passenger operations, allowing the program to evolve from its beginning state as a research hub. The passing and promoting of AAM policies at the state, local and federal levels through the AAM task force will lead to the dedication of funds towards this growth. The ecosystem will accelerate through the securement of partnerships and vendors to support broader logistics, commercial passenger operations, and cargo operations.

Exhibit 23: Recommendations to Accelerate AAM

Recommendation	Potential Methods	Value
Transition to Program Management Organization	• Secure consistent and long-term funding to support a PMO to manage the NJ AAM Innovation ecosystem. • Identify or establish an organization to manage AAM development, considering an organizational charter, leadership or board, relationship to state aviation groups, and reporting requirements. • Establish a PMO operating model and performance metrics.	• A separate organization will be responsible for managing and maturing the NJ Innovation Ecosystem (e.g., managing annual budgets, partner agreement, securing state/ federal investment).
Expand Ecosystem Partnerships Nationally & Globally	• Develop partnerships with broader NJ industry sectors including innovation, communications, and life sciences. • Develop AAM applications and use cases that are additive and/or draw from these industry sectors. • Expand partnership with internationally states and industries nationally in areas there the is mutual benefit or complimentary capabilities.	• The ecosystem will expand to be consistent with growth plans, including integration with existing NJ industry sectors and the expansion of national and international partnerships to support NJ AAM growth and development.
Mature R&D Goals and Capabilities, and ConOps	• Work closely with test corridors to identify research needs that improve benefits or range of commercial applications. • Coordinate with industry and federal agencies leading AAM research and operational integration to identify key focus areas and needs given the evolving regulatory frameworks or operational capabilities. • Support research that expands access to AAM (e.g., reduces cost per flight, expands number of routes).	• Research areas will expand in response to industry priorities and evolving national and state regulatory environment.

Recommendation	Potential Methods	Value
Expand Cargo Operations Technology and Infrastructure Concepts	• Mature partnerships with a major cargo hub and operators to develop and expand AAM applications that improve logistics and efficiency. • Expand AAM infrastructure support a higher volume of routine operations between cargo hubs and/or increase the capabilities of cargo operations (size /weight). • Build out additional cargo and AAM routes supported by state surveillance and UTM infrastructure.	• Cargo operations will expand beyond demonstration and test flight to support routine operations between cargo hubs and improve access for communities.
Partner with Operators to Identify ConOps for Passenger AAM	• Identify locations of high passenger activity and demand (e.g., transit locations) by conducting analyses regarding current transportation patterns and costs. • Consider potential Regional and Urban Air Mobility (e.g., intra-state and inter-state operations). • Evaluate existing infrastructure e.g., for landing/take-off, intermodal connectivity, air traffic complexity. • Evaluate community and environmental requirements and concerns related to new operations.	• Coordination with AAM passenger carriers to explore suitable routes for initial AAM passenger operations will lead to economically viable passenger routes with industry partners.
Conduct initial first passenger operations	• Work with operator and FAA to develop and approve AAM routes. • Support community engagement activities, federal, state, and local regulatory reviews, and approvals.	• The first AAM passenger route will be established, and initial passenger operations will be conducted.
Secure Investment and Partner Resources	• Identify initial state level investment to support expansion of state managed AAM infrastructure. • Secure expanded industry investment through use of research and testing facilities. • Export As a Service Models for commercial AAM operations that use State infrastructure.	• Limited State and Federal investment with increasing proportion of funding generated by commercial industry will provide economic independence for the R&D Hub.

SCALE
10-15 YEARS

Internationally integrated AAM R&D Hub to support key aspects of the AAM supply chain while achieving self-sustained commercial and passenger operations.

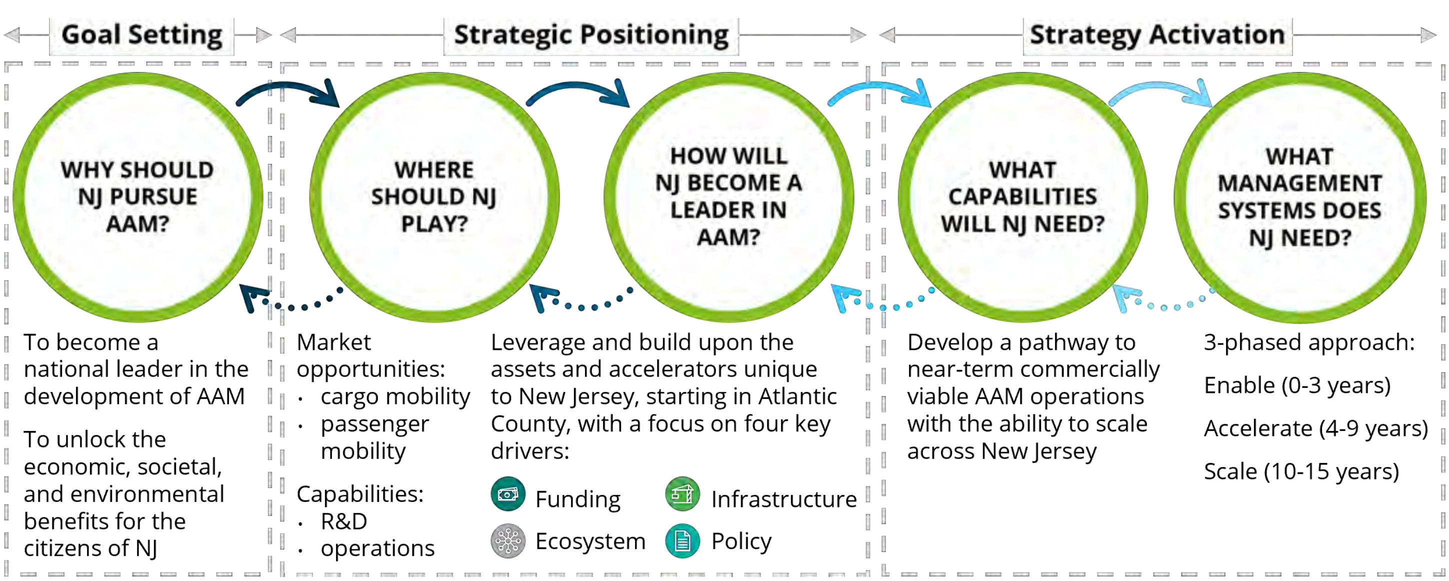
Optimize and grow New Jersey AAM infrastructure to integrate with national and international transportation and supply chain operations for expansion to other regions of the country. The maintenance of state-level relationships and funding that will support routine operations beyond state lines, along with expanding the technological capability of the ecosystem at the private level, will be vital in making sure that Atlantic County scales over time to meet the growing demand for regular AAM usage.

Exhibit 24: Recommendations to Scale AAM

Recommendation	Potential Methods	Value
Expand state and industry leadership	• Continue to drive growth in NJ AAM Sector though PMO. • Establish state authorities for oversight, planning, and development of AAM.	• State entities and other industry groups will support the PMO in maturing the New Jersey AAM industry.
Expand interstate and global partnerships and networks	• Maintain long-standing national and global partnerships for AAM. • Mature workforce development programs and integrate with academic institutions.	• Expanded national and global partnerships will secure New Jersey's position as a leader in AAM, and will attract investment across the state. .
Integrate R&D and Industry Sector	• Integrate the AAM ecosystem with other major NJ industry sectors as a leader in AAM technology and innovation. • Expand industry develop to support large volumes of operations (i.e., O&M, and other aspect of the supply chain).	• The AAM ecosystem integrated with a broad set of NJ industry sectors will support further development and growth, and evolve to address the supply chain and O&M needs of scaled AAM operations.
Implement Broader AAM infrastructure	• Integrate a network of state and industry-supported infrastructure to enable scaled operations. • Establish infrastructure maintenance programs and upgrades.	• A network of AAM infrastructure supported and maintained by the state and industry will enable a broad range of cargo and passenger operations.

Recommendation	Potential Methods	Value
Conduct Routine Commercial AAM Operations	• Integrate a network of commercial cargo and passenger operations including small UAS and Large eVTOL.	• Commercial operations will grow and scale across the state.
Secure Investment and Partner Resources	• Establish **policies and systems that create revenue streams to finance state AAM infrastructure, such as service fees or "as a service" technology applications.** • Establish **Federal and state programs for investment toward scaling AAM infrastructure.**	• **A self-sustaining ecosystem will be established for R&D and commercial operations.**

This section highlighted the strategy, near-term focus, and actionable recommendations in a three-phased approach, which answers the questions that comprise the Strategy Activation section of the strategic choice cascade.



Leaving a Lasting Legacy

Considering the Opportunity for New Jersey

New Jersey is poised to solidify themselves as a national leader in the AAM industry by leveraging unique assets established in Atlantic County, existing infrastructure, and favorable capacity for AAM operation and growth.

While AAM holds numerous benefits for the state, obstacles will continue to emerge that could hinder the implementation and integration of this technology. New Jersey should act swiftly to build momentum toward the development of AAM while following a logical, executable strategy to enable operational capability that could lead to significant economic, societal, and environmental impact for the state.

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REPORT AND RECOMMENDATIONS OF THE

Urban Air Mobility Advisory Committee

OCTOBER 2022

PREFACE

Advanced Air Mobility (AAM) is a next-generation transportation modality transforming America's regional and interregional connectivity for the movement of people and goods. AAM includes a broad range of innovative aeronautics technologies, including a large class of unmanned aerial systems, vertical take-off and landing (VTOL) aircraft, electric aircraft, and transformative air traffic management systems. Urban Air Mobility (UAM) is a subset of a complex AAM ecosystem that focuses on high-density automated aircraft operations over densely populated areas, especially aircraft operations below 4,000 feet.

The Texas Transportation Commission Urban Air Mobility Committee, constituted through the directive of SB 763, was tasked with assessing current state law regarding UAM and providing suggestions for potential changes, as well as providing guidance on the development of UAM operations and infrastructure for the State of Texas. The Committee embraced a broader interpretation of the directive to set a goal to identify and define the State's path to adopting this new transportation modality. The guiding vision of the Committee was to "Maximize Opportunity and Safety" and included four principles:

1. Texas will be the destination for the early adaptation and development of UAM Technologies.
2. UAM will provide extensive business and economic opportunities for our residents.
3. The adaptation of the UAM paradigm will create equitable upward social mobility for our residents.
4. Texas will be the national role model for the safe deployment of UAM.

Through four working groups (Technology, Airspace and Infrastructure, Safety and Security, and Commerce and Community Integration), the Committee explored the intersection of policy and technology doctrine to develop a set of recommendations to support the UAM ecosystem development for the State of Texas. The Committee collects and synthesizes information on (i) state, national, and global contexts, (ii) technology and maturation level, (iii) state and federal laws, and (iv) strategic advantage of our State in developing the recommendations. The recommendations are summarized in this report.

The Committee worked diligently to develop a robust set of recommendations that can be used as a foundation for developing new regulations (or potentially changing existing ones) that can facilitate the development of the State's UAM deployment and adaptation capabilities. However, due to the very short duration of the Committee, an extensive assessment of some of the important areas could not be done. Rapidly emerging AAM technologies and elasticity needed in the regulatory framework to address these evolving technology paradigms require much more in-depth analysis than those the Committee was able to provide. Regulatory impacts, challenges, and opportunities for high-density UAM, interoperability, cybersecurity, industry-regional government partnership, and workforce development issues must be fully considered before comprehensive UAM implementation guidelines can be developed. A comprehensive legal and regulatory review was not presented to this committee due to the statutory timeframe, including but not limited to relevant U.S. Supreme Court cases *United States v. Causby* and *Griggs v. Allegheny Cty.*; further legal analysis by appropriate independent experts is required. The Committee likely needs an additional 24 months of effort to provide more comprehensive assessments.

It was my privilege to serve as Chair of the Texas Transportation Commission Urban Air Mobility Committee and work with a group of very distinguished UAM stakeholders. Very special appreciation to the Texas Department of Transportation leadership and the Texas A&M Transportation Institute team for their extensive support to the Committee.

Ahsan Choudhuri, Ph.D.,
Chair, Texas Transportation Commission Urban Air Mobility Committee
and
Associate Vice President, Aerospace Center
Professor, Aerospace Engineering
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BACKGROUND & PURPOSE

In spring 2021, the Texas Legislature passed Senate Bill 763 in the 87th Regular Session requiring the Texas Transportation Commission to establish the Urban Air Mobility Advisory Committee "to assess current state law and any potential changes to state law that are needed to facilitate the development of urban air mobility operations and infrastructure in this state."

URBAN AIR MOBILITY (UAM) ADVISORY COMMITTEE *GUIDING VISION*

The UAM Advisory Committee established a vision that focused on maximizing opportunity and safety for the State of Texas. The core principles of this guiding vision are:

- Texas will be the destination for early adaptation and development of UAM Technologies.
- UAM will provide extensive business and economic opportunities for our residents.
- The adaptation of a UAM paradigm will create upward social mobility for our residents.
- Texas will be the national role model for the safe deployment of UAM.

Urban Air Mobility (UAM) envisions a safe and efficient aviation transportation system that will use highly automated aircraft that will operate and transport passengers or cargo at lower altitudes within urban and suburban areas.

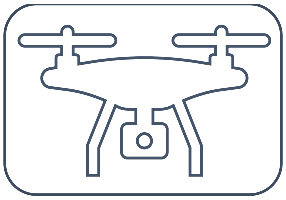
Advanced Air Mobility (AAM) builds upon the UAM concept by incorporating use cases not specific to operations in urban environments, such as:

- Commercial intercity.
- Cargo delivery.
- Public services.
- Private/recreational vehicles.

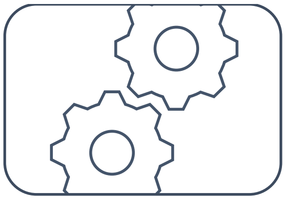
DEFINITIONS

UAM ADVISORY COMMITTEE MEETINGS

The Urban Air Mobility Advisory Committee held four public meetings which included opportunities for input from stakeholders and the general public. During the initial meetings, the committee identified four key areas for the success of UAM:



Technology



Airspace and Infrastructure

Safety and Security

Commerce and Community Integration

The working groups each held four meetings for a total of 16. All 20 of these meetings were posted in advance on the Texas Department of Transportation's (TxDOT's) website and were open to the public. Public comment was welcomed and received at all meetings. During the working group meetings, critical topics were established for each area based on the charge of the committee.

Technology	• Development of a UAM/AAM sandbox. • Airspace monitoring. • Fostering of collaboration across public and private entities.
Airspace and Infrastructure	• Alignment with FAA and airspace harmonization. • Fostering of a competitive environment for UAM. • Identification of existing policy and permitting gaps.
Safety and Security	• Safety in aircraft operations. • Standardization relating to safety.
Commerce and Community Integration	• Education and workforce development. • Public awareness.

The discussions on these critical topics concluded with the development of recommendations that were reviewed and approved by the full committee. The first recommendation was put forth by multiple working groups.

URBAN AIR MOBILITY ADVISORY COMMITTEE RECOMMENDATIONS

- Extend the work of the Urban Air Mobility Advisory Committee beyond the sunset date of January 1, 2023, to continue working in key areas of this emerging and quickly evolving industry in order to remain responsive to the needs of Texas and ensure Texas' role as a leader in this industry.

Technology

- Encourage the development of an urban air mobility/advanced air mobility sandbox by:
    a) Directing the preparation of a feasibility study to understand the market, differentiating factors from similar existing facilities, potential market/players, funding sources, revenue opportunities, locations, necessary digital and physical infrastructure, and potential use cases; and
    b) Pursuing the development of a facility that will provide opportunity for testing and commercialization that will attract business and move the industry and state forward.
    c) Having the State take the initiative to work with industry to determine additional standards in terms of communications, technology, and environmental awareness systems to encourage consistency and harmony at all levels of government and stakeholders.

> The committee's discussion regarding a sandbox focused on the concept of a designated place, either geographical or digital, where new technologies can be tested under liberal rules for a predetermined duration before a commercial rollout to the public.

- Consider the initial funding for a UAM/AAM Sandbox Feasibility Study and ultimately its development along with an incentive program to attract industry with the ultimate objective of using user fees to fund the ongoing operations and maintenance of the sandbox

- Encourage state agencies to adopt a technology-neutral/open architecture approach to the urban air mobility/advanced air mobility industry to allow easier adoption of new technologies and deployment into new regions.

- Identify areas where technology will drive standardizations.

Airspace and Infrastructure

- Provide consistency across Texas law by creating statutory uniformity and standard definitions pertaining to unmanned aircraft operations and urban air mobility/advanced air mobility.

- Develop an urban air mobility/advanced air mobility–centric research facility to test and evaluate technology, provide data collection opportunities, and coordinate with federal entities to share information and help guide data-driven public policy. The Texas Legislature is encouraged to consider the benefits of state funding for the successful development and operation of this facility.

- Develop a statewide plan, or integration within the Texas Airport System Plan, that addresses the potential locations for and classifications of vertiports and other associated infrastructure to help define the future operational environment of urban air mobility/advanced air mobility.

- Direct the State to work with municipalities to provide technical assistance to local governments in adapting and integrating urban air mobility/advanced air mobility in their communities.

Safety and Security

- In collaboration with the appropriate federal entities, the state will work to encourage the development of minimum standards/safety management systems for vertiport operations including passenger and goods movements and ground infrastructure.

- Recommend Texas law does not conflict with federal law.

- Encourage the Legislature remain an active participant in urban air mobility/advanced air mobility as the industry and technology will outpace current regulations and enable the appropriate state agency to lead and manage the regulatory concerns.

- Direct the Texas Department of Transportation to review existing state aviation standards and guidelines, airport facility planning, and compatibility guidance to ensure they apply to urban air mobility/advanced air mobility.

- Support the development of standardizations at the federal level and within industry as technology develops/changes so safety is prioritized as the technology matures.

- Encourage state-level cooperation with local governments to ensure appropriate preparation, training, and safety practices associated with vertiport operations including law enforcement, fire service, and emergency medical services associated with traditional aviation and advanced air mobility aircraft operations.

Commerce and Community Integration

- Direct all law enforcement and first responder agencies to adopt education and training recommendations as identified in *Unmanned Aircraft: Responding to and Recovering from Disasters* (State of Texas, November 2020), a report born out of House Bill 2340 (86R, 2019), establishing a small unmanned aircraft study group for a statewide response team.

- Create a statewide primary point of contact to direct urban air mobility/advanced air mobility workforce development efforts, lead public awareness and education efforts, and collaborate with local, regional, state, and federal entities to encourage more input and participation.

- Direct the State to provide resources and assistance on the use of urban air mobility/advanced air mobility technology infrastructure for cities, local and regional governments, transportation planning organizations, other entities, and industry to better identify what the different levels of government can do to integrate industry innovation and community vision and help promote urban air mobility/advanced air mobility technology.

- Direct the appropriate state agencies to jointly collaborate with local school districts, higher education institutions, and any interested private and/or public stakeholders on educational opportunities related to urban air mobility/advanced air mobility technologies.

IN CLOSING

The recommendations developed by this committee represent the culmination of many meetings and hours of discussion on how best to position our state to facilitate the emerging and quickly evolving advanced air mobility industry.

The committee recognizes that many of the recommendations may add additional workload to some agencies such as the TxDOT Aviation Division. The Aviation Division, which currently has responsibilities surrounding the planning, programming, and funding of airport projects across the state as well as some aviation education responsibilities, is likely to find itself as the focal point for several of these recommendations. The committee understands that many of the additional roles and responsibilities imbedded within its recommendations will be best addressed and carried out with appropriate accompanying resources.

The committee would like to thank the Texas Legislature and TxDOT for the opportunity to participate in this important work and their commitment to advanced air mobility.

INTRODUCTION

In spring 2021, the Texas Legislature passed Senate Bill 763 in the 87th regular session requiring the Texas Transportation Commission to establish the Urban Air Mobility Advisory Committee (*1*). The bill was passed in the Senate on April 20, 2021, and in the House on May 11, 2021. The governor signed the bill on June 14, 2021. The bill was authored by Sen. Beverly Powell and sponsored by Rep. David Cook.

TxDOT's Strategic Planning Division and Aviation Division began working with the Texas A&M Transportation Institute (TTI) in fall 2021 to provide support for the work of the Urban Air Mobility Advisory Committee upon its establishment. TTI assisted TxDOT by developing a literature review and background research for the committee as well as a review of activity in other states. TTI also provided supporting materials and assistance to the committee and TxDOT during the committee's work. Resource documents and meeting notes were maintained for the committee members' use in their work.

The primary charge and focus of the Urban Air Mobility Advisory Committee was to develop the recommendations found in the Key Areas in Urban Mobility section of this report, and the committee unanimously adopted the recommendations and accompanying report during a public meeting of the full committee on July 7, 2022. A draft report, as presented during the July 7th meeting, was posted to the committee's website for public comment; input provided during the public comment period is reflected as an appendix to the report.

COMMITTEE ESTABLISHMENT AND LEADERSHIP

The responsibility for establishing the Urban Air Mobility Advisory Committee fell to TxDOT and, more specifically, the Strategic Planning Division. TxDOT worked in late summer/early fall 2021 to identify and select members for the committee that met the representation requirements set forth in Senate Bill (SB) 763. Ultimately, 29 members were selected and approved by the Texas Transportation Commission at its November 2021 meeting. TxDOT was assisted by TTI in operating the committee, developing background resources, and facilitating the committee's work and public meetings.

At the committee's initial meeting in December 2021, a chair and vice chair were selected to lead the committee's activities. The committee elected Dr. Ahsan Choudhuri as the committee chair. Dr. Choudhuri currently serves as associate vice president and professor of aerospace engineering at The University of Texas at El Paso. He is the founding director of the university's Aerospace Center. The committee also elected Mr. Chad Sparks as the vice chair. Mr. Sparks is the director of strategy and enterprise growth alignment at Bell in Fort Worth, Texas.

During his first meeting as chair, Dr. Choudhuri shared his vision for how he saw the advisory committee working together going forward. Following discussion with the full committee, four working groups were established to allow the 29-member committee to begin addressing the multitude of issues and challenges that urban air mobility presents.

The four working groups, which are discussed in more detail later in this report, are:

1. Technology.
2. Airspace and Infrastructure.
3. Safety and Security.
4. Commerce and Community Integration.

Each working group was led by a lead facilitator who was selected by TxDOT following a request of the committee members to identify on which working group they would like to serve. The lead facilitators for the working groups were as follows:

1. Dr. Maruthi Akella, The University of Texas at Austin—Technology.
2. Mr. Nathan Trail, Supernal (Hyundai Motor Group)—Airspace and Infrastructure.
3. Mr. Ben Ivers, The Boeing Company—Safety and Security.
4. Mr. Michael Hill, Volatus Aerospace—Commerce and Community Integration.

The committee identified the topics and issues that fell under each of these areas, and the working groups used them as a starting point for their discussions. The working groups were charged with developing recommendations that fell within their group's purview.

Each of the working groups held four meetings and voted on the recommendations they developed on their fourth meeting. All working group recommendations were presented to the advisory committee as a whole at the June 14, 2022, meeting in Austin, Texas, where they were each discussed, amended if desired, and voted on. The committee adopted 20 recommendations that appear below under their respective working groups along with some additional context. This report of the Urban Air Mobility Advisory Committee was discussed and approved by the committee at its July 7, 2022, meeting in Austin, Texas.

COMMITTEE MEETINGS

The Urban Air Mobility Advisory Committee held four meetings between December 2021 and July 2022. The four working groups each held four meetings for a total of 16. Collectively, there were 20 meetings of the Urban Air Mobility Advisory Committee and its working groups. All meetings were posted in advance on TxDOT's website and were open to the public. Public comment was welcomed and received at all meetings, and the input was documented by TxDOT and TTI staff. There was a one-week public comment period following the committee's approval of the recommendations and report on June 14, 2022, and July 7, 2022, respectively. Figure 1 shows the timeline of the committee meetings.

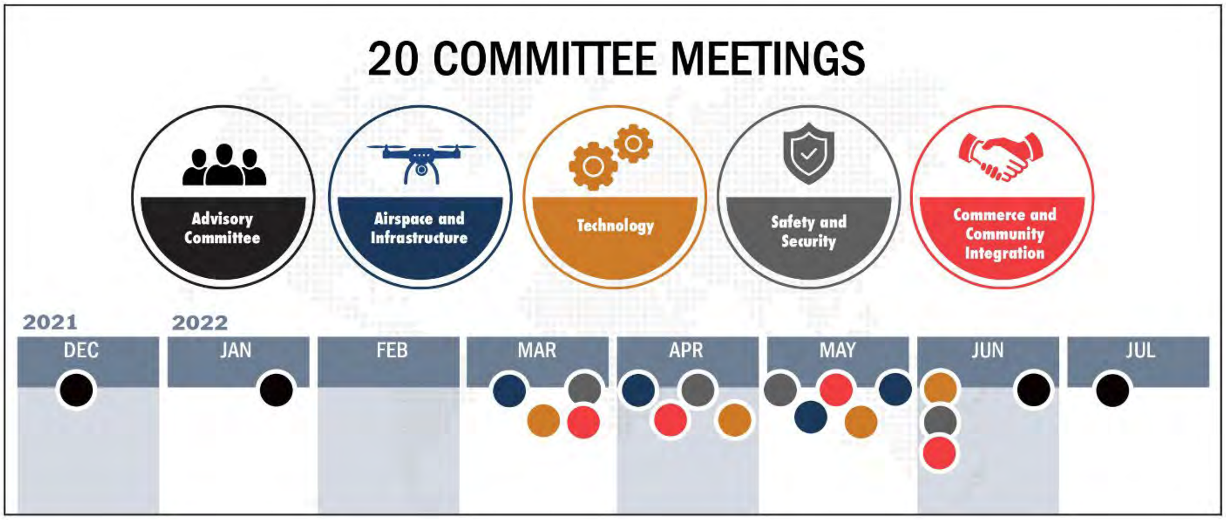


Figure 1. Timeline of Committee Meetings.

Notes and videos were taken for each of these meetings and are available at TxDOT's Urban Air Mobility Advisory Committee website: https://www.txdot.gov/inside-txdot/division/planning/urban-air-mobility-advisory-committee.html.

PURPOSE

The purpose of the Urban Air Mobility Advisory Committee and its efforts is clearly laid out in the legislation. The advisory committee is "to assess current state law and any potential changes to state law that are needed to facilitate the development of urban air mobility operations and infrastructure in this state" (*1*). The entire text of the legislation can be found in Appendix A.

DEFINITIONS

Both the National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA) have been involved in the early stages of urban air mobility. For the purposes of this research and the committee's work, this report uses these entities' definitions of urban air mobility. Further, the use of the term *urban air mobility* has been largely supplanted by the term *advanced air mobility* in an effort to be more inclusive and address these same technologies and services for areas beyond our urban areas. The use of these accepted terms and definitions will provide a common baseline and foundation from which the committee's work can take place.

FAA provides the following definitions for urban air mobility and advanced air mobility (*2*).

Urban Air Mobility

UAM envisions a safe and efficient aviation transportation system that will use highly automated aircraft (crewed or uncrewed/self-flying) that will operate and transport passengers or cargo at lower altitudes within urban and suburban areas.

UAM will be composed of an ecosystem that considers the evolution and safety of the aircraft, the framework for operation, access to airspace, infrastructure development, and community engagement.

Advanced Air Mobility

Advanced air mobility (AAM) builds upon the UAM concept by incorporating use cases not specific to operations in urban environments, such as:

- Commercial intercity (longer range/thin haul).
- Cargo delivery.
- Public services.
- Private/recreational vehicles.

To build upon these definitions, NASA has developed a vision for advanced air mobility. Currently, it almost exclusively uses the term *advanced air mobility* to be inclusive of its work on urban air mobility.

> NASA's vision for Advanced Air Mobility (AAM) Mission is to help emerging aviation markets to safely develop an air transportation system that moves people and cargo between places previously not served or underserved by aviation—local, regional, intraregional, urban—using revolutionary new aircraft that are only just now becoming possible. AAM includes NASA's work on Urban Air Mobility and will provide substantial benefit to U.S. industry and the public (*3*).

Aircraft and Airport

For the purpose of clarity, the definitions of *aircraft* and *airport* are provided as defined in the Texas Transportation Code. They are as follows.

> "Aircraft" means a device that is invented, used, or designated for air navigation or flight, other than a parachute or other device used primarily as safety equipment (*4*).

> "Airport" means: (A) an area used or intended for use for the landing and takeoff of aircraft; (B) an appurtenant area used or intended for use for an airport building or other airport facility or right-of-way; and (C) an airport building or facility located on an appurtenant area (*5*).

Unmanned Aircraft Systems

Unmanned aircraft system (UAS) is defined by the FAA Modernization and Reform Act of 2012 as follows.

> The term ''unmanned aircraft system'' means an unmanned aircraft and associated elements (including communication links and the components that control the unmanned aircraft) that are required for the pilot in command to operate safely and efficiently in the national airspace system (*6*).

Some additional clarification is also warranted regarding the use of the term "unmanned" in this report. It is used in this document for clarity and consistency reasons. The industry has seen myriad terms used over the recent years to describe aircraft being flown without a pilot whether it is autonomously or remotely. "Unmanned aircraft" and "drones" are two terms that have been widely used and even adopted by governmental agencies, industry groups, and universities within their organizations and publications. There is a clear trend to replace "unmanned" with the more gender-neutral "uncrewed" across government, industry, and academia. While the FAA still uses "unmanned", some universities, governmental agencies, and industry groups including AUVSI (Association for Uncrewed Vehicle Systems International), the largest non-profit organization committed to uncrewed systems, have already made this change. This report uses the historical term "unmanned" to avoid confusion regarding the documents it cites and the work that took place in developing the Committee's recommendations. However, it is recognized that there are proposals to change this nomenclature and future reports will abide by such taxonomy once adopted by the FAA.

Automation and Autonomous Operations

There can also be some confusion when it comes to defining automation and describing what autonomous flight really looks like. The FAA, in its *Concept of Operations v1.o* document, refers to several levels of aircraft automation. According to the FAA, in a sort of evolution, there is Human-within-the-Loop (HWTL), Human-on-the-Loop (HOTL) and Human-over-the-Loop (HOVTL). With Human-within-the-Loop, a human is always in control of the automation. With Human-on-the-Loop, a human has supervisory control and actively monitors the systems and has the ability to take full control of the aircraft. With Human-Over-the-Loop, the human is informed by the automation system, passively monitors the system and is informed by the system if any action is required, and they are engaged by the automation system for any exceptions that are not reconcilable. The physical location of the pilot is expected to transition from onboard initially to remotely.

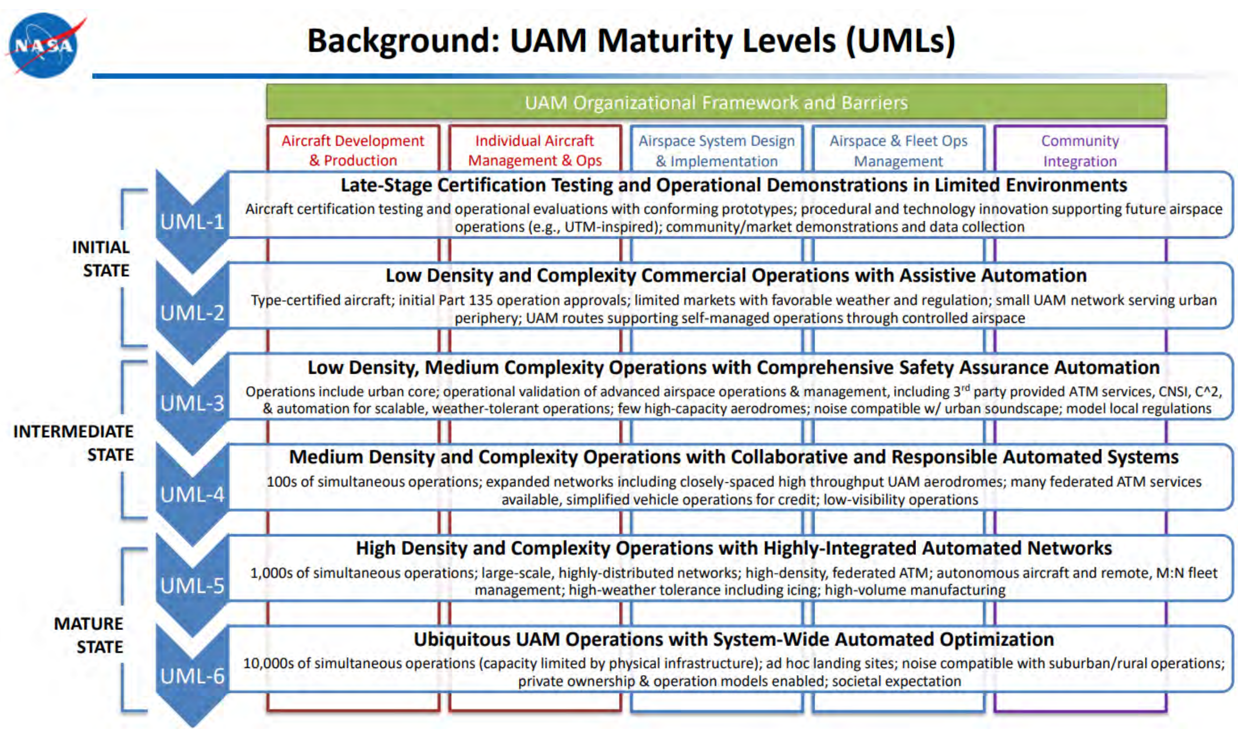
More advanced automation and piloting concepts are described by Garrow et. al. in their paper entitled *A Proposed Taxonomy for Advanced Air Mobility* (*7*). Their discussion of autonomous flight ranges from simplified vehicle operations where automation assist a pilot by reducing the necessary skills and workload of operating an aircraft through a multi-aircraft supervisor where a remote human is responsible for multiple aircraft and a remote supervisory operation (RSO) where one or more multiple aircraft supervisors are overseeing many, automated flights. While this is beyond the scope of this study, it is worth noting there is an increasing level of automation and complexity involved with AAM.

EMERGING AND EVOLVING INDUSTRY

As defined above by NASA, UAM, or AAM as it is now more commonly referred, is a quickly emerging and evolving industry that has seen significant investment from the private sector and been the focus of significant time and resources from federal, state, and local governments. The industry is rapidly changing with respect to the technologies it uses and will require widespread coordination across all levels of government and partnerships with private industry. The industry will also require unprecedented levels of coordination and cooperation as the technology is deployed. It will require integration into many aspects of our everyday life, bringing new challenges that must be met head on.

In June 2020, FAA developed a concept of operations that described the operational environment FAA envisioned that would support this industry as it grows (*8*). According to FAA, "The envisioned future state for UAM operations includes increasing levels of autonomy and operational tempo across a range of environments including metropolitan areas and the surrounding suburbs." This initial concept document specifically addresses engagement with NASA and industry stakeholders and defines the unmanned aircraft system (UAS) traffic management operating environment.

In the second concept-of-operations document, in an effort to articulate where this industry is headed and what the path toward wide-scale implementation may look like, NASA developed an organizational framework that illustrates what various maturity levels will look like (*9*). Figure 2 shows this framework.



Source: NASA (9)

Figure 2. UAM Organizational Framework and Barriers.

The maturity levels range from aircraft certification testing through full implementation and deployment of thousands of vehicles serving our urban, suburban, and rural populations. We are in the early stages of this complex and dynamic industry. Many of the issues outlined in this framework were the subject of significant thought and discussion by this advisory committee. This report documents the efforts of this committee over the last several months and includes the challenges and issues the committee considered and the recommendations that were developed for the state to consider in order to help facilitate advanced air mobility in Texas.

ORGANIZATION OF REPORT

This report begins with a regulatory overview of those issues most pertinent to urban air mobility. The report includes a regulatory overview that discusses recent legislation at the state level both in Texas and in other states across a number of issues including operations, privacy, noise abatement, electricity, and air rights. What follows is a discussion of the four key areas identified by the committee. Each of these four areas is served by a working group. The section is organized by working groups, and their respective subsections include background information on the associated topics, a summary of the activities and discussions of each group, and their recommendations. Each of the recommendations also has some additional context provided for clarity. The appendix includes the original legislation that established this committee as well as related state legislation from across the country.

REGULATORY OVERVIEW

The U.S. Government is given exclusive sovereignty of airspace in the United States in 49 USC § 40103(a)(1). This does not preclude states or local governments from passing any valid regulation within their traditional police powers, but courts generally recognize that Congress extensively controls much of the field. Where a state's exercise of police power infringes upon the federal government's regulation of aviation, state law is preempted. The FAA has been clear about the limitation of state and local police powers, but some grey areas may exist. The FAA has provided guidance on when to consult with the FAA as well as the FAA's authority in regulating drones (*10*, *11*).

The FAA was directed by Congress in the FAA Modernization and Reform Act of 2012 to "develop a comprehensive plan to safely accelerate the integration of civil unmanned aircraft systems into the national airspace system." To this end, the FAA developed 14 CFR Part 107 that applies to the "registration, airman certification, and operation of civil small, unmanned aircraft systems within the United States." While the federal government has noted that states have limited authority to regulate aircraft operations under their police powers, states have attempted to delineate parameters for operation within Class G airspace.[1]

RECENT LEGISLATIVE DEVELOPMENTS AT THE STATE LEVEL

There is recent development in state legislatures regarding AAM that shows an interest in the possible adoption of this new technology. In early 2022, bills were enacted in Michigan and Utah establishing a task force dedicated to exploring AAM opportunities for their state. Michigan passed SB 795 creating the advanced air mobility study committee comprised of 25 members (*13*). Similarly, Utah enacted SB 122 tasking its department of transportation to create a working group to study the feasibility of adopting AAM. This bill additionally defines what constitutes a criminal offense with respect to UAM; it is a crime to commit the offense using the aircraft or if the actor commits the offense by controlling the aircraft (*14*).

Other recent legislation prohibits local government from placing restrictions on AAM such as those enacted in Michigan and West Virginia. In addition to creating the AAM study committee, Michigan, through SB 796, prohibits the county, city, or any local government from owning aircraft or regulating AAM (*15*). West Virginia's HB 4667 contains similar language restricting local government jurisdiction over AAM, but the state has enacted additional instructions to draw in the industry. HB 4827, titled Promoting Public-Use Vertiports Act, is enacted by West Virginia to "promote the development of a network of vertiports that will provide equitable access to citizens of this State who may benefit from advanced air mobility operations for cargo and passenger service, and to avoid any vertiport monopolization or discrimination" (*16*). A more complete list of UAS state legislation is in Appendix B.

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[1] Per the GAO, "Class G airspace refers to uncontrolled airspace and generally extends from the surface to the base of Class E airspace, which in most areas is 1,200 feet above ground level, except for restricted or prohibited areas" (*12*).

Florida statute 934.50 regarding the use of UASs or drones was updated in 2021 to reflect the current interest in this technology. Named the Freedom from Unwarranted Surveillance Act, this law prohibits laws enforcement agencies from using drones to collect evidence or conduct surveillance. The statute does however include exceptions namely allowing the use of drones if there is high risk of a terrorist attack, if a search warrant was first obtained, and if quick action is needed (*17*). In late 2020, SB 44, Use of Drones by Government Agencies, was introduced and approved by the governor in June 2021 to amend this statute (*18*). Changes include expanding the use of drones by law enforcement to provide an aerial view of a crowd of more than 50 people, aid in traffic management except to issue citations, and facilitate the collection of evidence at a crime scene or traffic accident. Florida state agencies and political subdivisions may use a drone for the purposes of assessing damages caused by natural disasters and managing public vegetation and wildlife. The bill also introduces a security standard for drone use by a Florida agency. All Florida agencies are prohibited from using drones not on the Department of Management Services approved list. Additionally, starting July 1, 2022, all Florida agencies not using approved drones must submit a plan detailing how they will discontinue use of their drones. By January 1, 2023, all use of unapproved drones by a Florida agency must be discontinued.

THE TEXAS REGULATORY LANDSCAPE

The Texas legislative and regulatory environment has largely focused on the operations of small, unmanned aircraft systems to date, in terms of action at the state level. While unmanned aircraft is not explicitly defined in statute, Texas code regulates operations and privacy to a certain extent with protections also existing at the national level. Other portions of statute address some of the relevant issues related to UASs, such as noise abatement, electricity provision, and air rights. Table 1 provides an overview of the relevant legislation passed in Texas (*19*).

Table 1. Texas Legislation.

Year	State	Bill	Summary
1995	Texas	SB 971	This legislation requires a municipality to provide adequate soundproofing and noise reduction devices for each public building within the 65 or higher average day-night sound level contour as determined by the governing body in accordance with FAA Advisory Circulars for replacement airports (1995—recodification).
2013	Texas	HR 3035 SR 1084	Adopts two resolutions (House Resolution [HR] 3035 and Senate Resolution [SR] 1084) addressing legislative procedures needed to enact the new drone law.

Year	State	Bill	Summary
2013	Texas	HB 912	Enumerates 19 lawful uses for unmanned aircraft. The law creates two new crimes, the illegal use of an unmanned aircraft to capture images and the offense of possessing or distributing the image. *Image* is defined in the law as any sound wave, thermal, ultraviolet, visible light, or other electromagnetic waves, odor, or other conditions existing on a property or an individual located on the property. **Note: The previous provisions were impacted by *NPPA v. McCraw*.** Additionally, the measure requires the Department of Public Safety to adopt rules for use of UASs by law enforcement and mandates that law enforcement agencies in communities of over 150,000 people make annual reports on UAS use. Texas House Concurrent Resolution (HCR) 217 altered reporting requirements from the original HB 912.
2015	Texas	HB 1481	Makes it a Class B misdemeanor to operate UASs over a critical infrastructure facility if the UAS is not more than 400 feet off the ground. **Note: This provision was struck down by *NPPA v. McCraw*.**
2015	Texas	HB 2167	Permits individuals in certain professions to capture images used in those professions using UASs as long as no individual is identifiable in the image. **Note: This provision was impacted by *NPPA v. McCraw*.**
2015	Texas	HB 3628	Permits the creation of rules governing the use of UASs in the Capitol Complex and provides that a violation of those rules is a Class B misdemeanor.
2017	Texas	HB 1643	Adds structures used as part of telecommunications services, animal feeding operations, and a number of facilities related to oil and gas to the definition of critical infrastructure as it relates to UAS operation. **Note: Portions of this legislation were struck down by *NPPA v. McCraw* except for the following provision:** Prohibits localities from regulating UASs except during special events and when the UAS is used by the locality. The legislation defines *special event*.
2017	Texas	SB 840	Permits telecommunications providers to use UASs to capture images. Also specifies that only law enforcement may use UASs to capture images of real property that is within 25 miles of the U.S. border for border security purposes. The law also allows a UAS to be used to capture images by an insurance company for certain insurance purposes, as long as the operator is authorized by FAA. **Note: These provisions were impacted by *NPPA v. McCraw*.**
2017	Texas	HB 1424	Prohibits UAS operation over correctional and detention facilities. Also prohibits operation over a sports venue except in certain instances. The law defines *sports venue* as a location with a seating capacity of at least 30,000 people and that is used primarily for one or more professional or amateur sports or athletics events. An initial violation is a Class B misdemeanor, and subsequent violations are Class A misdemeanors. **Note: This provision was struck down by *NPPA v. McCraw*.**
2021	Texas	SB 1202	A *retail electric provider* does not include a person not otherwise a retail electric provider who owns or operates equipment used solely to provide electricity charging service for consumption by an alternatively fueled vehicle.

Source: National Conference of State Legislatures (*19*).

In March 2022 a ruling in the case of *NPPA v. McCraw* determined that parts of Texas's UAS law under Chapter 423 were unconstitutional as they violated the First and Fourteenth Amendments. The ruling struck down parts 423.002, 423.003, 423.004, 423.0045, 423.0046, and 423.006. The parts struck down by the ruling related to lawful uses of UAS, created offenses relating to unlawful uses, such as surveillance and operation over critical infrastructure and sporting venues. This ruling has removed certain provisions under Texas law and has therefore limited the regulatory environment for UAS within Texas. The remaining parts of Chapter 423 cover illegally or incidentally captured images not subject to disclosure, rules for use and reporting by law enforcement and regulation of unmanned aircraft by political subdivisions. The following sections provide an overview of laws relating to UAS and UAM in Texas noting where the court ruling has altered the regulatory landscape in Texas.

OPERATIONS

As it pertains to unmanned aircraft, Texas statute previously laid out multiple situations in which the use of UASs is prohibited. Within Texas Government Code Chapter 423, the operation of an unmanned aircraft was prohibited above a correctional facility, detention facility, or critical infrastructure facility. The types of facilities that qualified under these facility terms are defined within the statute and range from county jails to electrical power-generating facilities and many other things. The use of unmanned aircraft was also prohibited above sport event venues that have a seating capacity of 30,000 people or more and were primarily used for one or more professional or amateur sports or athletics events (*20*).

The caveat for unmanned aircraft operation in the situations mentioned is that operation was allowed if at a height of 400 feet or higher. However, a recent court ruling, *NPPA v. McCraw*, struck down the majority of Chapter 423 as unconstitutional under the 1st and 14th Amendments (*21*). This ruling will likely impact any proposed legislation or legislative changes related to UAM regulation of unmanned aircraft by political subdivisions. Section 423.009 does remain in effect and restricts the adoption of ordinances by political subdivisions, except for special events, use by the political subdivision, and use near property owned by the political subdivision (*22*).

PRIVACY

Previously, Texas Government Code Chapter 423 addressed the use of unmanned aircraft to capture images and creates penalties for doing so (*23*). It is illegal to use an unmanned aircraft to capture an image of an individual or privately owned real property in this state with the intent to conduct surveillance on the individual or property captured in the image. An offense is a Class C misdemeanor. However, a recent court ruling struck down the majority of Chapter 423 as unconstitutional under the 1st and 14th Amendments (*21*).

While the provisions noted above under Chapter 423 no longer apply, Texas recognizes a common law right to privacy. These violations include intrusion upon one's solitude or private affairs, public disclosure of private facts, and wrongful appropriation of one's name or likeness. All three of these violations are treated as civil torts and not criminal offenses. The Texas penal code does address specific crimes that violate a person's reasonable expectation of privacy, but these are narrow and tailored to the specific issues such as wiretaps or invasive or inappropriate photography. Any privacy legislation will have to consider the 1st Amendment implications as well as whether current statutes provide adequate protection already.

NOISE ABATEMENT

While not specific to UAS operations, the Texas Transportation Code contains requirements for noise abatement for county and municipal airports (*24*). The governing body of a municipality that owns an airport and has a grant agreement with FAA for the planning, design, and acquisition of land for a replacement airport is required to provide adequate soundproofing and noise reduction devices for each public building within the 65 DNL or higher average day-night sound-level contour. The municipality must also comply with the Aviation Safety and Noise Abatement Act of 1979 in federal code. Although this statute is limited to airports, there are potential implications in noise abatement for UAS facilities and operations.

ELECTRICITY PROVISION

Legislation passed in the 2019 session amended utilities code to exempt a person who owns or operates equipment used solely to provide electricity charging service for consumption by an alternatively fueled vehicle from consideration as an electric utility or retail electric provider (*25*). The bill also added text that allows the utilities commission to exempt from the definition of *retail electric utility* a provider who owns or operates equipment used solely to provide electricity charging service for a mode of transportation. While this addition to code captures a lot of activity currently related to alternatively fueled vehicles, this section could impact electricity provision for UAS operations as well.

AIR RIGHTS

The Texas Government Code acknowledges the existence of air rights and defines air rights as a piece of "real property," but air rights are not explicitly defined in Texas Code (*26*). Air rights have been established within case law, and Chapter 263 of the Local Government Code does acknowledge the leasing of air rights above certain property (*27*).

FAA and local zoning ordinances have traditionally regulated airspace for travel, and airspace above a property is subject to reasonable air traffic. Reasonable air traffic and specific air rights are not defined in statute, and questions related to the use of airspace above property may arise with increased UAS operations.

Although questions remain on authority to regulate certain areas within aviation and UAM, new or updated regulations at the federal and state level may be required in certain key areas to enable UAM, such as:

- Safety.
- Equipment.
- Operations.
- Airspace.
- Land use.
- Privacy.

- Environment.

KEY AREAS IN URBAN AIR MOBILITY

The urban air mobility ecosystem has several components that may need additional regulation, legislation, or infrastructure in order to operate safely and efficiently. The chair, Dr. Choudhuri, identified four key areas for the advancement of UAM in Texas that should drive the committee's initial work. These areas were technology, airspace and infrastructure, safety and security, and commerce and community integration. Figure 3 provides an overview of the topics involved with each key issue. The four key areas formed the basis of the working groups developed by the committee. Each area included potential topics for consideration, which served as a starting point for the working group discussion. Each working group began with these topics and, in the course of their discussions, identified those that the working group should focus on and be the subject of meaningful recommendations. Those focused topics identified for discussion by each working group are discussed later in this section.

This section of the report provides an overview of current research on each key areas before presenting the discussion by the working group and finally the recommendations developed along with their rationale.

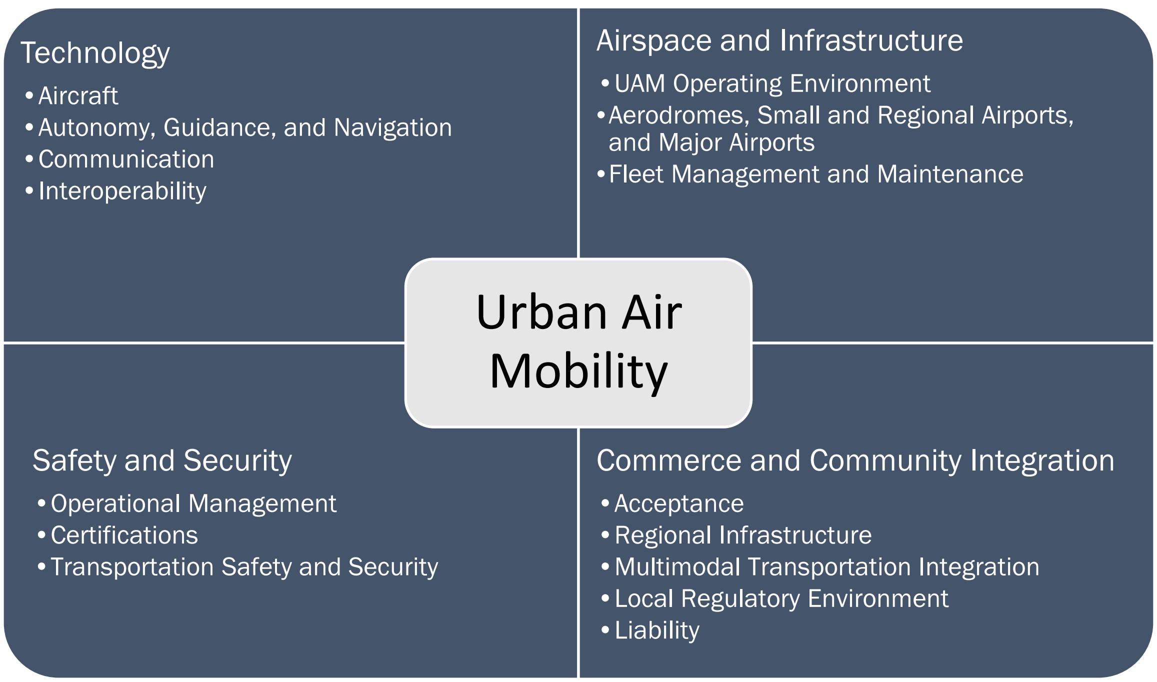

Figure 3. Key Issues for Urban Air Mobility.

TECHNOLOGY

When it comes to UAM and AAM technology, the working group decided on prioritizing airspace monitoring and testing sites, or sandboxes. Airspace monitoring technology includes from how the aircraft maneuvers around the airspace, how it communicates with other aircraft and surrounding environment, and how the aircraft itself is built, to name a few. The facility where this technology can be tested also needs to be considered to help launch UAM/AAM into commercialization. Aside from providing a controlled environment where tests can be conducted safely, these testing facilities may help attract industry leaders as well as promote the collaboration between the public and private sectors. This section discusses critical technical components needed in UAM/AAM and provides more insight into the work conducted at several of the testing sites across the United States. Additionally, the Technology Working Group's meeting is summarized including the topics discussed and those voted to become part of the recommendations.

Literature Review

UAM technology can encompass a variety of components, but some of the most critical in a system architecture are those responsible for airspace monitoring such as communication, navigation, and surveillance (CNS). The UAM aircraft will need to communicate with ground pilots through command and control (C2). A communication network must therefore enable various aircraft to communicate with one another through an unmanned air traffic management (UTM) system. For navigation, advancement in detect-and-avoid (DAA), or sense-and-avoid, technology can improve how the aircraft processes its surroundings with minimal human intervention. In situations where visibility is low, DAA is being refined to better detect its surroundings while simultaneously avoiding obstructions, following the designated routes, and spacing itself from other aircraft. In the context of traditional aircraft operations, sense-and-avoid technology uses a vision-based approach to maneuver the aircraft, whereas UAM technology can phase out manual operations in favor of electronic separation (*28*). Beyond-visual-line-of-sight (BVLOS) technology is likewise being adapted for UAM and AAM purposes, requiring the advancement of visual technology and remote operation. Wireless communication options such as 5G and GPS can be adapted to assist with surveillance at lower altitudes (*29*).

The surrounding landscape and environment influence the early adoption of UAM and AAM to such a degree that it is a concern discussed in CNS, weather tracking, and selection of suitable cities. Where UAM aircraft can fly is limited by their surroundings, which means they are subjected to flight restrictions such as no-fly zones. UAM and AAS aircraft are prohibited from flying through an airspace if obstructions and other dangers are present at lower altitudes. A no-fly zone is determined by several factors and are classified according to the following four categories:

- Safety related.
- Social.
- Operational based on system.
- Operational based on aircraft.

The most noticeable of these factors, for example, are buildings, but wind patterns fluctuate when in close proximity to these structures, adding another layer of complexity to acceptable airspace navigation (*29*). Other factors that comprise a no-fly zone can include privacy and noise considerations, which are restrictions created through regulations. Therefore, CNS technologies must have the ability to more granularly process their surroundings to avoid obstacles that would not normally be present at higher altitudes.

Weather

The weather, in addition to physical structures, also affects the development of technology. Some efforts focus exclusively on weather tracking and visibility, while others focus on weather barriers and identifying optimal locations. Technology typically used for commercial planes may not be completely applicable to UAM. For instance, UAM aircraft flying at lower altitudes experience a greater fluctuation of wind patterns caused by high rises and must observe a variety of thermal readings from surface landmarks. Weather patterns also differ across the country, requiring the aircraft to be customized with that specific location in mind (*30*).

Meeting the demands of UAM will require improvements in how the data are collected and processed. Standards will also need to be adapted to the unique conditions of UAM such as acceptable crosswinds or turbulence (*30*). To help understand weather in relation to suitable UAM sites, one report analyzed 10 urban areas across the United States, each experiencing unique weather patterns. Using weather data obtained from different sources, hourly weather conditions were scored from 1 to 10 according to severity, with drizzle being 1 to volcanic ash scoring a 10. It was found that urban areas located in the west exhibit favorable UAM weather conditions, which experience low scoring, high temperature, and instrument flight rule (IFR) conditions (*31*). This study is an example of how variable weather can be all over the United States and highlights how not all aircraft designs may be applicable across the country.

Aircraft

CNS is not the only technological advancement. Aircraft themselves are being modified to be lighter, more fuel efficient, and quieter than the standard aircraft. How the aircraft is designed depends on several factors such as seat capacity, cruise speed, noise levels, emissions, fuel source, and costs (*32*). In contrast to traditional aircraft already in service, UAM aircraft such as electrical vertical takeoff and landing (eVTOL) or short takeoff and landing (STOL) are switching from a combustion to a fully electric or hybrid-electric distributed propulsion system. The installation of multiple low-noise rotors, as opposed to the traditionally more expensive aircraft, will also help in noise reduction (*30*). Currently, several eVTOL designs are being tested, including a vectored thrust, lift and cruise, muliticopters, and rotorcrafts. All of these concepts are essentially attempting to find a compatible means to lifting the aircraft off the ground and switching over to cruise once it is ready to move toward its destination (*33*). UAM/AAM takes advantage of a number of new, innovative, and emerging technologies. This includes advances and continuing improvements in battery technology, the advancement of electric propulsion, and lightweight airframes. It also relies on new and innovative flight control systems, sensor technology, and communications systems that will eventually allow operations to evolve on the autonomous maturity spectrum and be integrated into the existing National Airspace System.

Airworthiness standards and certification for equipment and new aircraft types are needed to ensure safety and industry standards without slowing production or increasing costs. As identified in the GAO report, GAO-22-105020, one of the significant challenges faced by stakeholders is certifying this new technology (*34*). According to Uber Elevate, the target noise level produced by an UAM aircraft should be no greater than what the current smallest four-seat helicopter produces, which influences the aircraft's design (*35*). This trend toward electric operations requires updated regulation on electric propulsion, powered lift, and future aircraft concepts such as folding propellers. Current regulations partially address powered-lift operations but are based on conventional helicopter designs (*36*). FAA's Part 23 contains performance-based standards for normal category airplanes that help streamline the process and allow industry more flexibility in design but do not fully capture UAM needs (*34*). Building on the already existing regulations for manned aircraft and developing new standards that apply to the needs of UAM operations may prove to be the faster route to achieving certification. Operations and equipment certification are directly related to safe operation, which will be key to public acceptance and ensuring sufficient demand.

Unmanned Aerial Systems Traffic Management Systems

FAA is taking an interest in advancing UAS research across the United States through the launch of several programs. One of these programs is UAS Integration Pilot Program (IPP) (*37*). This three-year program was established to research ways to integrate UAS into the National Airspace System. Involved in the program are state and local organizations such as the Kansas Department of Transportation, the North Carolina Department of Transportation, the City of Reno, NV, and the City of San Diego, CA, with each entity focusing on research applicable to its state or region (*37*). As part of a different UAS measure, FAA has designated seven locations as UAS testing sites across states in the United States: New York, New Mexico, North Dakota, Nevada, Texas, Alaska, and Virginia (*38*). These sites were created to research and test different UAS topics of interest. Some of these sites focus their efforts into UTM as well as DAA, C2, and BVLOS operations (*39*). Additionally, the sites located in Nevada, North Dakota, and Virginia were selected to be part of phase one of the UTM Pilot Program (UPP), a program created to identify current UAS work that can improve UTM operations (*39*).

In addition to the UAS, other federal government agencies are taking an interest in promoting AAM. Although it is still awaiting approval from the Senate, HR 1339, the Advanced Air Mobility Coordination and Leadership Act, instructs USDOT to create an AAM interagency working group to work toward the understanding of safety, operations, infrastructure, and other factors related to the promotion of this new endeavor. NASA is also working with states to further AAM efforts. One of these efforts is the AAM National Campaign. The goal of this campaign is to promote AAM through public outreach to instill confidence in this movement (*40*). Furthermore, this program will serve to inform industry leaders on the changing regulatory and environmental landscape. NASA will also partner with the private sector to research barriers to AAM safety and adoption, highlight challenges associated with public perception and commercial feasibility, and identify software and system requirements for AAM. The campaign is scheduled to launch in 2022. This section will highlight the work being done related to AAM, UAS, and UTM by individual states.

Alaska

Alaska conducts UAS research through the Alaska Center for Unmanned Aircraft Systems Integration. This center is responsible for the testing of manned and unmanned operations as well as endurance testing in harsh weather conditions (*38*).

Maryland

In accordance with the Maryland Unmanned Aircraft Systems Research, Development, Regulation, and Privacy Act of 2015, which tasks the state to research the benefits of UAS, a UAS test site was created to aid state agencies in defining policies centered around UAS. The UAS test site at the University of Maryland works together with FAA, Naval Air Systems Command, and industry to further airspace integration. Consultation, airworthiness, vehicle aircraft system design, public outreach, and testing and flight operation are activities conducted at this site. Additionally, the UAS test site has access to military airspace and FAA authorizations that allow the site to be used for research usually limited by Part 107, the Federal Aviation Regulation (FAR) that governs unmanned aircraft systems.

New Mexico

The UAS testing site in New Mexico is designed to test different classes of UAS. Using resources located at the Las Cruces International Airport and the New Mexico State University, UAS is being tested for mapping, DAA, BVLOS, monitoring of UAS near airports, cybersecurity, and disaster preparedness and response (*41*).

New York

The New York UAS test site, located at the Griffiss International Airport, is managed by the Northeast UAS Airspace Integration Research Alliance, Inc. (NUAIR). This facility conducts research on UAS operations and provides consulting services. The test site's research includes UTM integration and understanding of performance requirements of UASs through the Performance Requirements Working Group (*42*, *43*). This group is tasked with researching CNS requirements such as determining testing and validation methodology for UTM operations and technology.

Nevada

The Nevada Institute for Autonomous Systems (NIAS) manages the Nevada UAS test site. This site is used to advance research on BVLOS, drone detection, and UTM. NIAS is also expanding its efforts through outreach. Its Attaining Resilience and Independence through Support and Education (ARISE!) program provides job training and mentorships in the autonomous systems field. NIAS has also partnered with other countries and is involved in state and federal organization (*38*). Furthermore, Nevada was selected by NASA to contribute to UTM research. This selection entails testing UAS flights across Reno, NV, for the purposes of large-scale services such as package delivery (*44*).

North Dakota

The North Dakota Department of Transportation is partnered with the Northern Plains UAS Test Site and with North Dakota's UAS network, Vantis, to further the research on UAS technology and traffic management (*45*). The test site is used to conduct research on UTM, DAA technology, and other communication and operations technology (*46*). Similarly, the Vantis network contains a ground control service station in addition to other operation system testing facilities used for UAS testing (*47*). The state's work in UAS has been acknowledged and was selected by USDOT, among other states and organizations, to be part of IPP and BEYOND, the next phase of IPP. As part of BEYOND, North Dakota's UAS network will be tasked with testing operations at a larger scale.

Ohio

Ohio is home to the Ohio Unmanned Aircraft Systems Center (*48*). This center manages all the work for the Ohio Department of Transportation related to UAS including flight operations, program development, and research. The center and other stakeholders have also invested in SkyVision, a DAA system designed to monitor UAS flights when they are outside of the line of sight (*49*). With respect to AAM, both the Ohio Department of Transportation (ODOT) and FlyOhio, a team made up of aircraft manufacturers, researchers, and health care professionals, are researching the impact of alternate modes. ODOT sponsored an economic impact analysis of AAM, which could help attract business. This report predicts AAM will contribute a total value of $13 billion from 2021 to 2045 (*50*). To reach this goal, the report recommends laying out a legislative and strategic framework to integrate AAM, attract businesses, and promote public awareness. FlyOhio was selected to contribute to NASA's AAM National Campaign; FlyOhio will be tasked with testing the delivery of people and good across the state.

The Springfield-Beckley Municipal Airport is investing in the National Advanced Air Mobility Center of Excellence to promote air mobility research (*51*). Located between Dayton and Columbus, OH, this airport is positioned to attract customers because it is already home to two maintenance facilities and the Ohio National Guard base. In addition, this location has the space for a 30,0000-square-foot center that will house industry and public research, specifically eVTOL.

Texas

The Texas A&M Corpus Christi UAS test site focuses on attracting economic opportunities and aiding FAA in advancing UAS research. Managed by the Lone Star UAS Center of Excellence and Innovation (LSUASC), an organization comprised of different stakeholders, the site conducts research on autonomous systems and showcased UTM capabilities, such as collision avoidance, drone communication, and operations in urban locations. The site is part of NASA's UTM efforts and has a demonstration project in downtown Corpus Christi, TX (*38*).

Virginia

Selected to contribute to UPP, the Virginia Tech Mid-Atlantic Aviation Partnership (MAAP) testing site conducts research on UTM. Flight demonstrations are conducted at this site to showcase how different UAS components work into UTM (*52*). Specifically, research is being done on UAS service suppliers (USSs), the equivalent to air traffic control software used for aircraft operations. Because USSs are created separately by different industries, the challenge is standardizing communication between the various USSs (*53*). Additionally, other research being conducted on this site includes the improvement of UAS communications and DAA.

Technology Working Group

Technology is a significant component to UAM but requires a regulatory foundation to promote its use and adoption. The challenging thing is that technology applies to several areas of UAM and subsequently impacts the development of regulations. From an aircraft perspective, airframe and propulsion dictate noise levels and areas where these can fly over, which may require establishing thresholds. Similarly, technology surrounding operations needs to be developed to ensure proper communication is occurring between the air and ground. Operating the airspace will require knowing where aircraft are located relative to each other and how the monitoring system will be integrated into already existing airspace operations. Therefore, design, operations, and the environment will need to be considered when developing technology regulations. Instructions for certification and communication standards to ensure acceptable practices and proper communication between different hardware will also be necessary. Consequently, regulations promoting the testing of UAM technology as well fostering collaboration between the private and public sector should be a first step. The following lists technology topics that the Technology Working Group discussed as important for the adoption of UAM:

- Design:
  - Airframe.
  - Propulsion.
- Operations:
  - System architectures.
  - Assured positioning, navigation, and timing.
  - Airspace monitoring.
- Environment:
  - Micro-weather forecasting.
  - Noise and noise thresholds.
- Regulation:
  - Airworthiness certification.
  - Communication standards.
  - UAM/AAM sandbox.
  - Fostering of collaboration.

However, due to time constraints, they key areas for Texas that will form the basis of the committee’s recommendation in regard to technology are:

- Development of a UAM/AAM sandbox.
- Airspace monitoring.
- Fostering of collaboration across public and private entities.

Development of a UAM/AAM Sandbox

An opportunity has presented itself for public-private collaboration through what the industry is calling a *sandbox*. As defined in the meeting, the term *sandbox*, in technology policy, refers to a designated place, either geographical or digital, where new technologies can be tested under liberal rules for a predetermined duration before a commercial rollout to the public. This sandbox is a site where UAM technology and operational procedures can be tested in a safe, controlled environment and include four main considerations:

- Convenor.
- Funding.
- Infrastructure.

- Transition to commercialization.

These sites can serve to showcase progress to stakeholders and the public while simultaneously attracting interest, possible investment, and collaboration. Public awareness and trust can also be generated through these sites by allowing the general population to be involved in the development of these technologies. FAA and other federal agencies understand the importance of properly testing and ensuring the safety of passengers and are well underway in funding UAM programs across the country.

Texas already is home to a UAS testing site that can be used to support sandbox activities, but other opportunity exists where available land or underutilized airports can be retrofitted for AAM purposes. Additionally, these sites can be tailored further to incorporate use cases of interest to the state. These can include uses for border patrol, oil and gas, agricultural, package delivery, and others. These use cases can also help distinguish the different operation considerations for urban versus rural flight, for example the difference between package delivery in a city or oil and gas monitoring in more remote areas of the state. Through the development of testing, legislative and regulatory considerations or challenges may also be highlighted that otherwise would not have been possible without these sites.

Airspace Monitoring

Airspace monitoring is an area where the state has minimal say on airspace, but Texas is in a position to help lead the conversation. Potential sandboxes established around Texas can be used for policy guidance that the federal government can use. The state can also help differentiate areas where the federal government has clear guidance and areas where Texas can provide some input. However, this will not be an easy task given that the evolving technology will shape the airspace regulations needed.

Another concern is operability in other states. Although the state can provide input that will best serve its needs, ensuring that cooperation and communication can still occur in other states as well as different networks will make airspace operations more feasible. Texas can look at the work completed by the North Carolina Department of Transportation and ODOT, for example. These two agencies have deployed technology that allows emergency medical services (EMS) and law enforcement to operate under the same network.

Texas should work with FAA on the potential for testing and sandboxes to help provide additional data and options for airspace monitoring. The potential for technological solutions to assist in the airspace monitoring should be followed by the state. New procedures, in terms of sense-and-avoid and enforcement of no-fly zones, and other regulations could benefit from new monitoring techniques. Communication across these technologies as well as data sharing will remain critical to ensure safety, security, and efficiency across all U.S. airspace.

Fostering of Collaboration across Public and Private Entities

The state can foster private-public partnerships through UAM and AAM technological innovation. The state can establish sandboxes and other infrastructure to serve public and private interests while still remaining a neutral participant. Collaboration and advancement can be further promoted by easing permitting restrictions and creating flexible regulations.

The state can also partner with cities and observe how they are working together with the industry, such as Wing in Little Elm, TX, and Flytrex in Granbury, TX, and determine options for scaling these arrangements to benefit Texas. Additionally, the state can note these companies' public engagement efforts and use them to gauge public acceptance as a whole.

On a federal level, the state is encouraged to engage with FAA, given its jurisdiction over airspace, and NASA due to its knowledge and ongoing efforts in the UAM/AAM space. The state can potentially draw in these agencies by allowing them access to their testing sites, thereby fostering the exchange of information between the federal and state level.

The state should also maintain an awareness of potential policy or permitting restrictions that may reduce technological development. Any regulatory decisions relating to technology should remain flexible to ensure the regulation does not hinder future developments or cause issues for local governments. In addition, any legislation or regulation should maintain neutrality in terms of technology selection but should support collaboration between different operators and manufacturers to ensure interoperability.

Recommendations

The third and fourth working group meetings focused on the drafting and development of recommendations related to the three topic areas identified in the first working group meeting. For example, the discussion focused on the possible needs and structure of a UAM sandbox, which use cases might be tested, and how best to recommend the idea of a regulatory sandbox. The working group also discussed issues surrounding standardizations and technology options. Because the UAM/AAM industry is in a stage of innovation and is constantly evolving, progress in technology should drive possible standardizations. In addition, it may be in the best interest of the state to maintain a technology-neutral approach so industry can develop and adapt as necessary. The Technology Working Group developed the following four recommendations:

1. **Encourage the development of an urban air mobility/advanced air mobility sandbox by:**
    d) **Directing the preparation of a feasibility study to understand the market, differentiating factors from similar existing facilities, potential market/players, funding sources, revenue opportunities, locations, necessary digital and physical infrastructure, and potential use cases; and**
    e) **Pursuing the development of a facility that will provide opportunity for testing and commercialization that will attract business and move the industry and state forward.**
    f) **Having the State take the initiative to work with industry to determine additional standards in terms of communications, technology, and environmental awareness systems to encourage consistency and harmony at all levels of government and stakeholders.**

An UAM/AAM sandbox will serve to advance this technology as well as promote public and private collaboration. The committee's discussion regarding a sandbox focused on the concept of a designated place, either geographical or digital, where new technologies can be tested under liberal rules for a predetermined duration before a commercial rollout to the public. Several facilities across the United States are already testing different aspects of AAM, including communication and environmental awareness systems such as micro-weather, air traffic, and micro-radar. Use cases specific for Texas such as gas, oil, border security, and package delivery can all be tested for the benefit of the state. Innovators and industry leaders can test the applicability of UAM/AAM in a controlled environment before launching at full scale. It may not be completely necessary to build new facilities for sandboxes because underutilized airports can be retrofitted or be integrated into Texas colleges to test advanced air mobility technology. In addition to finding solutions to current technological issues, through the use of these facilities, new issues may be identified that will place Texas at the forefront and enable the state to assist all levels of government.

Another opportunity derived from a sandbox is the potential for collaboration and coordination between public and private entities and across different levels of government. By establishing one common place where ideas can be exchanged, harmonization can occur across the board. This promotes the standardization of technology and communication, and ultimately commercialization, without discriminating against industries with limited resources. Additionally, this recommendation is not intended to discourage the use of certain technology or dictate what localities are allowed to use the sandbox. Rather, this recommendation is meant to attract industry participation while still allowing localities to provide their input.

2. **Consider the initial funding for a UAM/AAM Sandbox Feasibility Study and ultimately its development along with an incentive program to attract industry with the ultimate objective of using user fees to fund the ongoing operations and maintenance of the sandbox.**

Developing a UAM/AAM sandbox for Texas could require a feasibility study to determine the primary test use cases, the location, and potential industry partners. This study and the eventual development of a sandbox would benefit from state funding in the initial stages with the eventual goal of commercialization. Start-up funding would drive investment, testing, and data collection by industry for Texas-focused use cases and would provide possible industry-wide standards for operations, safety, and efficiency. Once regulations and standards are in place at the requisite levels of government, the site would transition to a self-sustaining mechanism such as a user fee to fund future operations to launch UAM/AAM into commercialization.

3. **Encourage state agencies to adopt a technology-neutral/open architecture approach to the urban air mobility/advanced air mobility industry to allow easier adoption of new technologies and deployment into new regions.**

A technology-neutral or open architecture approach will provide the necessary flexibility and allow the technologies to grow and evolve without regulatory harm. A technology-neutral approach has been taken with other emerging industries, such as connected autonomous vehicles, and UAM/AAM would also benefit from that flexibility. This would not prohibit the development of standards for safety and operations but would promote development of the best technologies while maintaining Texas’ economic competitiveness in regard to UAM/AAM.

4. **Identify areas where technology will drive standardizations.**

Technologies that support UAM/AAM are evolving rapidly. Supporting the development of the industry will require the state to remain neutral on the different technology options while also setting standards to ensure safety. In order to avoid disrupting industry progress, the state can focus on areas where available technologies will drive standards and required standardizations. These areas could include but not be limited to speed, operating hours, and density.

AIRSPACE AND INFRASTRUCTURE

Monitoring and managing airspace as well as providing the ground infrastructure necessary for UAM operations are two key components in enabling this new mode of transportation in Texas. This section presents a literature review on the core concepts within both airspace and infrastructure for UAM before presenting the committee's work on this topic. Airspace and Infrastructure are both broad, critical topics for UAM that offer a number of areas for state consideration; however, the committee chose to focus on three topics due to the time constraints of their effort:

- Alignment with FAA and airspace harmonization.
- Fostering of a competitive environment for UAM within the state.
- Identification of existing policy and permitting gaps that may hinder the development of UAM.

The recommendations to the State of Texas will focus on these three areas and the role in which legislation and regulation can ensure UAM safety and success.

Literature Review

The literature review considers both airspace and infrastructure challenges and opportunities identified in the literature separately, and addresses areas of overlap, such as takeoff and landing area (TOLA) selection with respect to surrounding airspace rules and regulations.

Airspace

Airspace Design and Regulatory Environment

The UAM Operating Environment (UOE) is still in the conceptual stages with the understanding that any rules and regulations should maintain flexibility toward new technological developments and operational changes, as well as FAA's full regulatory authority over the airspace (*30*).

Figure 4 shows an overview of the potential UOE from the concept of operations. The current UAM/AAM maturity level (UML-4) assumes that these services would be operating primarily within urban environments, but future maturity levels will move beyond the urban environment to consider regional and even rural considerations for the technology. Urban environments likely pose a greater regulatory challenge in terms of airspace due to the greater presence of structures, both permanent and temporary, in the proposed UOE.

Source: UAM Vision Concepts of Operations (*30*)

Figure 4. Isometric Operational View of a Representative UOE.

It is possible that FAA's role in terms of airspace would not include air traffic management (ATM) for the operators of UAM/AAM services. In early stages, only basic ATM services would be required to effectively manage the low level of traffic operating outside controlled airspace. However, even in those early stages, the ATM would need a way to communicate with air traffic control (ATC) to ensure safety around controlled airspace, such as airports, and in emergency situations. The intent is to reduce the burden on the human-operated ATC and maintain the greater efficiencies throughout the system. Although FAA would not be providing ATM, private or public operators that do would have to work under FAA rules and direction, with the ultimate regulatory authority falling to FAA. FAA describes a UAS UTM in its UTM Concept of Operations as "a community-based traffic management system, where the Operators and entities providing operation support services are responsible for the coordination, execution, and management of operations, with rules of the road established by FAA" (*9*). Ultimately, FAA would provide the regulatory and operational framework for operations and retains authority over aircraft operations in all U.S. airspace. FAA would exchange data with service providers and operators and would certify safety-critical elements within the UOE, which would include the providers and operators as well as their UTM system. Airspace constraints would also be communicated by FAA. While FAA would maintain the ultimate regulatory authority over airspace, leaving ATM to providers and operators offers a chance for state or local governments to play a role in developing a system that allows for interoperability rather than a patchwork of different UTMs that must communicate across a state or region.

The state and local government role will be greater under the current concept of operations, UML-4, than traditional aviation because of the UOE (*30*). The current expected urban operating environment provides a clearer role for state and local governments because zoning requirements, noise ordinances, and land use laws will allow them to influence the operation of UAM/AAM. The location of vertiports or TOLAs will be subject to those state and local laws and regulations, and this will ultimately impact the number of UAM flights and their routes. High-density routes will need to be determined in coordination with FAA, however. This will ensure communication and coordination with ATC as well as across controlled airspace. While ATM is assumed to be under the purview of the operator, coordination within the UOE will be required, which could benefit from an enhanced state and local role. Standards for such coordination are intended to be developed by industry, with FAA certifying and accepting these standards before they enter operation. Overall, the connection of airspace to ground infrastructure requires a greater state and local government role in managing air traffic, and there is the potential for a state or local role in managing or developing the framework for a UTM.

Operations

UAM operations concern both the operational mode of the aircraft and the airspace in which the aircraft will operate. Operational modes can differ significantly from traditional aviation through the use of autonomous, non-piloted operations or remote, ground-piloted, operations. Piloted operations also need to be considered in terms of passenger transport in UAM (*54–57*). In terms of airspace, questions remain over integration with traditional ATC and the need for a dedicated management system for UAM. Operational considerations also include integration into the existing transportation system, and the impact of weather and noise on operating areas.

The potential for new operational concepts, such as remotely or autonomously operated, provides new challenges for aviation alongside the introduction of UAM as a concept. The new operational concepts can be viewed as two different paths; the first uses traditional piloted operations with a steady move to remote operations, while the second path focuses on automation and views the mid-term phase of UAM as non-piloted (*57*). Piloted operations could function effectively under the current regulations and, as technology progresses, can implement remote operations to the greatest extent possible. Both remote and autonomous operations will require accurate, real-time data on hazards and obstacles that exist within the UAM environment as well as weather sensors to enable decisions relating to risk and handoff from autonomous to remote piloted operations (*54*). Estimates suggest that about half of the daily operations in Texas would be affected by weather conditions such as thunderstorms, IFR conditions, and vertical wind shear (*58*). In terms of weather, while vertical takeoff and landing (VTOL) suffers from rotor noise and vehicle efficiency issues, VTOL are less susceptible to weather conditions than STOL operations (*59*). VTOL may operate best for intracity trips, with STOL being capable of providing intercity operations (*32*).

The different operational concepts could interact in airspace differently and could require a separate management system from traditional ATC. While the use of ATC for piloted operations is considered (*56*), a framework for on-demand mobility highlights the need to separate out UAM operations (*28*). The framework has six key principles:

1. Should not require additional ATC infrastructure.
2. Will not impose an additional workload on ATC 3.
3. Does not restrict the operations of traditional airspace users.
4. Meets safety requirements.
5. Prioritizes operational scalability.
6. Allows for flexibility when possible and adds structure if necessary (*28*).

In enabling such a framework, the potential for geofencing or airspace cutouts is discussed; this would allow for the greater densities required to make UAM economically feasible (*54*, *60*). Airspace cutouts would not already be allocated for traditional operations and could be designed with minimum separation requirements that would eliminate the need for coordination with ATC. Both IFR and visual flight rule could be considered for these cutouts (*60*). While reducing conflicts and the need to coordinate with traditional ATC is key to "efficiency for UAM, trips with origins and destinations on or near airports would need to coordinate with ATC (*28*).

Infrastructure

Placement, Policy, and Permitting Considerations

The primary concern related to infrastructure is identifying TOLAs, or vertiport, site location. Finding a suitable location requires the consideration of several factors including development limitations, passenger handling, topology and aircraft handling, and regulation and policy (*61*). Infrastructure placement is an area of regulation that will likely fall under state or local jurisdiction due to their control over land use. Potential state or local regulation would cover landing areas and space requirements or separations from residential areas, and the potential need for traffic management at lower altitudes, as well as privacy and environmental conditions (*32*, *54*, *62*, *63*). Landing areas and vertiports or pads will need to be built to legal requirements. International standards for short takeoff and landing ports exist under the International Civil Aviation Organization, as do broader requirements under International Civil Aviation Authority Annex 14 (*64*–*66*). States may be responsible for ensuring compliance and regulating the location of these facilities; a key piece in regulating the UAM environment will be to establish a common language across governmental, industry, and regulatory partners (*67*). Privacy, environment, and noise may be regulated already at either the state or local level; these areas will require a greater consideration with respect to specific UAM use cases (*62*).

Several studies have looked at space availability to determine where TOLAs can be placed in different states. One such study narrowed down optimal vertiport locations according to three factors:

- Aircraft cannot fly below 500 feet above private property.
- Aircraft must be able to take off even at 45-degree crosswind.
- The site needs to be free of any obstructions according to FAA guidelines (*68*).

Other studies propose taking advantage of the already present surface infrastructure. One of the easiest suggested solutions is to place vertiports on barges, clover leaf intersections, and even the roof of parking garages (*28*, *68*). However, regulatory requirements for different cities and states will play a role in determining infrastructure site selection. Almost all states have statutes or requirements for local airport compatibility zoning ordinances; only five states do not have local initiatives that have led to compatibility zoning (*63*). *Airport Cooperative Research Program Research Report 206* found that state-level challenges can induce problems with local compatibility zoning, such as narrowly focused and rigid zoning laws and standards that do not take into account the nuance of different airport types (*63*). These challenges will likely be exacerbated for a new mode such as UAM. In addition, environmental review or environmental impact studies, community engagement and input, and local government codes can all impact the development of TOLAs. Streamlining these processes and removing barriers to development may require innovative methods; digital policies have been established by cities to manage emerging transportation technologies such as e-scooters. A digital policy establishes the framework for an operator or industry to work within a city or region and ensure regulatory compliance (*67*). In addition to cities, state aviation planning offices will have a role in setting standards, addressing appropriate land use, and guiding the necessary environment review and community engagement based on their experience with traditional airports.

The placement of UAM infrastructure also depends on the availability of airspace above private property, especially above highways. Rules dictating where and how high aircraft can fly limit UAM airspace availability. Additionally, complications such as nuisance, trespassing, and takings can arise if UAM operations occur above private property. Municipalities will be a key partner in terms of airspace through the provision of data on building height, other obstacles, and potential land use and zoning considerations (*67*). A proposed solution to avoid concerns over airspace availability is the leasing of airspace above highways. It is argued that choosing this route will give local and state governments more control over UAM operations, will discourage lawsuits, and will generate additional revenue (*69*). A report evaluating individual UAM state statutes generated a scorecard to show which states have the potential for an airspace surface network above highways. The states were scored according to present airspace lease law, vesting of air rights with landowners, avigation easement laws, drone program, and impact on jobs. The state with the highest score was North Dakota, while Texas was ranked ninth (*69*). With respect to Texas, previous efforts have been conducted to show how the leasing of the airspace above the right of way could be used to benefit the state. A 1992 report by TTI observed how other work done by states related to airspace could be applied to Texas. It was concluded that revenue could be generated if the state hires the necessary employees to manage the program, if property marketing and outreach are conducted, and if the program was made to be flexible to accommodate any changes in regulation and need (*70*).

Funding and revenue generation for infrastructure will be key concerns for state and local governments that want to promote the development of a UAM system. Beyond reducing regulatory roadblocks and promoting competition between operators of UAM services, governmental entities will have to consider the cost of infrastructure development for TOLAs and any support infrastructure or intermodal facilities (*34*). Leveraging existing federal funding may be possible to develop facilities at underutilized airports, but other federal programs may require changes to requirements or flexibility to assist UAM. States could consider developing their own funding programs or establishing a framework to enable public-private partnerships in this space. While funding will be a key piece of ensuring the necessary infrastructure is in place to support UAM, these technologies are in the early stages, so possible models and sources are still being determined.

Supporting Infrastructure

In addition to infrastructure sites, another concern is how well equipped the electrical grid is to handle the adoption of eVTOL. As one of the major challenges identified by stakeholders, electrical infrastructure may not have the capacity to handle the quantity of energy to charge eVTOL batteries and supporting operations (*34*). Another complication is how electricity will be provided given that utilities can be operated by multiple parties, which may require some time to coordinate. To illustrate the role of electricity in UAM, a market study focusing on the current grid and energy infrastructure, airspace characteristics, and the overall market for Los Angeles, Houston, and Baltimore/Washington, DC, examined the growth and cost of electricity infrastructure. For each city, the study identified the party responsible for managing the electrical grid and the number of airports and helipads in the city. Obtaining this information helped researchers narrow down further electrical infrastructure needs, specifically those requiring upgrades to meet the energy demand from eVTOL. These upgrades were broken down by charger, building, airport requirements, on-site energy storage needs and use, and estimated costs. Put together, the cost of upgrading and installing charging stations on five-story buildings, parking garages, and at ground-level can range from $900,000 to $10 million (*71*).

Although this report mostly covers infrastructure needs for eVTOL, it does acknowledge future efforts that will be needed to make UAM a reality. Among these is safety in the form of permitting, grid signaling, and cybersecurity. Collaboration with government agencies, building owners, transportation providers, and others will also be needed to better integrate UAM into the grid and to optimize communication with air control facilities. Ultimately, this report focuses on currently expected infrastructure needs, but further research into use cases and different UAM or AAM scenarios would provide greater context on infrastructure and design standards.

Vertiport Standards and Design

FAA is currently working on developing design standards and guidance for vertiports. Ironically, an FAA Advisory Circular on vertiport design was canceled in 2010 long before the boom of development of the current eVTOL aircraft (*72*). FAA also has a draft advisory circular on heliport design that is out for review. However, the draft advisory circular clearly states that it is not intended for operations by vertical takeoff and landing aircraft or unmanned aircraft (*73*). Instead, FAA has been working on the development of new standards and guidance for vertiports that are applicable to the new generation of eVTOL aircraft being developed. One of these efforts is vertiport design as drafted in FAA's Engineering Brief No. 105. This guidance draft was open for public input, is now closed for comments, and is intended to be a temporary solution until a more comprehensive, performance-based vertiport design is created. Among the guidance covered in this draft are markings, lighting, charging and electric infrastructure, vertiports located on airports, and site safety elements such as winter operations, weather, turbulence, and visual flight rule approach and departure (*74*). A new, performance-based Vertiport Advisory Circular is scheduled to be issued in 2024 or 2025 (*75*).

FAA has outlined a path toward this development that is already well underway. The agency issued a request for information from the industry to better understand aircraft design specifications, concept of operations, infrastructure design, and takeoff and landing profiles (*76*). In addition, the FAA path includes collecting information through the NASA National Campaign (formerly the Grand Challenge), through outreach to industry, and through additional research studies and gap analyses that have already taken place, testing and simulation, and a vertiport electrical infrastructure study (*76*). FAA is expected to develop interim guidance at some point in this process.

The vertiport design goals including addressing the operational requirements for landing areas (layout/geometry), approach/departure paths, load bearing requirements, electric propulsion and charging stations, safety requirements for batteries and other hazardous materials, and noise requirements. The dimensions will depend on the aircraft using the facility, and the agency understands there is no one-size-fits-all facility. FAA will, however, outline what a minimally developed facility will be required to have with respect to boarding and discharging of passengers and cargo (*76*).

Airspace and Infrastructure Working Group

Operational UAM requires a safely regulated airspace as well as strong supporting infrastructure on the ground. Airspace considerations must comply with current guidelines and laws under FAA, as well as coordinate with the agency to ensure regulation and ease of use outside of traditional air traffic-controlled space. Airspace considerations are also heavily linked to infrastructure, from vertiports and other takeoff and landing sites, such as underutilized airports, to power supply frameworks. The infrastructure environment for UAM involves a range of public and private actors including operators and general contractors. Development of UAM will require coordination between these actors, the leveraging of public funds to ensure strict design standards for safety, and assistance to local governments in incorporating this new mode into their transportation network and built environment. Since UAM is an emerging mode of transportation, policy and legislation may be needed to enable the build-out of supporting infrastructure while maintaining flexibility for municipalities on zoning and permitting. The discussion on airspace and infrastructure involved a range of topics including:

- Airspace:
    - Alignment with FAA.
    - Harmonization of rules across Texas.
- Funding:
    - Public infrastructure funding possibilities at the federal and state level.
    - State/federal/local match requirements and sources.
- Policy and legislation:
    - Existing policy and permitting gaps.
    - Areas for legislative change in relation to airspace and infrastructure.
    - Encouragement of growth of UAM/AAM, and collaboration between public and private industry under Texas law.
- Infrastructure environment:
    - Consideration of full infrastructure package.
    - Roles and responsibilities of public and private operators.
    - Fostering of a competitive environment.

However, some key areas for Texas are:

- Alignment with FAA and airspace harmonization.
- Fostering of a competitive environment for UAM.
- Identification of existing policy and permitting gaps.

Alignment with FAA and Airspace Harmonization

With the understanding that ultimately airspace will be regulated at the federal level by FAA, the committee focused on ways to align FAA, provide it with additional resources and data from testing in Texas, and ensure airspace harmonization across the state. FAA is working toward guidance for UAM, but issues remain on monitoring, traffic management, and safety procedures at lower altitudes. Texas could establish guidelines in coordination with FAA to enable UAM operations within the state and ensure that the guidelines reflect the operational standards and procedures seen in the industry. In addition, airspace regulations would need to expand past airports and current avigation easements. This provides room for states to propose regulations supported by data to FAA. One area that will fall under state and local jurisdiction will be takeoff and landing areas. Standards related to infrastructure and operations on the ground will also have implications for the use of airspace.

Ensuring airspace harmonization and reducing the likelihood of a patchwork of regulations will require both state and federal oversight of operations under local jurisdictions. HB 1643 (2017) prohibited local regulations on unmanned aircraft except during special events and to protect critical infrastructure owned by the local government (*77*). This preempts local governments from enacting different regulations and should ensure a smooth operating environment for unmanned aircraft; however, early UAM operations may still use manned or crewed aircraft, which would require a legislative change to address.

Fostering of a Competitive Environment

Ensuring a competitive environment within the UAM industry in Texas will provide greater benefits to the state and communities by enabling a range of different operators to meet demand. While the committee does not want to detract from first-mover advantage, there is a need to ensure competition and availability for a variety of different operators at vertiports or takeoff and landing areas for UAM. (*78*). Any legislative efforts by Texas would need to be mindful of FAA jurisdiction as well as their requirements or grant assurances for competitiveness. In addition to ensuring access to UAM infrastructure, the state could play a role in developing zoning and vertiport standards as well as other infrastructure regulations. Ensuring uniform and flexible standards across the state rather than varying from jurisdiction to jurisdiction promotes entrance into the market.

Rules and cost-sharing agreements may drive the public access or use by different operators of vertiports and other infrastructure. Vertiports will be needed outside of traditional airports as this mode and industry expands, and this infrastructure will require funding and revenue generation capabilities if public agencies will be building and/or operating them. Private vertiports needs to be included within current system planning efforts. There may be a concern with operators having exclusive access to vertiports, which could lead to inefficiencies if development of multiple sites within a small area occurs to accommodate the different operators. As UAM/AAM matures, the different models for vertiports, including public and private operations, will develop to reflect the needs of both the communities involved and industry.

In addition to supporting UAM operators and infrastructure developers, the state could highlight the opportunities for other industries, such as real estate developers, construction companies, and legal firms. Enabling this new mode of transportation and essentially new industry will require coordination and cooperation across multiple industries to determine site selection, build the infrastructure, and ensure all regulatory requirements are met. Highlighting the path for these industries to become involved in the UAM space could drive investment and create more opportunities.

Identification of Existing Policy and Permitting Gaps

Restrictive legislation and policy and permitting gaps can create unnecessary barriers to the development of the UAM industry. Identifying the potential policy and regulatory gaps is the first step in ensuring that the UAM industry can enter the Texas market. Any new legislation or legislative changes should take into account local needs and *the desires of the community, as well as accommodate evolving technological developments*. Avoiding a patchwork of regulations and ordinances across local governments in Texas is ideal, but there does need to be flexibility in any state-level law that reflects important differences between urban and suburban environments. Specific areas that could benefit from state-level technical assistance are zoning considerations and regulatory standards for vertiports. Municipalities may not have the resources or capacity to consider changes to zoning law or to develop their own codes for vertiports, so leveraging both federal- and state-level resources to provide technical assistance can better prepare them for introducing UAM.

New policy and permitting guidelines should be determined in coordination with the Texas Airport System Plan (TASP) (*79*). The last TASP was completed in 2010, and efforts are currently underway to update the TASP. Coordination with the TASP will assist with infrastructure placement and permitting issues and will identify related airspace considerations. Discussions around leveraging underutilized airports for both testing and operations would again need to consider the TASP and may be informed by those planning efforts.

Recommendations

The third and fourth working group meetings focused on the drafting and development of recommendations related to the three topic areas identified in the first working group meeting. The discussion considered the different policy considerations and regulatory efforts that may be required at each level of government. Reviewing current statutes and regulations is the first step to ensure a smooth introduction for industry. The working group identified the critical need for data in terms of operations within airspace as well as infrastructure design and standards. This discussion concluded with the following four recommendations from the Airspace and Infrastructure Working Group.

1. **Provide consistency across Texas law by creating statutory uniformity and standard definitions pertaining to unmanned aircraft operations and urban air mobility/advanced air mobility.**

UAM/AAM introduces a unique set of technologies, operational models, and physical infrastructure that may not currently be covered under Texas state laws. Vertiports and UAM aircraft should be included under current relevant statutory definitions to reduce the regulatory burden for UAM's introduction. Reviewing current statutes and regulations to ensure definitions meet the evolving industry standards enables Texas to remain ready to introduce UAM and to maintain safe operations. Statutes should remain flexible because UAM may transition from manned to unmanned operations as the technology progresses.

2. **Develop an urban air mobility/advanced air mobility–centric research facility to test and evaluate technology, provide data collection opportunities, and coordinate with federal entities to share information and help guide data-driven public policy. The Texas Legislature is encouraged to consider the benefits of state funding for the successful development and operation of this facility.**

This recommendation has similar goals as the Technology Working Group's recommendation on a UAM/AAM sandbox. One of the core needs for the industry today is data related to operations and safety, both of ground infrastructure and movement in airspace. Developing a research facility would allow the State of Texas to evaluate potential technologies or operators and to collect the data necessary to allow for the eventual scaling up of UAM/AAM for passenger and goods movement. Potential areas for testing at such a research facility include remote ID and traffic management. In addition, the facility may benefit from being co-located at or near a university that could support research activities and data collection efforts. The advisory committee also recommends that the legislature consider state funding for such a facility to allow for testing to occur outside of larger airports. Smaller communities may not have the resources or technical capacity to develop their own test site or facility and so would benefit from state support.

3. **Develop a statewide plan, or integration within the Texas Airport System Plan, that addresses the potential locations for and classifications of vertiports and other associated infrastructure to help define the future operational environment of urban air mobility/advanced air mobility.**

UAM/AAM will be a mixed aircraft environment that may include drones, helicopters, and crewed or uncrewed/self-flying eVTOL or STOL aircraft. Statewide planning efforts can provide clarity on the proper placement of vertiports or other required infrastructure. A statewide plan would provide recommendations on the conditions necessary for vertiport locations, rather than prescribing specific locations as well as help provision the infrastructure for the future to enable new technologies. Recommendations could address land use, airspace, and other safety and operational considerations to avoid gaps in infrastructure across the state. The TxDOT Aviation Division has begun a new TASP update effort that will incorporate some of these considerations.

4. **Direct the state to work with municipalities to provide technical assistance to local governments in adapting and integrating urban air mobility/advanced air mobility in their communities.**

UAM/AAM operations will require coordination with municipalities to develop ground infrastructure and to begin operations with public support. Municipalities may require assistance in adapting their current environment or integrating these operations into their city. The state should provide leadership in this area if UAM/AAM is to be effectively introduced into Texas. Technical assistance could range from guidance on interactions with FAA and airspace considerations to a roadmap for installing the appropriate ground infrastructure.

SAFETY AND SECURITY

Ensuring safety and security of UAM requires the consideration of risk at all levels, from the aircraft and related technology to the management of airspace to infrastructure considerations. This section presents a literature review on the core concepts within both safety and security for UAM before presenting the committee's work on this topic. Safety and security are broad topic areas that may offer a number of areas for state consideration; however, the committee chose to focus on safety in aircraft operations and areas for standardization in relation to safety and security due to the time constraints of the effort. The recommendations to the State of Texas will focus on these two areas and the role in which legislation and regulation can ensure UAM safety and success.

Literature Review

The literature review considers safety and security across the UAM/AAM landscape. This includes operational concerns and management, certifications, and standardization, as well as the safety and security of the public. Transportation safety and security under UAM will have to consider both passengers and the general public that this new transportation mode will operate above.

Safety

Operational Safety

Regulations could be developed at federal, state, and local levels; the literature generally agrees that safety, equipment, and operations will be regulated at the federal level with land use, privacy, and environmental issues more likely to fall to either the state or local levels (*32*, *36*, *55*). While Airspace will be regulated at the federal level, coordination may be required between multiple levels of government to ensure safe operations (*80*).

At the federal level, the current regulations are limited when considering operations, equipment, and safety (*36*, *55*). Operating within low-altitude airspace, generally below 500 feet, may require alterations to the current standards from legal separation to design separation. This would provide greater flexibility while ensuring safety of operations in denser traffic (*54*). The different operational concepts and business models may see automation entering the UAM space as well as greater data requirements and standards. CFR 14 does not include regulations relating to autonomous or no-pilot operations at this time, and while a "user certification" is mentioned in the regulation, no standards or requirements are presented (*81*). The current rules adequately cover onboard, certified, single-pilot operations under visual flight rules and instrument flight rules. However, the rules do not consider the potential for remote operations or ground-piloted operations, or allow a certified user to operate the aircraft when necessary (*36*). New flight crew licensing and training could be required to support nontraditional operations (*32*). If these regulations are not updated, an alternative means of compliance may be necessary to allow for more advanced UAM operations that incorporate autonomous technologies (*56*).

Incorporating autonomous technologies into the safety regulation environment for aviation also requires consideration of a mixed operating environment in the early stages. Both autonomous and non-autonomous operations will be occurring at certain stages, and the proposed method for ensuring safety is an in-time aviation safety management system

(IASMS) (*82*). An IASMS would augment the current safety systems of today and would allow operators to tailor their safety management system to their use case. For example, different safety considerations are necessary when handling cargo versus passengers. These systems are intended to be responsive and able to meet specific safety goals and performance measures based on need and operating environment. The basic components of the system would be to monitor, assess, and mitigate. Monitoring includes hazard identification and data collection. Assess requires data analysis and risk mitigation (RM) controls. Mitigation is based on safety performance and resource prioritization. The purpose of an IASMS is to monitor and consider all risks in an overarching framework, but each specific system will be based on defined risks and the expected use case (*82*). Safety management systems will be critical to operation of UAM/AAM, especially in mitigating the risk to passengers and the public impacted by these services.

Safety Standards and Certifications

Safety is a core concern for the public when considering a new mode of transportation. UAM represents an exciting new offering but one that will require strict safety requirements for both equipment and operation. In addition, the potential for autonomous or remote operations presents a new area for safety standards and regulations in aviation. Ensuring public acceptance of autonomous operations necessitates stricter safety standards than traditional aircraft or aviation practices (*54*). These standards should take into account handoff situations where the remote operator takes control of the aircraft (*56*). Handoff situations could include severe weather conditions, equipment or sensor malfunctions, and periods of dense traffic in the early stages of operation. The higher densities and greater number of origin and destination pairs present a key challenge for UAM; arrival and departure safety will be critical in terms of safety (*83*). In addition, safety standards and certifications are required for the new aircraft that will be operating in the UAM environment. Current regulations do not adequately cover electric propulsion, title wing powered lift, and future concepts such as folding propellers (*36*).

Regardless of operational concept, automated or piloted, UAM could benefit from collecting additional data that will allow for more effective decision-making. A new system for monitoring risk within the UAM environment could ease public concerns and ensure greater safety (*84*). UAM safety considerations will likely consider a mixture of human and autonomous control but should cover these key categories: safe separation, vehicle control, and mission and vehicle management (*56*). New standards for the vehicle and equipment and for operating within the defined airspace are critical for the safety of UAM operations. Strong traffic management that accounts for aircraft separation and control, either piloted, remote, or autonomous, is also crucial at the expected densities of UAM.

While standards exist that can ensure safety across approximately 80 percent of proposed UAM operations, some standards and protocols need to be expanded or revised to meet the needs of new eVTOLs and autonomous operations. ASTM International is working to develop these updated standards to ensure the safety of the industry throughout its operation (*85*). Furthermore, because no certification for AAM aircraft currently exists, FAA plans to certificate them using a process for aircraft that do not fall within the standard aircraft class. One approach to certifying AAM aircraft will be by adding special conditions to Part 23 that considers the uniqueness of these types of aircraft. Another approach FAA is considering is using the certifications standards of Part 23 as a foundation and combining other FAA regulations, such as those used for helicopters, to classify a new type of aircraft (*34*).

Security

There are two key elements to consider in terms of UAM security: the physical security at the vertiport and in the air; and cybersecurity related to equipment, operations, and passenger screening. Both elements play a role in the safety of UAM operations; however, physical security considerations may see the greatest departure from current aviation norms in an attempt to create faster and more efficient air travel.

Physical Security

Physical security encompasses a range of issues including access, transfers, and screening of both passengers and crewmembers. In terms of access, vertiport security and partnerships with law enforcement, fire departments, and emergency services are critical to maintain the integrity and safety of the UAM service while effectively coordinating with local agencies for emergency or incident management. The operational use of the vertiport or takeoff and landing site will play a large role in determining access to the area and the specific security considerations, such as perimeter security (*86*). In addition to operations, the location of the vertiport will determine the requisite security needed around airspace monitoring and communication, which links to cybersecurity issues as well.

One potential use case for UAM/AAM would bring in additional security challenges. Trips into airport environments would require different procedures if the UAM operations were dropping off passengers landside or past traditional security procedures controlled by the Transportation Security Administration (TSA). Beyond landings at airport, transferring between different modes or the use of intermodal facilities for UAM will have to consider the specific airspace, perimeter, and access security at those transfer points.

Finally, screening of those working at vertiports and passengers will be required to a certain extent, especially as UAM operations grow (*86*). While traditional TSA operations may be too burdensome in terms of the time and space required, the ability to vet crewmembers and ensure the safety of both the crew and passengers will be required for airborne operations. Industry groups are intending for short dwell times within the terminal to both expedite service and maintain low levels of passengers on site. This short dwell time has the advantage of minimizing the terminal space required at the vertiport or TOLAs and allowing for a limited crew to be able to monitor and assist passengers. The intent is to leverage technologies for expedited security checks as UAM operations grow, but in the early stages, passenger profiles would be the main screening check (*86*). TSA is working with industry groups to determine the potential security risks and needs as UAM develops.

Cybersecurity

The technological nature of UAM/AAM services, especially when considering remote or autonomous operations, will require strict cybersecurity protocols and standards. The confidentiality, integrity, and availability (CIA) triad is often used in discussing the cybersecurity needs of TOLAs and the aircraft and management systems (*86*). Ensuring *confidentiality*, or privacy, of data requires authorization and authentication of users to restrict access to data. Data classification and labeling determine the necessary security measures and protocols for each type of data. In addition, industry may follow data privacy laws from outside the United States to enable interoperability. For example, the General Data Protection Regulation sets the standard for the European Union, and operators wishing to conduct business in Europe may benchmark their data protection protocols against this standard even in the United States. *Integrity* refers to data security; the key components of integrity are preventing data tampering, using digital certificates to minimize risk, and ensuring data are encrypted at all points. Finally, *availability* refers to the redundancy functions and the ability to audit the cybersecurity or data protection framework. This involves building in redundancy within the system, ensuring hardware fault tolerance, and developing plans to recover data and enacting denial-of-service protection mechanisms.

In terms of specific threats to cybersecurity, recent research has highlighted four main components:

- Cyber physical systems.
- End users.
- Cloud services.
- On-premises computing (*87*).

End users include operators, the public, and partners such as public safety agencies. Threats were categorized using a MITRE Adversarial Tactics, Techniques, and Common Knowledge framework. These threats include:

- Eavesdropping.
- "Man in the middle" attacks. These can be eavesdropping but more often alter data and compromise data integrity.
- Phishing attacks.
- Distributed denial of service (DDOS). DDOS attacks disrupt an entire environment and can degrade service.

These threats pose a great risk to UAM, especially in terms of degradation of service. Cybersecurity moves beyond a privacy or data protection concern and can lead to safety issues. Potential safeguards against these threats would include:

- Encryption of data.
- Testing of application programming interfaces for vulnerabilities.
- Training and awareness, especially in terms of phishing attacks.
- Security detection methods in coordination with temporary automatic lockouts.

Ensuring safeguards and security management practices are in place will require regulation across all aspects of UAM; one potential method for cyber and information security would be through standardization. The International Organization for Standardization (ISO) has a certificate for information security management that could be referred to as a benchmark or required of industry partners. ISO/IEC 27001 provides requirements for information security management systems (*88*). While ISO does not certify, other certification bodies can be used to certify an agency or corporation. Understanding the benchmarks used for information security and cybersecurity will be critical in ensuring safety and security across UAM.

Cybersecurity will be key for both ground infrastructure and airspace monitoring and traffic management systems and will support physical security through screening processes.

Safety and Security Working Group

Safety and security in UAM are crucial to the development of UAM, not just in Texas but across the globe. While many standards and regulations will be set at the federal level, states have an opportunity to assist in the development of these standards through pilots and testing in different settings. Safety forms a component of a number of different aspects within UAM and AAM, infrastructure and operations safety, safety guidelines and regulations, cybersecurity, and education of the public and public agencies. Each of these broad areas has specific subtopics, which were discussed by the working group:

- Infrastructure and operations safety:
    - Vertiport safety.
    - Recommendations for vertiport structural requirements, especially in non-airport settings.
    - Safety of aircraft operations, including safety management systems.
    - The need for blackbox safety standards for UAM/AAM crash review.
- Safety guidelines and regulations:
    - Study rules and guidelines from a safety perspective.
    - Review of Government Code 423.
    - Review of *aircraft* definitions across statutes to identify possible hinderances to UAM/AAM.
    - Recommendations on standardization.
- Cybersecurity:
    - Security in manufacturing.
    - Potential interference scenarios and penalties.
- Education:
    - First responder safety and security education.

However, some of the key topics that the working group feels Texas can play a role in shaping are:

- Safety in aircraft operations.
- Standardization relating to safety.

Safety in Aircraft Operations

Safety in operations will be key to public acceptance of UAM, and safety must consider passengers, the public on the ground, and the crew or staff at vertiports. UAM will be operating in airspace that usually sees limited traffic, which could raise concerns over aircraft and flight safety as well as noise and environmental considerations. Safety management systems must incorporate public safety as their main consideration to ensure that operations do not disrupt or cause harm, especially in dense urban environments where operations can be more complex. Urban operating environments will also necessitate data sharing between public agencies and operators. There should be some consideration of data interoperability standards and the mechanisms to share the data with the state. The

Texas Department of Public Safety uses a flight risk assessment tool that helps pilots navigate in denser environments and report structures that impact the airspace. This is currently reported by pilots, and for UAM, operators will likely need a real-time reporting system and mapping capabilities to identify both permanent and temporary structures that impact operations. Current systems suffer due to interoperability constraints that would need to be addressed before UAM can scale.

Any guidance provided by the State of Texas in terms of safety or safety management systems would have to follow the FAA guidelines on the topic. However, since UAM safety standards are not fully established, there may be a role for testing and operations in Texas to develop models or minimum standards for safety and safety management systems. While any regulations or standards related to operations in the air would be under FAA's purview, ground infrastructure and the location of that infrastructure can be regulated at the state level. This would include safety in terms of ground operations with regard to both power supply and manufacturing issues.

While vertiport design standards are being developed at the federal level, the state does have minimum standards for general aviation airports that follow federal standards. A similar set of standards could be developed for UAM that would guide vertiport design as well as takeoff and landing areas to ensure safety. Since UAM is an emerging industry, standards would need to be developed in coordination with FAA and remain flexible to changing technology and power supplies. Recommendations could also be made in terms of passenger movements in and around vertiports to ensure security.

Standardization Relating to Safety

Safety in operations will require standardizations in procedures at various stages of the process. Passenger movements and interactions with ground crew will require a screening process, especially if the movement enters controlled airspace. Coordinating with TSA and other agencies to ensure the security of passengers, crew, and the public will be necessary. For movements that do not enter controlled airspace, some form of screening will be required but will need to be less burdensome than traditional airport security. Other areas that will require standardization are flight operations and incident review. Ensuring thorough procedures before and after takeoff as well as safety reviews after incidents should improve the overall safety of operations and assist with public acceptance. Penalties and regulations relating to interference with operations were also discussed as critical to safety and security. However, any standards should focus on maintaining safe operations without pushing smaller companies out of the market due to difficulties with enforcement or compliance. While many of these standards will ultimately be determined and regulated at the federal level, the current status of standards within the UAM industry provides an opportunity for Texas to guide these standards through the work that is ongoing in the state.

Entirely new standards are not necessary at this stage, and the committee recognizes that existing standards can be used and updated to reflect the unique challenges of the UAM industry. Standards organizations, such as ASTM International, are taking a similar approach by modifying and updating existing standards to ensure safety. TxDOT's Airport Rules and Standards webpage provides a starting point to determine the appropriate standards for UAM and where modifications or expansions will be needed (*89*). Using existing standards where possible can ease the burden on operators entering the market as protocols are established and are not relying on new review processes.

Recommendations

The third and fourth working group meetings focused on drafting and developing recommendations related to the safety and security of UAM in Texas and across the United States. The working group understands the significance of safety to introducing and developing the UAM industry both within the state and in interactions at the federal level. FAA will take the lead in developing broad standards, requirements, and certifications, but the state should work in coordination with both FAA and other federal entities to provide available data that can assist and support safety standards. Where possible, the state can review current aviation safety regulations and training to better prepare the state for UAM/AAM's introduction. In support of those goals, the Safety and Security Working Group developed the following seven recommendations.

1. **In collaboration with the appropriate federal entities, the state will work to encourage the development of minimum standards/safety management systems for vertiport operations including passenger and goods movements and ground infrastructure.**

Federal regulations surrounding AAM are still in development. In March 2022, FAA posted *Draft Engineering Brief No. 105, Vertiport Design,* for public comment. The intent is for FAA to review comments and finalize the engineering brief. The original expectation was that this would occur in June 2022. This brief provides interim guidance on the design of vertiports for VTOL operations, which is subject to change as new data or analysis becomes available. The UAM Advisory Committee recommends that the State of Texas encourage the development of these standards and collaborate with FAA where possible to ensure the safe movement of passengers and goods under AAM. An FAA Advisory Circular on vertiport design is not expected until 2024 or 2025.

2. **Extend the work of the Urban Air Mobility Advisory Committee beyond the sunset date of January 1, 2023, to continue working in key areas of this emerging and quickly evolving industry in order to remain responsive to the needs of Texas and ensure Texas' role as a leader in this industry.**

The UAM/AAM space is at a stage of rapid development, and the industry is constantly evolving. In order to best position the state for adoption and advancement of UAM, the committee should be extended to continue working in key areas. An extension of the committee should consider the industry standard terminology and alter the scope to AAM. AAM reflects the potential for regional air mobility, or connections between cities, and intracity transportation. Further, AAM allows for the consideration of UAS and the interactions between passenger and small goods movement in the same airspace. Continuing the work of this group will build on the current progress and keep the momentum going to best position the state to adopt and integrate this new technology. A similar recommendation was made by the Commerce and Community Integration Working Group.

3. **Recommend Texas law does not conflict with federal law.**

The UAM/AAM space will see an evolution of regulation and rulemaking in the next few years. Texas should remain on the forefront of any regulatory efforts to ensure safety and efficient operations. However, state law should not conflict with federal laws on UAM/AAM. Coordination with federal legislators and agencies will allow Texas to lead in this area and develop legislation that coincides with federal laws. This coordination will prevent ambiguity and uncertainty and will enable UAM/AAM operations to safely develop in Texas.

4. **Encourage the Legislature remain an active participant in urban air mobility/advanced air mobility as the industry and technology will outpace current regulations and enable the appropriate state agency to lead and manage the regulatory concerns.**

Appointing an existing agency to lead and manage concerns, especially regulatory, regarding UAM/AAM allows the state to remain at the forefront of this evolving industry. The legislature should remain informed on the progress of UAM/AAM and be aware of industry developments and federal regulations, including those from FAA and other relevant agencies. Allowing a state agency to act as a point of contact will ensure that the legislature remains informed on industry progress and any developments that may require state review or enactment of legislation.

5. **Direct the Texas Department of Transportation to review existing state aviation standards and guidelines, airport facility planning, and compatibility guidance to ensure they apply to urban air mobility/advanced air mobility.**

Existing aviation standards and guidelines may apply to new technologies developed under UAM/AAM. TxDOT is encouraged to review current aviation standards and guidelines to determine where adaptations can be made and which standards and guidelines may apply to UAM/AAM in their current form. This approach saves time and serves as a foundational starting point in developing appropriate safety standards. Additionally, to expedite regulations and standards in this area, the development of compatibility guidelines, safety systems, and facility planning could be the responsibility of TxDOT, where principals in airspace, safety, commerce, and UAM/AAM management can all be assigned within the department.

6. **Support the development of standardizations at the federal level and within industry as technology develops/changes so safety is prioritized as the technology matures.**

The safety and security of UAM/AAM operations are the most important consideration for both government and industry. Since this industry is developing and introducing new technologies, such as eVTOL and STOL, standards will be developed to ensure safe operations. Many of these standards will be developed at the federal level, especially in terms of aircraft, but the State of Texas should support these standardizations wherever possible. In addition, safety standards for infrastructure must be considered by the state due to its greater role in ground infrastructure regulation and funding.

7. **Encourage state-level cooperation with local governments to ensure appropriate preparation, training, and safety practices associated with vertiport operations**

including law enforcement, fire service, and emergency medical services associated with traditional aviation and advanced air mobility aircraft operations.

Ground infrastructure, such as vertiports, will be subject to local zoning and permitting considerations, but the state should cooperate with local governments to ensure that law enforcement, fire departments, and EMS are prepared for the unique challenges related to UAM/AAM operations. As this mode of transportation grows, operations may occur in areas with limited aviation experience. To this end, the state can provide guidance on the necessary preparation, training, and safety practices to local governments. Enabling UAM will require this cooperation between the state and local levels to ensure safety and security of operations.

COMMERCE AND COMMUNITY INTEGRATION

Commerce and community integration is a critical component to UAM that will impact the public. Public awareness and education efforts will be required to prepare and secure their approval. Safety, noise, access to UAM facilities, and privacy are some of the concerns listed as barriers to public acceptance. Similarly, because UAM is a new technology that many members of the workforce may not have been exposed to, UAM training programs will be needed to prepare the community for integration. This section discusses regulatory and infrastructure considerations, the factors affecting public acceptance, current education and training efforts and needs, and demand. A summary of the topics the Commerce and Community Integration Working Group discussed and those most important to Texas adoption is also included.

Literature Review

Legal precedent has established a right to enjoyment and use of a landowner's property; however, there is no established limit to the use of airspace by FAA. While the legal operating environment is still being established, communities should still be engaged to ensure that UAM operations and infrastructure match community needs and vision. Infrastructure placement is a key consideration in terms of both introducing commerce opportunities and integrating into the existing community. One concern is that some cities may not have the appropriate physical or regulatory conditions for UAM adoption, which could cause complications. Poor TOLA placement can lead to issues such as increased travel time, costs, and congestion. For example, by selecting Los Angeles, CA, as its case study, a study found specific instances where adopting on-demand mobility (ODM) may not be feasible. With regard to infrastructure, low TOLA availability would cause passengers to drive longer distances, leading to greater congestion, and would limit aircraft staging and deployment capacity (*61*). Another complication is regulations at the local level, often influenced by community input, that could potentially affect infrastructure placement. The California Public Utilities Code and the California Code of Regulations, for instance, both contain rules that could slow or hinder the development of TOLAs, such as requiring the approval of the city board or performing an environmental impact study (*62*). Therefore, making the public aware and educating them on AAM and UAM will set the foundation for promoting public acceptance at the community level.

Public Acceptance

Public acceptance is critical for any new technology, development, or transportation option. UAM presents new, unknown technologies, a different mode of public transportation, and large development in the aviation sector. Ensuring public acceptance will rely on promoting and proving the safety of UAM operations, providing easy access, maintaining privacy, and reducing noise where possible. Cotton and Wing believe that strict safety standards will be necessary to assuage public concern (*54*). Research is already underway to gauge public perception regarding UAM. Safety, trust, and a preference for automation were found to be key to the public accepting UAM; if automation is not initially used, safety standards will still be critical to easing public concern (*32*, *90*). While autonomy and automation are often used interchangeably, it should be pointed out that autonomous operations of an aircraft itself represents a range of control that, simplistically, includes pilot-controlled flight, pilot supervision of automation systems, and pilots passively monitoring autonomous operations and being notified if human intervention is required. In addition, the pilot may physically be located on the aircraft or at another location with the ability to control the aircraft remotely (*8*). When considering autonomous operations, lessons could be learned from the testing and deployment of AVs. Strong communication between the passenger and the aircraft can help ease concerns, as can the ability to communicate with a remote operator in certain conditions (*64*). Other measures can be taken to earn public acceptance, but it is also important to identify challenge areas.

The availability and access to UAM impact public use and acceptance. Fast access and egress to vertiports and intermodal connections will be required to incentivize UAM usage (*32*). Flight capacity and takeoff and landing availability have been cited as primary constraints for UAM adoption alongside noise (*61*). Complete trip times need to be faster than other modes to incentivize use; the access to vertiports and efficient boarding will be a key component when competing with transit or car trips. Vertiport placement should be considered to provide routes that allow the user to avoid congested highways and to provide an efficient number of flights available per day. The on-demand aspect of UAM is critical to attracting users but will present challenges when considering cost and efficiency. Stakeholders also noted in a GAO report, *Transforming Aviation*, that for the AAM industry to be accepted among the general public, equitable access must be included in the transportation network rather than be its own separate service (*34*).

Privacy concerns, both in terms of data security and the potential intrusion over private property, also play an important role in UAM adoption. Community members in Melbourne, Australia, cited a UAM application as an invasion of privacy when presented with the option of a helipad on top of a high-rise building (*91*). Data security and privacy also have an increased role with the use of on-demand mobility solutions for UAM; operators should be aware of the use and protection of user data to reduce concerns over data breaches and cybersecurity issues (*32*, *90*).

Finally, noise is considered a primary constraint and a key issue that should be addressed before adoption of UAM (*61*, *62*, *91*, *92*). Half of the respondents to a survey on UAM were concerned with the type and volume of sound that would be produced by the aircraft. This would also be impacted by the time of day flights operated and the aircraft altitude (*92*). The impact of noise on public acceptance highlights the importance of obtaining community input when considering routes, hours of operation, and especially the location of vertiports or vertipads. Current noise mitigation strategies should be explored, as well as aircraft technology and modes of operation that reduce noise pollution (*62*). When considering technologies that reduce noise, such as electric operations, the potential reduction in environmental costs can contribute to greater public acceptance of UAM (*32*, *91*).

Demand

Public acceptance of UAM is inherently linked to demand; however, factors outside of safety, access, privacy, and noise will impact the use of this mobility option. Travel time and cost are key to ensuring demand for UAM services (*32*, *93*). A German study found that the optimal aircraft has four seats and a range of 550 km, and users are willing to pay 0.5 to 0.8 euros per kilometer, which is approximately $0.9 to $1.44 per mile (*94*). Garrow et al. believe that UAM must be price competitive with AVs in order to capture the necessary market share (*33*). When modeled, UAM ticket costs were lower under dense vertiport availability with costs ranging from $0.30 to $7.20 per km for different densities by area sizes ranging from 150 to 450 km^2 (*95*).

Although vertiport density can increase efficiency, the unpredictability of on-demand aviation will require efficient routing and cost reduction wherever possible to ensure economic success (*96*). Goyal et al. estimate that AAM could replace non-discretionary trips over 45 minutes, which represented approximately 0.5 percent of mode share under their analysis (*93*). Due to the current high cost of UAM, the key demand areas are generally viewed as dense, high-income urban environments that would benefit from an alternative travel option to reach destinations within a shorter time frame (*97*). A study on design optimization found that a double landing pad may be the best design to optimize output (*98*). Operators must consider the cost, efficiency, and travel time savings because they will have the largest impact on demand and routing decisions.

Education and Workforce Development

To generate public awareness and interest in UAM, educating the public on what this technology is and how it will affect their lives should be considered to achieve community integration. An organization already taking on this responsibility is the Community Air Mobility Initiative (CAMI). Its work prioritizes education on a local and community level by providing resources to the public in the form of brief documents highlighting various components of UAM (e.g., public acceptance, eVTOL, operation, and benefits). In addition to providing resources, CAMI hosts events dedicated to introducing UAM to state and local decisionmakers (*99*). Universities are also undertaking this effort by integrating courses related to UAM and AAS into their curriculum and housing some UAS testing sites. Recourses are also available for teachers who wish to teach their students about UAM. NASA's *Advanced Air Mobility (AAM): STEM Learning Module* for example contains guides on different of AAS topics. Students can participate in activities such as air taxi design challenges, coding, package delivery, and others as instructed in the educator and student guides (*100*). It will also be essential to earmark funds to support these programs, especially those in disadvantaged communities.

Commerce and Community Integration Working Group

Although major decisions regarding UAM will be made at the federal and state levels, preparing local communities for the introduction of this new technology is a wise action for the acceptance of UAM. The working group discussed a number of topics, including the following:

- Education and workforce development, including the recommendation for the state to offer more educational grants for training.
- Law enforcement integration, including training opportunities for law enforcement and the public.
- Public awareness, including consideration of a community integration bill at the federal level.
- Economic impact, including reviewing what other states do in regard to fund generation, environmental impacts, and impacts on mobility.
- Review of recommendations originally based on HB 2340.
- Review of the best practices on how UAM can integrate with the physical build of an area.

However, the key issues the working group focused on related to education, workforce development, and public awareness.

Education and Workforce Development

Providing education and public awareness programs will have an impact on readiness and acceptance; therefore, the reallocation of training and educational grants will be required. Strategies need to be developed for disaster and incident management as well as public education and awareness training in matters related to UAM and AAS. Identifying appropriate education and workforce development programs that can promote UAM/AAM will be critical for preparing those who will often need to interact with this technology. Similarly, identifying those in need of training will influence how the education and workforce programs are developed. With the advancement of this new technology, the workforce needs to be prepared for how to properly interact with aircraft. This could include involving emergency responders, law enforcement, community leaders, and others early in the decision-making process. Additionally, introducing the younger population to this technology while they are still in school may encourage them to join the UAM workforce. Schools can introduce AAS programs into their curriculum or clubs that give students firsthand experience. However, securing funding for these education and training programs may require legislative changes or the creation of new grant programs.

Workforce development and training will have to shift focus to electronic and autonomous travel. It is expected pilots will be needed to operate UAM aircraft in the short run. The challenge, however, is attracting talent in a field whose future is uncertain, will eventually be replaced by autonomous piloting, and where skills may not be entirely applicable in other areas (*101*). In addition to pilots, EMS and fire department officials will have to adapt to carry out emergencies involving UAM. The role of law enforcement will need to be redefined, potentially using HB 2340 as a foundational guide. For pilots, streamlining certification standards could be a viable solution given the amount of time and complexity of current training programs. Not all commercial piloting skills will be required for UAM operations; some of the certification requirements have already been eliminated (*101*). Furthermore, states already offer funding opportunities for training programs in similar fields (*102*). To take advantage of these resources and because not all programs are applicable to UAM, it would be necessary to create new classification codes to allow for the specific funding of UAM and AAS training in the future. It will also be essential to create public-private partnerships to contribute and fund the development of this new workforce.

Public Awareness

Public awareness is the first step to ensuring public acceptance of UAM services in the future. It will be critical to educate the public on the different uses of these technologies, the operational considerations, and especially the safety standards and design of these systems. Making the public aware of the safety protocols, standardizations, and operational design that has been vetted for safety should ease concerns over the introduction of this new mode. The different operational styles in terms of VTOL and eVTOL need to be explained to the public to pave the way for community integration and eventually use of UAM services. Promoting the benefits of this new mode, such as use by emergency services, could also help to ease concerns. The committee discussed the potential for leveraging existing federal resources, such as the community engagement toolkits (*103*), and the possibility of planning grants if HR 6270 were to pass at the federal level (*104*).

To successfully generate public awareness, it is necessary to tailor each action to the appropriate community. These communities include community leaders, elected officials, community members, and others, with each having their own interest. Some industries have already established guidelines for how to best improve public awareness, as in the case with Wing, which launched small-scale UASs at two locations in the United States, Finland, and Australia. Wing and Virginia Tech's MAAP developed a community engagement guide based on their experience in establishing small drone delivery services in cities (*105*). Their strategy involves engaging the community through three pillars: education, listening, and responding. Before launching this kind of service around the community, it is advisable to educate the public on how it will impact their community. Being present in person also enables the community to be heard and part of the process. Responding refers to considering community input and employing those changes in the industry's operations; this demonstrates the industry values what community members have to share and will take action to solve any concerns. This guide also identifies outreach opportunities within the community such as setting up a station in farmers' markets, festivals, or conferences (*105*).

Lastly, materials need to be presented in a manner that is visual and quick and easy to understand. Some examples include social media, press releases, interviews, videos, and websites (*106*).

Engaging the federal government, especially FAA, will require a different approach that is more focused on providing information to this agency in order to help it make informed decisions. One approach is to contact FAA's Noise Ombudsmen and Office of Environment and Energy, which respond to community concerns. Providing data to FAA obtained from noise and annoyance measurements will ensure that proper decisions are made concerning noise levels and minimal inconveniences to the public. This extends to crafting noise and environmental standards that most of the public accepts, which FAA could be made aware of based on data provided to it (*106*).

Recommendations

The third and fourth working group meetings involved the drafting and development of recommendations that would spur commerce and economic development and would integrate this new technology into Texas communities. The working group discussed the need for education and workforce development within the state to ensure Texas remains competitive. In addition, leadership and guidance at the state level will allow local and regional governments to effectively introduce UAM/AAM within their communities with public support. With that in mind, the Commerce and Community Integration Working Group developed the following five recommendations.

1. **Direct all law enforcement and first responder agencies to adopt education and training recommendations as identified in *Unmanned Aircraft: Responding to and Recovering from Disasters* (State of Texas, November 2020), a report born out of House Bill 2340 (86R, 2019), establishing a small unmanned aircraft study group for a statewide response team.**

Previous work relating to UASs and their use relative to emergency preparedness was conducted to acclimate first responders to this technology. First responder input was obtained to develop the report and assessed pilot selection, funding allocations, and the best approaches to educating law enforcement. Not all law enforcement and first responders will have experience with this technology, so it is important to reach out and educate them at the local level.

2. **Extend the operation and activities of the Urban Air Mobility Advisory Committee to continue addressing the current and future issues associated with these emerging technologies in this quickly evolving industry to maintain Texas' economic competitiveness and create economic development opportunities.**

The UAM/AAM industry is rapidly evolving, and the work of the Urban Air Mobility Advisory Committee should extend beyond the current sunset date of January 1, 2023, to maintain Texas' economic competitiveness. Texas is on the forefront of planning for this industry but ensuring sound economic development will require continued communication and coordination with the industry, government, and other stakeholders represented through this committee. A similar recommendation was made by the Safety and Security Working Group.

3. **Create a statewide primary point of contact to direct urban air mobility/advanced air mobility workforce development efforts, lead public awareness and education efforts, and collaborate with local, regional, state, and federal entities to encourage more input and participation.**

A statewide primary point of contact would smooth the introduction of this industry through increased input and participation from relevant stakeholders. The point of contact would also provide a place to consider the workforce development, public awareness, and education needs for the state to remain economically competitive in this area. The point of contact should be a public agency to ensure that Texas remains neutral in terms of technology and other industry considerations. Considerations by the committee for the point of contact included TxDOT, specifically the TxDOT Aviation Division, whose purview includes both facility development and aviation education. A similar recommendation was made by the Safety and Security Working Group.

4. **Direct the State to provide resources and assistance on the use of urban air mobility/advanced air mobility technology infrastructure for cities, local and regional governments, transportation planning organizations, other entities, and industry to better identify what the different levels of government can do to integrate industry innovation and community vision and help promote urban air mobility/advanced air mobility technology.**

Information asymmetries exist across a number of industries, but UAM/AAM is likely to use areas and environments that do not have the current expertise, capacity, or resources to effectively integrate operations in their region. This recommendation focuses on promoting communication and cooperation across levels of government, industry, and other relevant stakeholders to ensure that information and resources are effectively disseminated across all levels of governments, especially to smaller regional and local entities. Research and planning are ongoing at regional entities, such as council of governments and metropolitan planning agencies, but this is often not communicated across the state to smaller, local, and rural entities. Providing these resources and assistance can ensure that UAM/AAM operations and infrastructure reflect the community's vision for transportation and do not disrupt quality of life.

5. **Direct the appropriate state agencies to jointly collaborate with local school districts, higher education institutions, and any interested private and/or public stakeholders on educational opportunities related to urban air mobility/advanced air mobility technologies.**

A key component of economic competitiveness will be a prepared workforce. Texas should promote efforts on workforce development that begins with current school curriculums. Appropriate state agencies to lead this collaborative effort could be the Texas Education Agency and the Texas Higher Education Coordinating Board. The Texas Innovation Alliance could also play a key role regarding the involvement of cities, transportation agencies, and research institutions. Collaboration with the private sector is also encouraged for industry to share its expertise, provide training, and provide equipment that can advance educational opportunities around UAM/AAM. While certain cities and school districts are working on educational options that would support the knowledge, skills, and abilities required for UAM/AAM, rural school districts and those without adequate resources will need greater assistance. Any educational opportunities or curriculum updates should emphasize equity and ensure programs or educational development opportunities are accessible to all. Efforts in all areas of UAM/AAM should focus on equity and accessibility but especially efforts surrounding education and ultimately workforce development.

CONCLUSION

The recommendations developed by this committee represent the culmination of many meetings and hours of discussion on how best to position our state to facilitate the emerging and quickly evolving advanced air mobility industry. The advisory committee discussed the numerous topics and challenges that such an emerging industry presents while keeping focused on those that the state could more readily pursue. Over the last six months, the full committee met four times including two in-person meetings. These meetings were also public meetings and duly posted as such with public comment noted on the agenda and the committee chair presiding over a public comment period.

The committee chair also established four working groups to cover this vast topic. Each working group met four times in meetings that were also open to the public. Many members of the public provided comments during all 20 of committee's and working group's meetings.

Each working group developed its own set of recommendations that fell within its purview. They were voted on, and those receiving a majority of votes were sent up to the full advisory committee. The full advisory committee then reviewed, amended, and voted on the entirety of the recommendations, approving 20 recommendations in all.

The recommendations range from specific changes to legislation and policy and the ongoing work efforts of some state and local entities to larger, more foundational issues that would better position the state going forward. The committee recognizes that many of the recommendations may add additional workload to some agencies such as the TxDOT Aviation Division. The Aviation Division, which currently has responsibilities surrounding the planning, programming, and funding of airport projects across the state as well as some aviation education responsibilities, is likely to find itself as the focal point for several of these recommendations. The committee understands that many of the additional roles and responsibilities imbedded within its recommendations will be best addressed and carried out with appropriate accompanying resources.

The committee would like to thank the Texas Legislature and TxDOT for the opportunity to participate in this important work and their commitment to advanced air mobility.

The committee was supported by teams at TxDOT and TTI:

- TxDOT team:
  - Darran Anderson.
  - Dan Harmon.
  - Zeke Reyna.
  - Brenna Lyles.

- TTI team:
  - Jeff Borowiec.
  - Brianne Glover.
  - Jacqueline Kuzio.
  - Bill Prieto.

URBAN AIR MOBILITY ADVISORY COMMITTEE BIOGRAPHIES

AHSAN CHOUDHURI, THE UNIVERSITY OF TEXAS AT EL PASO

Dr. Ahsan Choudhuri is the Associate Vice President of the Aerospace Center at The University of Texas at El Paso. The Aerospace Center has expanded beyond its initial research focus when Dr. Choudhuri founded it in 2009 as the Center for Space Exploration Technology Research. In partnership with NASA, the Department of Defense, the Department of Energy and many industry partners, this premier, minority-serving research center explores new technologies and challenges in space, aeronautics, defense and energy using digital tools and skills that are transforming the way we design, build and test systems. Under Dr. Choudhuri's leadership, the Aerospace Center has developed an expansive vision to exponentially expand our nation's talent-force by unleashing new opportunities for students from every background and every zip code through cutting-edge, applied research in aerospace, defense and energy. Fully embracing UTEP's commitment to access and excellence, the Aerospace Center has developed a student-centered model that is an engine of social and economic mobility for the students who are hired as research assistants.

Dr. Ahsan Choudhuri is an internationally renowned expert in aerospace and defense systems and has led the growth of UTEP's aerospace, defense and energy education and research program from its infancy to a program that is nationally recognized. Under his leadership, the Aerospace Center has grown from a 3,000 square foot lab employing 30 students as research assistants to over 35,000 square feet in laboratory space and 8,000 acres of test facilities employing 200 students today. In 2021, The University of Texas System Board of Regents approved a new degree proposal by UTEP to establish a Bachelor of Science in Aerospace and Aeronautical Engineering, and the Aerospace Center is developing the skills and curriculum for digital engineering which will transform the way we design and build the aerospace and defense systems of tomorrow. Dr. Choudhuri has formed strategic collaborations and partnerships with NASA, DOE, DOD, and aerospace and defense industries that have fueled the Aerospace Center's growth and created unparalleled opportunities for students. His new mission focuses on leveraging the research preeminence of the Aerospace Center and our sister center, the W.M. Keck Center for 3D Innovation, to create jobs and business opportunity in aerospace, defense and advanced manufacturing in El Paso. Dr. Choudhuri is a member of the Executive Committee of the Lunar Surface Innovation Consortium (LSIC), which supports NASA's Space Technology Mission Directorate. Dr. Choudhuri chairs the Urban Air Mobility Committee that advises the Texas legislature on a strategic and regulatory framework to take advantage of the economic opportunities of unmanned aerial systems while ensuring maximum safety.

Dr. Choudhuri is a proud alumnus of Khulna University of Engineering and Technology, where he received his B.S. in Mechanical Engineering. He received his M.S. and Ph.D. from the University of Oklahoma School of Aerospace and Mechanical Engineering.

CHAD SPARKS, BELL

Chad Sparks currently serves as the director of strategic campaigns and business development focused on building technology partnerships and customer relationships for Bell's newest innovation products including unmanned vehicles.

Prior to this role, Mr. Sparks was the commercial program director for medium helicopters and responsible for leading the integrated team executing the product strategy, aircraft deliveries, and product support for the Bell 412 medium twin product line. Previously, he was responsible for the development and flight demonstration of advanced capabilities and upgrades for the V 22 program including reliability improvements, aerial refueling, and advanced weapons. He has also led the team responsible for the tactical and strategic procurement of approximately $200 million in annual purchases of complex aircraft systems for Bell's commercial and military platforms. From 1996 to 2009, he served as an engineer at various levels of increasing responsibility in the Bell Military Research and Development organization.

Mr. Sparks holds a B.S. and M.S. in aerospace engineering from Texas A&M University and The University of Texas at Arlington, respectively. He is also certified in Six Sigma design practices.

AMANDA NELSON, BRISTOW GROUP, INC.

Mandy Nelson was appointed to the role of director of strategic relationships, AAM, in January 2022. In this role, she supports Bristow's global AAM efforts through cultivating robust and productive strategic relationships with AAM partners, manufacturers, and other key global AAM stakeholders. Prior to this, Ms. Nelson served as Bristow's director of government affairs, focusing much of her time on policy engagement related to the emerging AAM space. Earlier in her career, she served in the role of global account manager for Era Helicopters, where she focused on market diversification initiatives and growing Era's core vertical flight business. Ms. Nelson served in various commercial and managerial functions supporting Era's Alaska and tour business units. She is also a commercial pilot (Multi-Engine Land [MEL], Single-Engine Land [SEL], and Instrument Airplane).

BEN IVERS, THE BOEING COMPANY

Ben Ivers has been the director of autonomous systems for global safety and regulatory affairs since August 2020. He leads enterprise-wide regulatory affairs and advocacy for AAM, UAS, and autonomous systems. Prior to this role, Mr. Ivers led commercial airplanes product development for systems and autonomy. There, his team was responsible for research and development of new and derivative airplane systems as well as advanced technologies. Other past Boeing assignments include leadership roles in electronic systems, airspace design/air traffic management, certification, and electrical design. Mr. Ivers joined Boeing in 2004. He has a bachelor's of science in electrical engineering from California State Polytechnic University, Pomona and an MBA from the University of Washington.

BILL GOODWIN, JOBY AVIATION

Bill Goodwin works on law and policy at Joby, a company building the most advanced and comfortable electric vertical takeoff and landing aircraft the world has ever seen. He leads policy development in markets and spends most of his time thinking about how people move and live in cities.

Previously, Mr. Goodwin was the head of the government affairs team and the first legal hire at Skyryse. Skyryse operated an air taxi service in Los Angeles, CA, while building the technology foundation for self-flying helicopters. Before that, he was the first lawyer and general counsel at AirMap, a pioneer in the small UAS UTM space, where he headed the legal and policy teams. Prior to in-house life, Mr. Goodwin practiced law in the San Francisco office of Morrison and Foerster, with a split practice of commercial litigation, tech transactions, and regulatory counseling on UAS.

BRENT KLAVON, ANRA TECHNOLOGIES

Brent Klavon is the vice president of global operations at ANRA Technologies, headquartered in Washington, DC. He is a retired U.S. naval pilot and an FAA-certified commercial and remote pilot. Mr. Klavon participates in several regulatory, technical, and standards organizations helping to shape the direction for industry and government actions for uncrewed aircraft systems. He represents industry as a thought leader, being well versed in the nexus between policy, regulations, standards, technology, and social acceptance. He currently participates in autonomous aircraft programs with NASA, FAA, and the U.S. Department of Defense, and with groups in the United Kingdom, Australia, Japan, Australia, and Switzerland, collaborating with private industry and government stakeholders to forge autonomous system integration. He is an FAA-certified commercial pilot and remote pilot.

BRENT SKORUP, MERCATUS CENTER AT GEORGE MASON UNIVERSITY

Brent Skorup is an attorney and senior research fellow at George Mason University's Mercatus Center, specializing in transportation policy and telecommunications law. He has developed expertise in the areas of federal transportation and UAM policy, drone law, and wireless technology and is often invited to brief policy makers, including White House policy staff and an FAA Drone Advisory Committee (DAC) working group, about drone and UAM technology and policy. Mr. Skorup's drone traffic management recommendations were featured in DAC's Working Group 3 final report and in GAO reports to Congress. His drone and UAM research has been published in law journals and in popular media and trade publications, including the *Wall Street Journal, USA Today, GovTech,* and *Air Traffic Management* magazine.

Mr. Skorup has been appointed to serve on several federal and state advisory positions in recent years, including on TxDOT's Connected and Autonomous Vehicle Task Force, on FCC's broadband deployment advisory committee, and as a drone law adviser to the Virginia Department of Aviation.

CAMERON WALKER, PERMIAN BASIN METROPOLITAN PLANNING ORGANIZATION

Cameron Walker has practiced municipal and regional planning for over 37 years. He has worked in Victoria, TX, and Midland, TX for 30 years. He is currently serving as the executive director of the Permian Basin Metropolitan Planning Organization (since 2013).

Mr. Walker is an effective leader with proven successful endeavors with the City of Midland and the Permian Basin Metropolitan Planning Organization as well as in non-work-related settings. He serves as a member of the Midland Chamber of Commerce. He also serves on the Permian Road Safety Coalition, an agency with direct connections to the oil and gas industry and the trucking industry. The coalition exists to educate and ultimately to improve road safety in the Permian Basin. He also served on the Ports-to-Plains Advisory Committee

(I-27), the Border Trade Advisory Committee, the I-20 Corridor Committee, and a regional Freight Advisory Committee.

Mr. Walker is a professional urban and regional planner. He holds a bachelor's and master's degree from Texas A&M University. He is a member of the American Institute of Certified Planners.

CHRIS ASH, HILLWOOD

Chris Ash has been an integral part of the development and success of the Fort Worth Alliance Airport and Alliance Aviation Services fixed-base operator during the past 25 years, touching every aspect of the airport operating companies. Mr. Ash currently serves as senior vice president of aviation business development for Alliance Air Services and Alliance Aviation Services, a subsidiary of Hillwood, at the Fort Worth Alliance Airport.

Prior to joining Alliance Aviation Services, Mr. Ash was employed for three years at United Parcel Service in the aircraft division as an aircraft load master. A Texas native and graduate of Embry-Riddle Aeronautical University, he currently serves on the North Central Texas Council of Governments as a member of the North Texas Safety and Integration Task Force.

DAVID FIELDS, AICP, CITY OF HOUSTON

David Fields, AICP, is the City of Houston's first chief transportation planner. He believes a great community provides safe transportation choice for all. He is experienced planning and implementing multiple modes (walking, biking, heavy rail, light rail, on-street bus services, and transportation network companies), parking and curb management, and policy (transit-oriented development and transportation demand management)—all based on meaningful community participation. Current city initiatives include Vision Zero so that travel by all modes is safe across city streets, implementation of over 1,500 miles of high-comfort bike lanes, and conversion of the North Houston Highway Improvement Project into a project that supports the city's values and supports the local communities.

FRED UNDERWOOD, TRINITY COMPANY

Fred Underwood is president of the Trinity Company, a cotton bale storage facility in Lubbock, TX. He is past president of the Cotton Warehouse Association. He has also serviced as vice president and director of the National Cotton Council. As an aviation enthusiast, Mr. Underwood began flying in 1990. He is a commercial-rated pilot, commercial helicopter pilot, and commercial gyrocopter pilot and holds a fixed-wing instrument rating. He previously served as chairman of the Lubbock International Airport Board and as a board member of the Lubbock Chamber of Commerce, Mr. Underwood is a past member of the Texas Transportation Commission. He was first appointed to the Aviation Advisory Commission on February 23, 2017, and was reappointed on September 30, 2021. He lives in Lubbock, TX.

GUS KHANKARLI, PHD, PE, PMP, CLTD, CITY OF DALLAS

Dr. Ghassan "Gus" Khankarli currently serves as the director of the City of Dallas Department of Transportation. In his current position, he leads the department's multimodal strategic vision including the integration of transportation assets with emerging technology needs. Dr. Khankarli has over 30 years of professional experience including 24 years in various capacity with TxDOT. He is a member of Transportation Research Board Standing Committees on Aviation Administration and Policy (AV 010) and Intermodal Freight Transport (AT 045), and serves on several North Central Texas Council of Governments committees. Dr. Khankarli holds a doctoral degree in public affairs from The University of Texas at Dallas, an MBA from the University of Dallas, a master of engineering and a bachelor of science in civil engineering from The University of Texas at Arlington. He is a licensed engineer and certified project management professional, and is certified in logistics, transportation, and distribution.

JASON JONMICHAEL, CITY OF AUSTIN

Jason JonMichael serves as an assistant director in Austin transportation where he oversees smart mobility, public-private partnerships, placemaking, mobility services, parking enterprise, and travel demand management. He leads a cross-functional team of community, mobility, technology, policy, data, and user experience specialists to deliver outcomes that improve mobility, safety, and access to Austin residents.

A national leader and subject matter expert in smart cities, Mr. JonMichael is also an executive board member and past chairman of OmniAir®, the global certification organization for vehicle communications; executive board member of the Global Autonomous Vehicle Partnership, advancing emerging and next-gen vehicle technologies; and president of the Austin Smart Cities Alliance, a local non-profit member-based organization of public, private, academic, and individual contributors.

JASON L. DAY, TEXAS DEPARTMENT OF PUBLIC SAFETY

Jason Day serves as the UAS Program Manager for the Texas Department of Public Safety. Mr. Day is a Navy Veteran with 24 years in military, civilian and public safety aviation and is regarded as a subject matter expert in the UAS community with an emphasis on public safety UAS operations and administration. Mr. Day developed, implemented and is lead instructor for the departments UAS Remote Pilot in Command training program. This training program was profiled in Airbeat Magazine and is used as a template for many federal, state and local public safety agencies. Mr. Day has assisted more than 35 public safety agencies to develop their UAS program.

Mr. Day is very active in the UAS community and has a strong working relationship with the Federal Aviation Administration. As a member of the Texas HB2340 Committee, Mr. Day has assisted in the development of policy, procedures and training standards for the use of UAS by public safety agencies in Texas during a disaster. Mr. Day is an UAS instructor for the Airborne Public Safety Association, works closely with the National Institute of Standards and Technology and is a member of the ASTM International Standards Committee on Homeland Security Applications; Response Robots (E54.09).

JEFF BILYEU, AAE, TEXAS GULF COAST REGIONAL AIRPORT (BRAZORIA COUNTY)

Jeff Bilyeu currently serves as the director of the Texas Gulf Coast Regional Airport in Brazoria County. He oversees a staff of 13 along with the day-to-day operations, maintenance, and fixed-base operator functions of an FAR 139 certificated reliever airport for the Houston metropolitan area and Gulf Coast.

Mr. Bilyeu is a licensed flight instructor and commercial pilot with instrument and multi-engine ratings. He is an accredited airport executive and a past president of the South Central Chapter of the American Association of Airport Executives. He has served on the Board of Directors of the American Association of Airport Executives and remains active in both regional and national affairs including currently serving on the Policy Review Committee. Locally, he is involved and serves on airport and transportation committees with the various chambers and is a current chairman of the board for the Angleton Chamber of Commerce.

JEFF DECOUX, AUTONOMY INSTITUTE

Jeff DeCoux is the founder and chairman of the Autonomy Institute. The Autonomy Institute is a 501(c)(3) consortium of over 100 industry, government, and academia organizations. The core focus is accelerating the path to commerce for intelligent and autonomous infrastructure and autonomous systems. The Autonomy Institute is leading the deployment of the intelligent infrastructure that is the foundation for Industry 4.0 solutions. Industry 4.0 includes connected autonomous vehicles, UAS, and AAM. Past positions include founder/CEO of Hangar Technologies, Inc., eCustomers, Inc., SMART Technologies, Inc., and SMARTNAP. Mr. DeCoux has raised over $100 million for venture and business operations in Texas. He has over 30 years' experience within the high-tech industries where his attention has been focused on founding companies that enhance business productivity through automation.

Mr. DeCoux is the founder and chief executive officer of ATRIUS Industries, Inc. With the unprecedented advancement in autonomous robotics, ATRIUS was founded to leverage these new innovations to effect massive change across industry. ATRIUS is working with an ecosystem of partners to develop the highways and byways in order to support more efficient mobility, automated city services, autonomous cars and trucks, autonomous shuttles, air taxis, inspection drones, and many intelligent city applications. ATRIUS works with leading partners that focus on smart cities, autonomous systems, advanced wireless networks, radars, UTM, position-navigation-timing, and intelligent infrastructure supporting autonomy.

JIM PERSCHBACH, PORT SAN ANTONIO

Jim Perschbach joined Port San Antonio in 2014, leading a team that provides strategic support to grow advanced industries on the 1,900-acre technology innovation campus, including aerospace, cybersecurity, defense, manufacturing, and global trade. The port is one of South Texas' fastest-growing economic engines—home to over 80 tenant customers and their more than 16,000 employees, which generate a regional economic impact of over $5.6 billion annually. Previously, he worked as an attorney in private practice with one of the nation's largest law firms, where he counseled clients in sectors that include aerospace and advanced manufacturing.

In addition to his work at the port, Mr. Perschbach serves his community in other leadership roles. He is a past chair of both the San Antonio Chamber of Commerce's Aerospace

Committee and Alamo Colleges' Scobee Education Center/Challenger Learning Center. Currently, he serves on the boards of the United Way of San Antonio and Bexar County and Our Lady of the Lake University.

In 2018, Mr. Perschbach was appointed honorary commander of the 502nd Airbase Wing/Joint Base San Antonio. He has also been named by the *Business Journals* as one of the country's top 100 executives to watch in 2019. He holds an undergraduate degree in business administration from the George Washington University and earned his law degree from the University of Houston Law Center.

JOHN ACKERMAN, TEXAS COMMERCIAL AIRPORT ASSOCIATION AND DALLAS FORT WORTH INTERNATIONAL AIRPORT

John Ackerman serves as executive vice president of global strategy and development at the Dallas Fort Worth International Airport (DFW). He leads DFW's airline relations, cargo, aviation strategy and enterprise analytics, government relations, and quantitative pricing functions. Mr. Ackerman joined the DFW staff in January 2015. He directs DFW's efforts to raise the airport's global profile through international air service and business development. He helped develop the airport's strategic plan, which is focused on being the premier gateway between Asia and Latin America for both passengers and cargo.

Prior to DFW, he worked as Denver International Airport's chief commercial officer, was a pilot and executive at United Airlines, and was a senior director of product management at Standard and Poor's. Mr. Ackerman served as an active-duty officer and pilot in the U.S. Marine Corps and holds a Bachelor of Arts in economics from Duke University. He is active in the community and is a board member of the Society for the Prevention of Cruelty to Animals of Texas, Uptown Dallas, Inc., Visit Dallas, North Texas Commission, and Dallas Sports Commission, and serves on the Guest Experience Committee of the Dallas Zoo.

JOSH CRAWFORD, PE, GARVER

Josh Crawford is a vice president and the director of Texas aviation for Garver, leading a team of aviation professionals throughout the state. With nine years in the construction industry and 17 years of airport design and project management, his experience includes a multitude of improvements in the aviation industry for landside, airside, and terminal developments. As a licensed pilot, Mr. Crawford understands and incorporates a pilot's perspective into engineering designs, construction plans, and aviation planning documents. Other responsibilities include serving as Garver's aviation military resource, where he offers his expertise in designs for U.S. Army Corps of Engineers, Naval Facilities Engineering Command, and Air Force Civil Engineer Center projects. His approach to management and coordination with state aviation departments, FAA, and military agencies, as well as his assistance to clients for capital improvement planning, has proven to be a valuable resource for airport sponsors, assisting them in continuing growth and implementing improvements at their airports.

KEN PETERMAN, PARAGON VTOL

Ken Peterman is the founder and CEO of SpyGlass Group, an innovative thought-leading organization that has helped shape aerospace and defense strategic trajectories in the tactical communications, mobile networking, cybersecurity, and satellite sectors since 2012. As a passionate, creative and forward-leaning leader in the global aerospace and defense market, he serves on a variety of boards and advisory groups.

A distinguished leader in aerospace and defense, Mr. Peterman has enjoyed successful executive leadership tenures at Viasat, ITT/Exelis, Rockwell Collins, and Raytheon. Broadly respected as a thought leader and innovator among U.S. and international senior leaders, he currently serves on a variety of boards and advisory groups. He received a Bachelor of Science in electrical engineering (high honors) from Tri-State University (now Trine) and completed executive programs at the Stanford University Graduate School of Business and Pennsylvania State University.

KEVIN RISTER, EXXONMOBIL

Kevin Rister is an aviation advisor with over 30 years of experience in the aviation industry. He currently holds a commercial airplane, helicopter, and UAV pilot's license.

In his position, he provides aviation consultation and oversight of operations to ensure compliance with the ExxonMobil *Aviation Operations Guide* and applicable local, state, and federal regulations. His area of responsibility includes all aviation operations in support of ExxonMobil in Texas.

Mr. Rister's specific areas of expertise include UAV programs, serving as the global ExxonMobil UAV subject matter expert, and helideck and heliport design and inspection.

KEVIN RUSSELL, CITY OF BRYAN

Kevin Russell has 30 years of municipal government experience. His current titles are director of development services, director of economic development, and airport director. His 30-year career in municipal government has been with the City of Bryan. In his current role, he has been involved in the recruitment of new industries, has helped current businesses expand, has promoted the orderly development of the city, and has recently administered over $12,000,000 of investment in the City of Bryan's general aviation airport, Coulter Airfield. Mr. Russell attends the TxDOT Aviation Conference annually and works to continue to improve the city's airport infrastructure to allow this asset to have a greater impact as a gateway into the city.

Mr. Russell attended Sam Houston State University where he earned a B.S. in agriculture economics. He is currently or has been a member of the International Economic Development Council, International Council of Shopping Centers, American Planning Association, Harvey Little League Board of Directors, Salvation Army Advisory Board, Junior League Community Advisor, and Texas Economic Development Association.

KIMBERLY WILLIAMS, METROPOLITAN TRANSIT AUTHORITY OF HARRIS COUNTY

Kimberly J. Williams heads up the Office of Innovation for the Metropolitan Transit Authority of Harris County in Houston, TX. Ms. Williams led implementation of Houston's first AV shuttle service and deployed public-private partnerships to begin Wi-Fi on transit and microtransit service. She chairs Team Houston of the Texas Innovation Alliance, a collaboration of the region and state's mobility stakeholders. She is also a member of the

City of Houston's Rapid Mobility Working Group, Smart City Advisory Council, and Resiliency Council. Active in the Houston innovation community, she is a member of the Density and Inclusion Working Group of Houston Exponential, Houston's innovation non-profit, and the Greater Houston Partnership's Innovation Corridor Committee.

Ms. Williams is active in the industry as a member of the American Public Transit Association's (APTA's) Board of Directors and co-chair of the Procurement and Supply Chain Committee, its Strategic Planning Steering Committee, Automated and Connected Vehicles Committee, and the Innovation Officer Peer Exchange Group. She is also a graduate of Leadership APTA, ENO's Senior Transit Executive Program, and Transportation for America's Smart City Program. Ms. Williams is a graduate of Howard University and Wayne State Law School, where she served as survey editor of the *Wayne Law Review*. She is a proud volleyball mom to daughter, MacKenzie.

MARUTHI R. AKELLA, THE UNIVERSITY OF TEXAS AT AUSTIN

Maruthi Akella is the founding director for the Center for Autonomous Air Mobility and the faculty lead for the control, autonomy, and robotics area within the Department of Aerospace Engineering and Engineering Mechanics at the University of Texas at Austin. His research program encompasses coordinated control aerospace systems, adaptation and physics-based learning, guidance for hypersonic vehicles, and computationally lightweight vision-based sensing solutions. For his high-impact research contributions, he was recognized by the American Institute of Aeronautics and Astronautics (AIAA) Mechanics and Control of Flight Award, the American Astronautical Society (AAS) Dirk Brouwer Award, the Institute of Electrical and Electronics Engineers (IEEE) Control Systems Society (CSS) Award for Technical Excellence in Aerospace Control, and the IEEE Judith A. Resnik Space Award. He is currently editor in chief of the *Journal of the Astronautical Sciences* and serves on the AAS Board of Directors. He is a fellow of IEEE, AIAA, and AAS, and was elected to the rank of academician with the International Academy of Astronautics.

MICHAEL HILL, VOLATUS AEROSPACE

Michael Hill is an FAA Part 107 pilot, accumulating over 2900 hours of flight time, within 4200 incident-free missions. As the director of unmanned operations for the Texas Wing of the Civil Air Patrol, he has become a certified search and rescue drone pilot, having flown over 300 search-and-rescue exercise missions throughout the United States. Serving as an uncrewed aviation consultant to organizations on integrating AAM vehicles into their respective industries, he has helped develop a training curriculum for workforce development within several organizations and school districts around the country. He regularly speaks at community and industry events on the advancements of AAM.

Mr. Hill volunteer work includes serving as the chairperson for the North Central Texas UAS Taskforce Legislative and Policy Committee, as well as a sitting member of both the Texas HB 2340 Public Safety UAS committee and the Texas SB763 AAM Committee. In these roles, he works to engage politicians, government officials, and large businesses, helps to develop UAS and AAM policies and procedures, and helps change these regulations in Texas. He is part of the leadership team for the North Texas Public Safety Unmanned Response Team. He volunteered as the team's training officer to help in establishing an organizational presence, which included offering his experience to help fire departments, law enforcement, and emergency management teams on any number of tasks from event surveillance to flight trainings.

MICHAEL SANDERS, LONE STAR UAS CENTER OF EXCELLENCE AND INNOVATION

Since 2018, Mike Sanders has served as the executive director of Texas A&M University–Corpus Christi's LSUASC. LSUASC is a Texas A&M University System Board of Regents–designated Center of Excellence and is one of seven FAA UAS test sites. Mr. Sanders leads LSUASC's effort to advance the integration of UAS and autonomous aviation technologies across educational, public, and commercial agency interests while informing governing agencies on UAS and autonomous aviation operations in the national airspace system. Prior to joining the staff at Texas A&M University-Corpus Christi, Mr. Sanders served as an infantry and simulation operations officer in the U.S. Army for 30 years in a variety of command and leadership positions. He holds a bachelor's degree in history and Master of Science degrees in administration, industrial engineering (interactive simulation and training systems), and strategic studies.

NATHAN TRAIL, SUPERNAL, HYUNDAI MOTOR GROUP

Nathan Trail is the director of international state and local policy at Supernal, which is the advanced air mobility subsidiary of Hyundai Motor Group. He is responsible for working with international, state, and local legislators, regulators, community stakeholders to develop policies and regulations that will foster the AAM industry and drive public acceptance. He serves as an industry resource and expert for the AAM industry to governments and lawmakers throughout the United States and internationally.

Mr. Trail previously served as the director of technology policy and state legislative affairs at the Consumer Technology Association (CTA), North America's largest technology trade association. During his time at CTA, he grew the association's state and local government affairs presence and managed a portfolio of policy issues including UAS, sharing economy, micromobility, blockchain, and fintech.

Mr. Trail has testified on behalf of the technology industry in over 30 state legislatures and municipalities and frequently speaks at industry panels and events. He has also authored op-eds for legislative publications for some of the leading state and local policy organizations in the country. He holds a B.A. in government and politics from the University of Maryland in College Park, MD.

NICK DEVEREUX, WING

Nick Devereux joined Wing in 2019 as manager of policy and government affairs, where he focuses on U.S. policy on the federal, state, and local levels. He leads Wing's work on congressional relations and advocacy, and coordinates Wing policy and government relations work across numerous states. Upon initially joining Wing, he led state, local, and community engagement efforts leading up to Wing's launch of service in Christiansburg, VA—the first on-demand residential drone package delivery service in the United States.

Prior to Wing, Mr. Devereux spent 10 years on Capitol Hill, serving as legislative counsel and senior policy advisor to U.S. Sen. Mark R. Warner. In that capacity, he covered a broad portfolio of issues including judiciary, labor, transportation/infrastructure, and NASA policy, and developed major legislative initiatives ranging from infrastructure financing to accelerating drone/UAS integration to reestablishing American leadership in aeronautics research. He received a B.A. from Johns Hopkins University in Baltimore, MD, and a J.D. from Washington and Lee University School of Law in Lexington, VA.

NIRAV VED, CAPITAL AREA METROPOLITAN PLANNING ORGANIZATION

Nirav Ved is the Capital Area Metropolitan Planning Organization's program manager for data and operations. In this capacity, Mr. Ved's responsibilities include systems and transportation network operations. He is also responsible for the Capital Area Metropolitan Planning Organization's safety initiatives and Congestion Management Program. Mr. Ved is being nominated as the regional representative for the Central Texas area.

APPENDIX A: LEGISLATION CREATING THE ADVISORY COMMITTEE

S.B. No. 763

AN ACT

relating to the creation of the urban air mobility advisory committee.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF TEXAS:

SECTION 1. Subchapter A, Chapter 21, Transportation Code, is amended by adding Section 21.004 to read as follows:

Sec. 21.004. URBAN AIR MOBILITY ADVISORY COMMITTEE. (a) The commission shall appoint an advisory committee to assess current state law and any potential changes to state law that are needed to facilitate the development of urban air mobility operations and infrastructure in this state.

(b) The commission shall appoint to the advisory committee members to represent:

(1) diverse geographic regions of the state;

(2) state and local law enforcement;

(3) the urban air mobility industry;

(4) transportation experts;

(5) commercial airport representatives;

(6) vertical takeoff and landing operators;

(7) local governments; and

(8) the general public.

(c) The advisory committee shall:

(1) hold public hearings in locations across the state or via electronic means; and

(2) receive comments through an Internet website, by mail, and by other methods, if appropriate.

(d) Not later than September 1, 2022, the advisory committee shall report to the commission and to the members of the legislature the committee's findings and recommendations on any changes to state law that are needed to facilitate the development of urban air mobility operations and infrastructure.

(e) The advisory committee is abolished and this section expires January 1, 2023.

SECTION 2. This Act takes effect immediately if it receives a vote of two-thirds of all the members elected to each house, as provided by Section 39, Article III, Texas Constitution. If this Act does not receive the vote necessary for immediate effect, this Act takes effect September 1, 2021.

President of the Senate   Speaker of the House

I hereby certify that S.B. No. 763 passed the Senate on April 20, 2021, by the following vote: Yeas 30, Nays 1; and that the Senate concurred in House amendment on May 27, 2021, by the following vote: Yeas 29, Nays 2.

Secretary of the Senate

I hereby certify that S.B. No. 763 passed the House, with amendment, on May 11, 2021, by the following vote: Yeas 110, Nays 33, two present not voting.

Chief Clerk of the House

Approved:

Date

Governor

APPENDIX B: UAS STATE LEGISLATION

For the last several years, legislation concerning unmanned aircraft systems (UASs), or drones, has been introduced in different states. Even more recently, decisions on advanced air mobility bills have been approved that could encourage other states to enact similar laws. The following set of tables describe states that enacted and updated UAS legislation. For more information, please see the National Conference of State Legislatures' Current Unmanned Aircraft State Law Landscape (*19*).

In 2013, 12 states enacted laws or created resolutions to define and restrict certain activities related to unmanned aerial vehicles.

Table 2. Legislation by Other States: 2013.

Year	State	Bill	Title
2013	Idaho	SB 1134	An Act relating to Aeronautics; to Define a Term, to Establish Provisions Relating to Restrictions on the Use of Unmanned Aircraft Systems, to Provide Exceptions, to Provide for a Civil Cause of Action, to Provide for Certain Damages and to Provide that an Owner of Certain Facilities Shall Not Be Prohibited from Using and Unmanned Aircraft System to Inspect Such Facilities
2013	Illinois	HB 1652	An Act Concerning Wildlife
2013	Illinois	SB 1587	An Act Concerning Criminal Law
2013	Indiana	SR 27	Study committee on unmanned aerial vehicles.
2013	Maryland	HB 100	An Act concerning Budget Bill
2013	Montana	SB 196	An Act limiting the use of Unmanned Aerial Vehicles by law enforcement; and prohibiting the use of unlawfully obtained information as evidence in court
2013	Nevada	AB 507	An Act relating to state financial administration
2013	North Carolina	SB 402	An act to make base budget appropriations for current operations of state departments, institutions, and agencies, and for other purposes
2013	North Dakota	SB 2018	An Act to provide an appropriation for defraying the expenses of the department of commerce
2013	Oregon	HB 2710	An Act relating to drones; and declaring an emergency
2013	Pennsylvania	HR 172	A resolution beseeching the United States Department of Defense to reconsider the order of precedence for the newly created Distinguished Warfare Medal
2013	Tennessee	SB 796	An Act to amend Tennessee Code Annotated, Title 29 and Title 39, relative to surveillance
2013	Virginia	HB 2012 SB 1331	Drones; moratorium on use of unmanned aircraft systems by state or local government department, etc.

Ten states created legislation in 2014 to further define law enforcement uses or other prohibitions against unmanned aircraft operations. The states also began creating criminal offenses for certain conduct.

Table 3. Legislation by Other States: 2014.

Year	State	Bill	Title
2014	Alaska	HB 255	An Act relating to unmanned aircraft systems; and relating to images captured by an unmanned aircraft system
2014	Alaska	HCR 15	Relating to the task force on Unmanned Aircraft Systems
2014	Illinois	SB 2937	An Act concerning criminal law
2014	Indiana	HB 1009	Surveillance and privacy
2014	Iowa	HF 2289	An Act relating to the regulation and use of Unmanned Ariel Vehicles
2014	Louisiana	HB 1029	An Act to enact R.S. 14:336 and 337, relative to offenses against the public; to create the crimes of unlawful aiming of a laser at an aircraft and unlawful use of an unmanned aircraft system
2014	North Carolina	SB 744	An Act to make base budget appropriations for current operations of state departments, institutions, and agencies, and for other purposes.
2014	Ohio	HB 292	An Act to enact section 122.98 of the Revised Code to create the Ohio Aerospace and Aviation Technology Committee.
2014	Tennessee	SB 1777	An Act to amend Tennessee Code Annotated, Title 70, Chapter 4, Part 3, relative to hunter protection
2014	Tennessee	SB 1892	An Act to amend Tennessee Code Annotated, Title 29, and Title 39, relative to the protection of privacy
2014	Utah	SB 167	Establishes provisions for the appropriate use of an unmanned aerial vehicle
2014	Wisconsin	SB 196	An Act to amend 114.04; and to create 175.55, 941.10 and 972.113 of the statutes; Relating to: restricting the use of drones and providing a penalty

2015 saw the expansion of state authority to institute prohibitions and use parameters for unmanned aircraft.

Table 4. Legislation by Other States: 2015.

Year	State	Bill	Title
2015	Nevada	AB 239	Regulates operators of unmanned aerial vehicles in this State
2015	New Hampshire	SB 222	An Act relative to harassment of hunting, fishing, or trapping
2015	North Carolina	SB 446	Clarify that agents or agencies of the State or political subdivision of the State shall have authority to procure and operate unmanned aircraft systems upon approval of the State Chief Information Officer and to modify the regulation of Unmanned Aircraft Systems to conform to FAA Guidelines
2015	North Dakota	HB 1328	An Act to provide for limitations on the use of unmanned aerial vehicle for surveillance
2015	Oregon	HB 2354	An Act relating to unmanned aerial systems
2015	Oregon	HB 2534	Relating to the regulation of drones by the State Fish and Wildlife Commission

2015	Tennessee	HB 153	An Act to amend Tennessee Code Annotated, Title 39, relative to criminal offenses
2015	Utah	HB 296	Government use of Unmanned Aerial Vehicles.
2015	Virginia	HB 2125 SB 1301	An Act to amend the Code of Virginia by adding in Chapter 5 of *Title 19.2* a section numbered 19.2-60.1, relating to use of unmanned aircraft systems by public bodies; search warrant required. Unmanned aircraft systems; use by public bodies during execution of a search warrant, exception.
2015	West Virginia	HB 2515	Relating to elk restoration

In 2016, there was an uptick in states enacting unmanned aircraft legislation. Twenty states passed 32 bills or resolutions. As time progresses, the legislation becomes more specific with bills specifying law enforcement activities, flights over correctional facilities, emergency management related to wildfires, and other more granular issues.

Table 5. Legislation by Other States: 2016.

Year	State	Bill	Title
2016	Alaska	AB 1680	An act making appropriations for the operating and loan program expenses of state government and for certain programs
2016	Arizona	SB 807	Unlawful operation of model or unmanned aircraft; state preemption; classification; definitions
2016	California	HB 195	An act to amend Section 402 of the Penal Code, relating to crimes
2016	California	Executive Order	An act to add Section 43.101 to the Civil Code, and to add Chapter 4.5 (commencing with Section 853) to Part 2 of Division 3.6 of Title 1 of the Government Code, relating to unmanned aircraft systems
2016	Delaware	SB 1213	An act to amend Title 11 of the Delaware code relating to Unmanned Aircraft Systems
2016	Georgia	HB 5808	That a Commission on Unmanned Aircraft Technology appointed by the Governor is hereby created to make state-level recommendations to the Governor consistent with current FAA regulations as well as the State's business and public safety interests
2016	Idaho	HB 1013	An Act relating to fish and game; amending section 36-1101, Idaho Code, to prohibit the use of Unmanned Aircraft Systems for hunting, molesting or locating game animals, game birds and furbearing animals
2016	Illinois	HB 1246	The Unmanned Aerial System Oversight Task Force Act is amended by changing Sections 15 and 20
2016	Indiana	SB 319	An Act to amend the Indiana Code concerning criminal law and procedure
2016	Indiana	SB 249	An Act to amend the Indiana Code Concerning criminal law and procedure

Year	State	Bill	Title
2016	Kansas	HB 335	An Act concerning civil procedure; enacting the public speech protection act; relating to habeas corpus; the protection from stalking act; venue under the small claims procedure act
2016	Kansas	SB 73	An Act making and concerning appropriations for fiscal years ending June 30, 2016, June 30, 2017, and June 30, 2018, for state agencies
2016	Louisiana	HB 635	An Act to amend and reenact R.S. 3:43(A)(2) and to enact R.S. 3:48, relative to fees for unmanned aerial systems; to establish a registration fee for unmanned aerial systems; to establish an agricultural education and safety training course fee for operators of unmanned aerial systems; and to provide for related matters
2016	Louisiana	HB 19	An Act to enact R.S. 14:108(B)(1)(e), relative to the crime of resisting an officer; to add the knowing interference with a police cordon to the definition of "obstruction of" an officer; to provide additional definitions; and to provide for related matters
2016	Louisiana	SB 141	An Act to amend and reenact R.S. 14:283(A)(1), 283.1(A), and 284(B) and to enact R.S. 14:283(G), 283.1(C), and 284(D), relative to crimes affecting public morals; to amend crimes involving the observation and invasion of privacy of another to include the use of unmanned aircraft systems; to define unmanned aircraft systems; and to provide for related matters
2016	Louisiana	SB 992	An Act to amend and reenact R.S. 14:337(A), (D), and (E) and to enact R.S. 14:337(B)(3)(d) and (4)(e), relative to unlawful use of an unmanned aircraft system
2016	Louisiana	Executive Order	An Act to amend and reenact R.S. 14:63(B) and (C) and 337(D), relative to crimes involving unmanned aircraft systems
2016	Michigan	HB 2599	An Act to provide for the operation and regulation of unmanned aircraft systems in this state
2016	North Dakota	HB 4066	Amends UAS Test Site Authority
2016	Oklahoma	SB 5702	An Act relating to unmanned aircraft; defining terms; prohibiting operation of an unmanned aircraft over a critical infrastructure facility; excepting conduct of specified entities or persons; prescribing punishment for violation; providing for codification; and providing an effective date.
2016	Oregon	HB 7511 SB 3099	An Act relating to unmanned aircraft systems; creating new provisions
2016	Oregon	HB 2376	Relating to state financial administration; and declaring an emergency.
2016	Rhode Island	SB 2106	Unpiloted Aerial Vehicle Regulation. Relating to aeronautics – unpiloted aerial vehicle regulation
2016	Tennessee	HB 126	An Act to amend Tennessee Code Annotated, Title 39, Chapter 13, relative to unmanned aircraft
2016	Tennessee	HB 3003	An Act to amend Tennessee Code Annotated, Title 39 and Title 40, relative to criminal offenses

Year	State	Bill	Title
2016	Utah	SB 155	Unmanned Aircraft Revisions
2016	Utah	HB 29, HB 30	Unmanned Aircraft Amendments
2016	Vermont	HB 412	An Act relating to privacy protection and a code of administrative rules
2016	Virginia	SB 670	Budget Bill
2016	Virginia	SB 338	An Act to amend the Code of Virginia by adding in Article 1 of chapter 9 of Title 15.2 a section numbered 15.2-926.3, relating to local regulation of certain aircraft
2016	Wisconsin	AB 1680	An Act to amend 114.04; and to create 114.045 of the statutes; relating to: the operation of drones over correctional institutions and providing a penalty
2016	Wisconsin	SB 807	An Act relating to: interfering with hunting, fishing, and trapping and providing criminal penalties

The trend continues into 2017 with 19 states enacting 24 bills or resolutions.

Table 6. Legislation by Other States: 2017.

Year	State	Bill	Title
2017	Alaska	SCR 4	Relating to the Task Force on Unmanned Aircraft Systems
2017	Colorado	HB 1070	Concerning the use of unmanned aircraft systems to perform government functions relating to certain public-safety functions, and, in connection therewith, requiring the center of excellence within the department of public safety to perform a study and operate a pilot program
2017	Connecticut	SB 975	An Act concerning municipalities and unmanned aircraft
2017	Florida	HB 1027	Unmanned Devices
2017	Georgia	HB 481	An Act to amend Chapter 1 of Title 6 of the Official Code of Georgia Annotated, relating to general provisions regarding aviation, so as to provide for preemption for unmanned aircraft systems
2017	Indiana	SB 299	An Act to amend the Indiana Code concerning criminal laws and procedure
2017	Kentucky	HB 540	An Act relating to aviation safety
2017	Louisiana	SB 69	An Act to enact R.S. 2:2, relative to unmanned aircraft
2017	Minnesota	SF 550	An Act relating to natural resources
2017	Montana	HB 644	An Act revising laws relating to wildfires and unmanned aerial vehicle systems
2017	Nevada	AB 11	An Act relating to unmanned aerial vehicles
2017	New Jersey	SB 3370	An Act concerning the operation of unmanned aircraft systems and amending and supplementing various parts of the statutory law
2017	North Carolina	HB 337	An Act to make various revisions to the laws governing the use of Unmanned Aircraft Systems

Year	State	Bill	Title
2017	North Carolina	HB 128	An Act to prohibit the use of an Unmanned Aircraft System near a local confinement facility or state or federal correctional facility
2017	North Dakota	SCR 4014	A concurrent resolution supporting the development of the unmanned aircraft systems industry in North Dakota and throughout the United States, congratulating the Federal Aviation Administration on the first Beyond Visual Line of Sight Certificate of Authorization in the United States, and encouraging further cooperation with the Federal Aviation Administration to safely integrate unmanned aircraft systems into the national airspace
2017	Oregon	HB 3047	An Act elating to unmanned aircraft systems; and declaring an emergency
2017	South Dakota	SB 80	Regulate the use of drones under certain conditions and to provide a penalty therefor
2017	South Dakota	SB 22	An Act to exempt certain unmanned aircraft systems from the requirement to be registered as aircraft
2017	Utah	HCR 21	Concurrent resolution encouraging NASA to consider Tooele County for a test facility
2017	Utah	SB 111	Unmanned Aircraft Amendments
2017	Utah	HB 217	Livestock Harassment
2017	Virginia	SB 873	An Act to amend and reenact § 27-15.1 of the Code of Virginia, relating to the authority of a fire chief over unmanned aircraft at a fire, explosion, or other hazardous situation
2017	Virginia	HB 2350	An Act to amend the Code of Virginia by adding a section numbered 18.2-130.1, relating to use of electronic device to trespass; peeping into dwelling or occupied building; penalty
2017	Wyoming	SF 170	An Act relating to aeronautics; authorizing the Wyoming aeronautics commission to promulgate rules related to unmanned aircraft

Both Michigan and Virginia passed several laws in 2018 related to unmanned aircraft operations. Additionally, several states new to UAS legislation enacted bills either defining terms or creating limitations.

Table 7. Legislation by Other States: 2018.

Year	State	Bill	Title
2018	Arizona	2018 Ariz. Laws, Ch. 116	Amending section 26-314, Arizona Revised Statutes; Relating to Emergency Management
2018	California	2018 Cal. Stats., Ch. 333	Unmanned aircraft systems: correctional facilities
2018	Colorado	2018 Colo., Sess. Laws, Ch. 385	Concerning prohibiting the use of unmanned aircraft systems to obstruct public safety operations.
2018	Delaware	2018 Del. Laws, Ch. 264	An Act to amend title 11 of the Delaware code relating to unmanned aircraft systems
2018	Kansas	2018 Kansas SR 1759	A resolution urging the Federal Aviation Administration to accept Kansas' application for the

Year	State	Bill	Title
			Unmanned Aerial Systems Integration Pilot Program.
2018	Kentucky	2018 Ky. Acts, Ch.26	An Act relating to public safety
2018	Kentucky	2018 Ky. Acts, Ch.168	An Act relating to trespass
2018	Louisiana	La. Acts 2018, 630	An Act to amend and reenact R.S. 14:283(A)(1) and to enact R.S. 14:283(H), relative to offenses affecting public morals; to provide relative to the crimes of video voyeurism; and to provide for related matters
2018	Michigan	2018 Mich. Pub. Acts, Act 444	An Act to provide for the operation and regulation of unmanned aircraft systems in this state; to create the unmanned aircraft systems task force; to provide for the powers and duties of state and local governmental officers and entities; and to prohibit conduct related to the operation of unmanned aircraft systems and prescribe penalties
2018	Michigan	2018 Mich. Pub. Acts, Act 468	An Act to provide for the operation and regulation of unmanned aircraft systems in this state; to create the unmanned aircraft systems task force; to provide for the powers and duties of state and local governmental officers and entities; and to prohibit conduct related to the operation of unmanned aircraft systems and prescribe penalties
2018	Michigan	2018 Mich. Pub. Acts, Act 445	An Act to revise, consolidate, and codify the laws relating to criminal procedure and to define the jurisdiction, powers, and duties of courts, judges, and other officers of the court under the provisions of this act
2018	Michigan	2018 Mich. Pub. Acts, Act 469	An Act to revise, consolidate, and codify the laws relating to criminal procedure and to define the jurisdiction, powers, and duties of courts, judges, and other officers of the court under the provisions of this act
2018	New Jersey	2018 N.J. AR 29	Urges Congress and President to fund FAA Drone Test Site Program
2018	Oregon	2018 Or. Laws, Ch. 120	Relating to public safety; creating new provisions
2018	Pennsylvania	2018 Pa. Laws, Act 78	Unlawful use of unmanned aircraft and prohibiting local regulation of unmanned aircraft
2018	South Carolina	2018 S.C. Acts, Act 184	Drones, unlawful operation at corrections and local detention facilities
2018	South Dakota	2018 S.D. Sess. Laws, Ch. 269	An Act to revise certain provisions regarding aviation
2018	Tennessee	2018 Tenn. Pub. Acts, Ch. 970	An Act to amend Tennessee Code Annotated, Title 39 and Title 40, relative to unmanned aircraft
2018	Utah	2018 Utah Laws, Ch. 40	This bill prohibits certain operations of an unmanned aircraft system related to correctional facilities

Year	State	Bill	Title
2018	Vermont	2018 Vt. Acts, Act 101	An Act relating to prohibiting the use of drones near correctional facilities
2018	Virginia	2018 Va. Acts, Ch. 654	An Act to amend and reenact § 19.2-60.1 of the Code of Virginia, relating to use of unmanned aircraft systems by public bodies; search warrant required; exception
2018	Virginia	2018 Va. Acts, Ch. 2	An Act for all appropriations of the Budget
2018	Virginia	2018 Va. Acts, Ch. 851	An Act to amend and reenact § 15.2-926.3 of the Code of Virginia, to amend the Code of Virginia by adding a section numbered 18.2-121.3 and by adding in Article 8 of Chapter 7 of Title 18.2 a section numbered 18.2-324.2, and to repeal the second enactment of Chapter 451 of the Acts of Assembly of 2016, relating to trespass; unmanned aircraft system; penalty
2018	Virginia	2018 Va. Acts, Ch. 419	An Act to amend and reenact § 19.2-60.1 of the Code of Virginia, relating to use of unmanned aircraft by a locality; search warrant; exception
2018	Virginia	2018 Va. Acts, Ch. 546	An Act to amend and reenact § 19.2-60.1 of the Code of Virginia, relating to use of unmanned aircraft systems by public bodies; search warrant required; exception
2018	Virginia	2018 Va. Acts, Ch. 617	An Act to amend and reenact § 5.1-1 of the Code of Virginia, relating to the Department of Aviation; unmanned aircraft systems
2018	West Virginia	2018 W.Va. Acts, Ch. 61	An Act to amend the Code of West Virginia, 1931, as amended, by adding thereto a new article, designated §61-14-1 and §61-14-2, all relating to regulation of unmanned aircraft systems
2018	West Virginia	2018 W.Va. Acts, Ch. 168	Unlawful methods of hunting and fishing and other unlawful acts; Sunday hunting
2018	West Virginia	2018 W.Va. Acts, Ch. 175	Powers of the director with respect to the section of parks and recreation
2018	Wisconsin	2018 Wis. Laws, Act 322	An Act to renumber and amend 114.105; to amend 114.04 and 175.55 (1) (a); and to create 114.105 (1), 114.105 (3) and 114.105 (4) (b) of the statutes; relating to: the operation and regulation of unmanned aircraft and providing a penalty

Many of the bills enacted in 2019 created criminal offenses for violations to state laws regarding unmanned aircraft. Additionally, several states appropriated money to purchase UAS equipment or to study or continue UAS programs.

Table 8. Legislation by Other States: 2019.

Year	State	Bill	Title
2019	Alaska	2019 Alaska Sess. Laws, Ch. 2	An Act making a special appropriation from the earnings reserve account for the payment of permanent fund dividends; and providing for an effective date
2019	Arkansas	2019 Ark. Acts, Act 508	An Act concerning the offense of unlawful use of an unmanned aircraft system; to amend the definitions of "critical infrastructure" and "unmanned aircraft system"; and for other purposes.
2019	Arkansas	2019 Ark. Acts, Act 1000	An Act concerning the offense of unlawful use of an unmanned aircraft system; to amend the definition of "critical infrastructure"; and for other purposes
2019	California	2019 Cal. Stats., Ch. 749	An Act to amend Section 647 of the Penal Code, relating to privacy
2019	Delaware	Vol. 82, Del. Laws, Ch. 190	An Act to amend title 11 of the Delaware code relating to unmanned aircraft systems
2019	Georgia	2019 Ga. Laws, Ch. 67	Correctional Institutions of the State and Counties; use of unmanned aircraft systems to deliver or attempt to deliver contraband to a place of incarceration; prohibit
2019	Hawaii	2019 Hawaii Sess. Laws, Act 248	A bill for an Act relating to fireworks
2019	Indiana	2019 Ind. Acts, P.L. 136	An Act to amend the Indiana code concerning criminal law and procedure
2019	Kentucky	2019 Ky. Acts, Ch.61	An Act relating to drones
2019	Michigan	2019 Mich. Pub. Acts, Ch. 32	An Act to amend 2016 PA 436, entitled "An act to provide for the operation and regulation of unmanned aircraft systems in this state"
2019	Montana	2019 Mont. Laws, Ch. 178	An Act allowing information collected by an unmanned aerial vehicle investigating a motor vehicle crash scene to be admitted into evidence or used to obtain search warrants
2019	Nevada	2019 Nev. Stats., Ch. 551	An Act relating to aeronautics; requiring the establishment and carrying out of a program relating to certain unmanned aircraft systems; making an appropriation; and providing other matters properly relating thereto
2019	New Jersey	2019 N.J. Laws, Ch. 153	An Act concerning medical cannabis, revising various parts of the statutory law, and supplementing P.L.2009, c.307
2019	New Jersey	2019 N.J. Laws, Ch. 150	An Act making appropriations for the support of the State Government and the several public 9 purposes for the fiscal year ending June 30, 2020 and regulating the disbursement thereof

Year	State	Bill	Title
2019	North Carolina	2019 N.C. Sess. Laws, Ch. 231	An Act, consistent with house bill 966 of the 2019 regular session, to enact a budget for the department of transportation, to make additional appropriations, transfers, and reductions to the department, and to make other modifications related to the operations of the department.
2019	Ohio	Vol. 10, 2019 Ohio Laws, HB 166	Creates FY 2020-2021 operating budget
2019	Oregon	2019 Or. Laws, Ch. 337	Relating to unmanned aircraft systems; creating new provisions; and amending ORS 837.360 and 837.374
2019	Tennessee	2019 Tenn. Pub. Acts, Ch. 40	An Act to amend Tennessee Code Annotated, Title 39, Chapter 13, relative to unmanned aircraft
2019	Tennessee	2019 Tenn. Pub. Acts, Ch. 60	An Act to amend Tennessee Code Annotated, Title 39, relative to unmanned aircraft
2019	Virginia	2019 Va. Acts, Ch. 781	An Act to amend and reenact § 19.2-60.1 of the Code of Virginia, relating to use of unmanned aircraft systems by law-enforcement officers; persons sought for arrest
2019	Virginia	2019 Va. Acts, Ch. 612	An Act to amend and reenact § 18.2-121.3 of the Code of Virginia, relating to trespass; unmanned aircraft system; penalty
2019	Washington	2019 Wash. Laws, Ch. 415	An Act relating to fiscal matters

By 2020, many states were refining and adding criminal offenses to their existing unmanned aircraft laws.

Table 9. Legislation by Other States: 2020.

Year	State	Bill	Title
2020	Florida	HB 5001	General Appropriations Act
2020	Florida	HB 659	Drones
2020	Idaho	HB 486	An Act relating to restrictions on the use of unmanned aircraft systems
2020	Massachusetts	HB 5164	An Act making appropriations for the fiscal year 2021 for the maintenance of the departments, boards, commissions, institutions and certain activities of the commonwealth, for interest, sinking fund and serial bond requirements and for certain permanent improvements
2020	Minnesota	SF 3072	Use of Unmanned Aerial Vehicles
2020	Minnesota	SF 3258	Unmanned Aerial Vehicle Prohibition
2020	Minnesota	HB 1963	Modifies provisions relating to Transportation
2020	South Dakota	HB 1059	Revise certain provisions regarding hunting with drones
2020	South Dakota	HB 1065	Revise drone surveillance protections

Year	State	Bill	Title
2020	South Dakota	SB 124	An Act relating to governmental structures protecting the public health, safety and welfare
2020	Virginia	HB 30	Budget bill
2020	Virginia	HB 742	Unmanned aircraft; political subdivision may regulate take-off and landing of system, etc.
2020	Virginia	HB 1017	Commonwealth of Virginia Innovation Partnership Authority; created

By 2021 and 2022, legislation related to advanced air mobility was introduced.

Table 10. Legislation by Other States: 2021 and 2022.

Year	State	Bill	Title
2021	Florida	SB 44	Use of Drones by Government Agencies
2022	Michigan	SB 795	A bill to amend 1945 PA 327, entitled "Aeronautics code of the state of Michigan," (MCL 259.1 to 259.208) by adding section 207.
2022	Michigan	SB 796	A bill to amend 1945 PA 327, entitled "Aeronautics code of the state of Michigan," (MCL 259.1 to 259.208) by adding section 206a
2022	Utah	72-14-103	Preemption of local ordinance
2022	Utah	SB-0122	Unmanned Aircraft Amendments
2022	West Virginia	HB 4667	Use of Unmanned Aircraft Systems
2022	West Virginia	HB 4827	Promoting Public-Use Vertiports Act

APPENDIX C: PUBLIC COMMENT

As noted in the report, the primary charge and focus of the committee was to develop the recommendations found in the Key Areas in Urban Mobility section of this report. The report was put out for public comment from July 7 to July 14, 2022, and, recognizing some members of the committee and/or members of the public may hold individual, differing opinions from that of the report, all public input provided during the public comment period is included in this appendix. These public comments are not part of the Recommendations and Report as voted out by the Urban Air Mobility Advisory Committee but may reflect the separate opinions of members of the committee and or the public. The comments detailed in this appendix were based on a previous draft of the report. The final report takes these comments into account.

Comments of the UAS and AAM industries on Texas Transportation Commission Advisory Committee Report and Recommendations

General comments

The UAS and AAM industries offer extensive safety, sustainability, economic, and other benefits of these technologies. We are pleased that the Texas Transportation Commission has recognized these benefits, and we are grateful for the opportunity to work with the state to be a leader in these technologies for the benefit of its constituents. While some of our members participated in the Advisory Committee, we do not believe that the draft Report and Recommendations (the "Report") reflects a consensus view of the Committee. Over the course of the past year, those members have explained in detail their concerns with the perspective voiced by some Committee members of a restrictive view of FAA's regulatory authority and the suggestion – in our view, wholly erroneous – that property owners maintain rights in the airspace above their land that allows them to exclude or prevent aircraft overflight. We had hoped that the Report would reflect these concerns and would set out a narrative and framework on which the full Advisory Committee could agree.

Instead, the Report recites several positions that are at best controversial interpretations of disputed areas of law and at worse flatly inaccurate statements. We therefore provide the following comments on the Report, with the hope that the final Report can still be amended to reflect a consensus view of the entire Advisory Committee.

Our main concern is with the analysis on pages 11-12 entitled "Regulatory Overview." As set forth below, this analysis is replete with imprecise and, in some cases incorrect, statements of the law and, as such, would require a substantial overhaul at a minimum to address these fundamental flaws. This Regulatory Overview is also superfluous and beyond the scope of the Committee's charge under its enabling legislation to assess current Texas law and whether there is any need to change Texas law. The Regulatory Overview injects the Advisory Committee into a debate about the scope of airspace regulation on which it simply need not take a position. Because this section is not necessary as a basis for the rest of the Report and Recommendations, we believe that the simplest way to mitigate our concerns is to delete this section of the Report in its entirety. If staff believes that the final Report must contain a Regulatory Overview section, we urge that changes be made to address the following issues.

Specific comments on Regulatory Overview

The Regulatory Overview repeatedly employs the concept of "surface airspace," a term that appears to have been very recently coined by certain property rights activists based on outdated court decisions from a century or more ago, long before enactment of the Federal Aviation Act of 1958. The term betrays a bias in favor of a state and local police power role over navigable airspace, a role that does not exist under our constitutional system, in which Congress has vested the Federal Aviation Administration ("FAA") with exclusive authority over navigable airspace. Because there is no actual legal concept of "surface airspace," this term should be removed from the Report.

The Regulatory Overview should also be removed because portions appear to be taken nearly verbatim from a 2020 Mercatus Working Paper, without attribution to this paper. Moreover, statements in the Regulatory Overview are contradicted by statements in other portions of the Report.

The first paragraph (page 11) claims that the "biggest legal question seems to be who has authority to regulate" and that "Congress has not clarified the division between federal and state roles regarding airspace issued [sic]." Neither proposition is correct. In fact, Congress has very clearly delineated federal and state roles regarding airspace issues. The Report (page 11) recognizes that Congress has granted the federal government exclusive sovereignty over U.S. airspace. As the Supreme Court put it in *Causby*, “the air is a public highway.” *United States v. Causby*, 328 U.S. 256, 261 (1946). Congress has also given plenary authority to the FAA to define and regulate the navigable airspace, as the Report elsewhere acknowledges (“the FAA’s full regulatory authority over the airspace”) (page 28). “Navigable airspace” in the Federal Aviation Act includes not just the airspace above FAA-set minimum safe altitudes, but also any airspace necessary for takeoff and landing of aircraft, and the definition of “aircraft” includes UAS (or drones) and eVTOL aircraft.

Further, the FAA has been regulating the operations of UAS for more than a decade. In its Part 107 rule adopted in 2016, the FAA has clearly established that small UAS operations should—and, indeed, in nearly all circumstances *must*—take place below 400 feet above the ground, which of necessity means that the “navigable airspace” for small UAS is from 0 to 400 feet. *See* 14 C.F.R. § 107.51. Based on the foregoing, there is no state or local role in regulating aircraft operations in the navigable airspace, and thus there is no “division” of roles for Congress to clarify. *See* Report at 28.

The Regulatory Overview also incorrectly states at page 11 that the “federal government has not stated its legal position.” The FAA’s position was stated in its December 2015 Fact Sheet, *see* State and Local Regulation of Unmanned Aircraft Systems, (UAS) Fact Sheet, https://www.faa.gov/uas/resources/policy_library/media/UAS_Fact_Sheet_Final.pdf, and its Busting Myths document on its website: “The FAA is responsible for the safety of U.S. airspace from the ground up.”

Simply put, state and local police powers are limited to designating landing and takeoff areas and protecting citizens from torts such as invasions of privacy, aerial trespass, and nuisance. They do not extend to regulating flight operations themselves.

While there have been proposals in Congress and by non-government organizations to create a line in the sky, below which state or local authorities would govern drone and eVTOL aircraft operations, these efforts have to date not been adopted and should not purport to reflect current law.

Indeed, while the first paragraph of the Regulatory Overview section refers to "influential law drafters" to include the Uniform Law Commission ("ULC") and the American Law Institute's ("ALI") draft "airspace trespass" provision, neither body has yet produced an operative text in this area. After studying the matter for two years, the ULC elected not to adopt a drone tort law and is currently not engaged on this matter. And while the ALI is in the process of drafting the Restatement (Fourth) of Property, the ALI's charter is to *restate* the law and not draft new law. The drone industry raised this very issue in opposing ALI's proposed "trespass-by-overflight" provision. At this point there is no clear indication of what the Restatement might say on this point when and if a draft is ultimately adopted. In any event, whatever the contours of an aerial trespass or trespass-by-overflight provision, the FAA's authority over aircraft operations in the navigable airspace is clear. Lastly, the citation links to an FAA page about Urban Air Mobility and Advanced Air Mobility; the cite is wrong and instead should likely reference the 2020 Mercatus Working Paper by Brent Skorup identified in note 14.

Furthermore, the preemption law discussion is muddled at best and suffers from several incorrect assertions. Rather than cite to a law review or state bar association article, the Report should cite solely to judicial precedent.

The Regulatory Overview also incorrectly states that the Supremacy Clause "requires that federal laws preempt any conflicting state or local regulations" (page 11). A federal law may permit a conflicting state or local regulation if that statute so provides. The Supremacy Clause declares that federal law is the supreme law of the land. It operates to invalidate state or local laws, not federal laws. It is not a command to Congress to enact preemption statutes. The sentence should be deleted.

The next sentence should be revised to state: "Congress does not need to explicitly state a purpose to preempt; a court may infer preemption from the federal law, in which case a court concludes that Congress has impliedly preempted state law."

It is also not correct that "[t]here are two types of preemption: Field preemption and Conflict preemption" (page 11). These are two types of *implied* preemption, as opposed to express preemption, where Congress uses express language to prohibit state and local regulation. In the aviation context, for example, Congress has expressly preempted a range of state and local powers in the Airline Deregulation

Act, which prohibits these governments from regulating prices, routes, and services of an air carrier providing air transportation.

Notably, the FAA explicitly referenced field preemption in its 2015 Fact Sheet when it explained that a "patchwork quilt" of differing state and local restrictions could hamper FAA flexibility in promoting safe and efficient air traffic flow. Fact Sheet at 2. The Report is too quick to dismiss the importance of field preemption in aviation safety, given the FAA's insistence that "[a] navigable airspace free from inconsistent state and local restrictions is essential to the maintenance of a safe and sound air transportation system." *Id.* (collecting cases). Quoting from the Supreme Court decision in *Arizona v. U.S.*, 567 U.S. 387, 401 (2012), the Fact Sheet stated "Where Congress occupies an entire field . . . even complementary state regulation is impermissible. Field preemption reflects a congressional decision to foreclose any state regulation in the area, even if it is parallel to federal standards." *Id.* at 2-3.

The statement (page 11) that conflict preemption "is when compliance with both state and federal regulations is impossible" is too narrow. Where compliance with both federal and state law is impossible, that indeed poses a conflict. But so-called "impossibility preemption" is only one type of conflict preemption. A conflict may also exist where a state law imposes an additional requirement than the federal law. For instance, a state may seek to require eVTOL aircraft to be equipped with ADS-B, even though the FAA has not so required. That would be a conflict, but it would not be impossible to comply with both federal and state law. A third type of conflict preemption is "obstacle" preemption, where the state or local law stands as an obstacle to the objects and purposes of federal law.

Moreover, the use of "regulations" in the text quoted above is underinclusive. Federal law preempts inconsistent state or local law no matter what form either takes. That is true whether the federal law is a provision in the federal Constitution, a federal statute, or a regulation.

The Report's statement that the court in *Singer v. City of Newton* "found that FAA explicitly contemplates state or local regulation of pilotless aircraft" (page 11) is taken out of context. The *Singer* court was referencing the FAA's 2015 Fact Sheet, which distinguishes "any regulation of the navigable airspace" from traditional police powers. If the final Report references *Singer*, it should explain that the court ultimately found that the city's drone ordinance *was* preempted, because its restrictions on drone use below 400 feet conflicted with federal law.

The next paragraph contains another general statement of preemption. This statement is an amalgam of express and implied preemption principles. It is largely duplicative of the preceding text, without classifying the preemption principles as a court decision would do. It would be preferable to quote from a court decision rather than a secondary source. The first category, "(1) Congress expresses a clear intent to preempt state law[,]" may be intended to describe "express preemption," although that doctrine follows the *words* in a statute or regulation, as this is how a "clear" expression of "intent" is shown.

Furthermore, it is incorrect to state that *Causby* "set the stage for future trespass and privacy cases involving airspace above private property" (page 12). First, *Causby* is a Takings Clause decision premised on interference with the use of property rather than rights to airspace above private property. *Causby* did set the stage for the *aerial* trespass tort in section 159 of the Restatement (Second) of Torts (1965). There is no reference to aerial trespass in the entire "Regulatory Overview," and yet it is the aerial trespass tort (as opposed to a traditional trespass tort) that is the progeny of *Causby.* Second, the *Causby* decision has had no effect on privacy law.

The statement "Surface airspace has typically been treated as real property by the courts" (page 12) is simply wrong—indeed, as noted above, *Causby* led to the creation of a specific "aerial trespass" tort that was distinct from traditional trespass precisely because courts and commentators recognized that there is a difference between traversing property on the surface and flying over the same property. As a result, aerial trespass contains elements of both property and nuisance law. While a property owner can prove trespass on the surface by merely showing that the tortfeasor intruded on her property, to prove *aerial* trespass the property holder must demonstrate that the aircraft substantially interfered with her use and enjoyment of the land. This additional element in the aerial trespass tort exists to acknowledge the reality, as *Causby* held, that the sky is a public highway and that aircraft are entitled to make use of it, so long as they do not engage in flights that are so low and frequent as to cause injury to those below. *See Causby* at 266.

Moreover, the source for this statement also appears to be incorrect. It likely should be another reference to the Skorup article at note 14, not an FAA document. As noted above, "surface airspace" is a wholly invented term and not one that has any meaning in the case law. A reading of that Working Paper does not show any court decision in which the term “surface airspace” was used. And using the passive present perfect tense (“has typically been treated”) disguises the fact that all the court decisions cited by the Working Paper antedate the Federal Aviation Act of 1958 by decades. They have no relevance in determining whether a state has jurisdiction over any airspace. At most, they concern a landowner’s property rights, but the Court in *Causby* also stated that the airspace is a public highway, adding that *ad coelum* doctrine upon which many earlier cases relied “has no place in the modern world.” *Causby* at 261.

It is also not correct to state that *Causby* “created an upper and lower airspace” (page 12). The citation incorrectly points to a NextGen document. It is likely instead a quote from a state bar association publication (note 18). The quoted passage refers to a 500-feet altitude, which is not part of *Causby*, but appears to be taken from a comment on Restatement (Second) of Torts 159. And while 500 feet is set by the FAA as the minimum safe altitude in many circumstances, it is not a universal dividing line. Helicopters routinely fly below 500 feet. Small UAS are generally limited by rule to less than 400 feet. And all aircraft, no matter how large or small, must “navigate” the airspace below 500 feet to take off and land.

Moreover, even if 500 feet could be said to be a dividing line between navigable and non-navigable airspace (and it cannot), the Report does correctly note that *Griggs* held that a taking of an easement can occur even in the navigable airspace. So where is this purported division between upper and lower airspace? Neither *Causby* nor *Griggs* “created” this upper-lower division, as it simply does not exist.

Finally, the quotation from the Michigan Court of Appeals decision in *Long Lake Township v. Maxon* should be removed as the Michigan Supreme Court on May 20, 2022, vacated the judgment of the Court of Appeals and remanded the case for further proceedings. It would be inappropriate at this point to rely on the reasoning in *Maxon*.

Specific comments on other portions of the Report

Page 15, the fact that Texas’s attempt to regulate small UAS flights has been struck down on First Amendment grounds warrants substantially more discussion than a single, throw-away sentence.

Page 16, “Air Rights.” The reference to the Texas administrative code provision on leasing of air rights should not be taken as a general license for the state to lease air rights. Serious constitutional questions would be raised with any attempt to lease airspace.

Page 17 states that new rules may be needed in several enumerated areas, without noting that Texas may have no lawful role in promulgating rules in the first four subjects.

Pages 24-25. The concept of "airspace monitoring" is nebulous and should be clarified.

Pages 28-29, Airspace Design and Regulatory Environment. This section should be revised to clarify the limited authority for state and local governments to play a role "in airspace design." Zoning, noise, and land use may well inform airspace design, but that does not mean that states would be allowed to "govern" advanced air mobility operations in the navigable airspace, even if limited to the conceptual UAM Operating Environment (UOE), as the Report correctly notes the "FAA's full regulatory authority over the airspace."

Page 30. The statement at bottom of page 30 – "Potential state or local regulation would cover landing areas and space requirements or separations from residential areas, airspace and the potential need for traffic management at lower altitudes." – goes too far as we have explained. State and local governments may not regulate the airspace or engage in traffic management at any altitude.

Pages 31-32. The reference to leasing airspace does not appear to be relevant to the subject of placement, policy, and permitting of infrastructure considerations. It refers to an airspace leasing proposal, the legality and efficacy of which are very much in doubt. It also refers to the Scorecard of state laws published by Brent Skorup of the Mercatus Center. The UAS industry has developed a rejoinder to this Scorecard, which is attached to these comments. The paragraph ending on page 31 and continuing onto page 32 should be removed from the sentence beginning with "A proposed solution."

Page 34. The need to align with the FAA is stated three times, and these statements are necessary. Therefore, the statement that alignment with the FAA "will require both state and federal oversight of operations under local jurisdictions" is unclear and should be clarified.

Page 38, Operational Safety. The first sentence on federal and state roles is unobjectionable. The next statement – that "airspace is a more complex area for regulation" – is not correct. Airspace regulation is within the FAA's purview, not the purview of state or local governments.

In sum, for the reasons explained above, the "Regulatory Overview" section should be removed from the Report in its entirety. In addition, the issues and inaccuracies identified in other sections of the Report should be addressed.

We hope that these comments are helpful in laying out the sources of disagreement and potential controversy in the Report, and that they also help illuminate some of the factual and legal errors in the Report as currently drafted. The commercial UAS and AAM industries look forward to continuing to work productively with the Advisory Committee to the extent that the Committee's mandate is extended. We believe it is imperative, however, that the final Report adopt the suggested revisions above to reflect the consensus of the Committee's members and be considered as a trusted, neutral source of information for Texas regulators and lawmakers.

Association of Uncrewed Systems International

Commercial Drone Alliance

Consumer Technology Association

Small UAV Coalition

July 14, 2022

Attachment

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REPORT AND RECOMMENDATIONS OF THE

Urban Air Mobility Advisory Committee

PREPARED FOR THE
Texas Transportation Commission and the Texas Legislature

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https://www.txdot.gov/inside-txdot/division/planning/urban-air-mobility-advisory-committee.html

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