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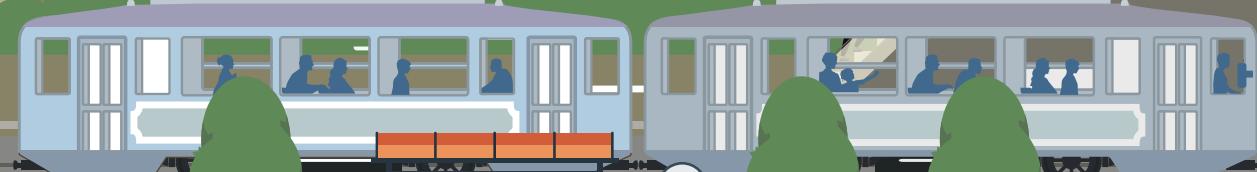
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P A S R E P O R T 606

PLANNING FOR ADVANCED AIR MOBILITY

Adam Cohen, Susan Shaheen, PhD, and Yolanka Wulff, JD

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ON THE COVER

Art by Kat Earnest, San Jose State University

TABLE OF CONTENTS

PREFACE 5

EXECUTIVE SUMMARY 6

CHAPTER 1 AN INTRODUCTION TO ADVANCED AIR MOBILITY 9

- What Is Advanced Air Mobility? 10
- Key AAM Concepts 11
- Planning for AAM Impacts 13
- About This Report 14

CHAPTER 2 BACKGROUND AND STATE OF THE INDUSTRY 16

- Flying Car Concepts 17
- Early Air Taxi Services 18
- Today's State of the Industry 18
- AAM Market Potential 20
- Conclusion 20

CHAPTER 3 POTENTIAL CHALLENGES OF ADVANCED AIR MOBILITY 22

- Operational Challenges 23
- Community Impacts 26
- Public Perception and Community Acceptance 30
- Conclusion 31

CHAPTER 4 SOCIAL EQUITY AND ADVANCED AIR MOBILITY 36

- Potential Social Equity Impacts of AAM 37
- Assessing AAM Through the STEPS Equity Framework 41
- Stakeholder and Community Engagement 41
- Conclusion 44

CHAPTER 5 VERTIPORT INFRASTRUCTURE AND MULTIMODAL INTEGRATION 46

- Types of AAM Takeoff and Landing Infrastructure 47
- AAM Infrastructure Business Models 49
- Vertiport Planning and Design 50
- Conclusion 57

CHAPTER 6 INTEGRATING ADVANCED AIR MOBILITY INTO PLANNING PRACTICE 63

- AAM in the Comprehensive Plan 64
- Local Policy and Regulatory Considerations for AAM 69
- Public Investment Considerations for AAM 71
- Partnerships and Collaboration for AAM Planning 72
- Conclusion 72

CHAPTER 7 LOOKING AHEAD 77

- What We Know 78
- Areas of Uncertainty 79
- Priority Areas for Research, Engagement, and Policy 79
- Preparing for the Future 80

APPENDIX A: GLOSSARY 81

APPENDIX B: ACRONYMS USED IN THIS REPORT 84

APPENDIX C: AAM RESOURCES FOR PLANNERS 85

APPENDIX D: METHODOLOGY 89

REFERENCES 92

ACKNOWLEDGMENTS 96

Today, a convergence of technological, social, economic, and environmental trends is contributing to transformational changes in transportation. Across the globe, advanced air mobility—a rapidly evolving sector within aviation encompassing a range of innovative aircraft, technologies, and infrastructure—has the potential to create new transportation options. While there is great interest in the future of transportation, there is a need to approach emerging technologies and the future of urban planning with pragmatic optimism.

Recognizing the potential impacts of these aviation technologies on communities, the Mineta Transportation Institute (MTI) and the American Planning Association are pleased to partner on this endeavor and present PAS Report 606, *Planning for Advanced Air Mobility*. This report delves into the intricacies of this emerging mode of transportation. In doing so, the report aims to provide planners, policymakers, industry leaders, and the public with valuable insights that can inform strategic decisions, foster collaboration, and guide the evolution of advanced air mobility.

MTI is proud to collaborate and to be a part of the practical and intellectual discussions about the planning issues and technologies that have the potential to influence how communities access mobility, goods, and emergency services in the future. Our goal is that together, we can continue to explore, innovate, and enhance the future of transportation—for individuals, for communities, and for the planet. It is our hope that this PAS Report inspires meaningful discourse and contributes to the creation of a transportation ecosystem that is not only advanced but also safe, multimodal, equitable, and environmentally conscious.

Karen Philbrick, PHD
Executive Director
Mineta Transportation Institute

EXECUTIVE SUMMARY

Advanced air mobility (AAM) could result in fundamental changes to land use and the built environment and transform how people access essential services (e.g., emergency and medical services), goods, and mobility. While the impacts of these innovations remain to be seen, planners and policymakers need to prepare for these changes to minimize the potential for adverse impacts and maximize the likelihood of sustainable and equitable outcomes.

This PAS Report presents planners and policymakers with the foundational knowledge to understand potential AAM considerations and community impacts, and it provides information for the public sector to integrate AAM into planning and policymaking at the local and regional levels of government. The report also discusses the role of community planners with respect to AAM, and the importance of local and regional governments working with the Federal Aviation Administration, which is the safety regulator for the U.S. aviation industry and the National Airspace System.

WHAT IS ADVANCED AIR MOBILITY?

AAM is a broad concept focusing on emerging aviation markets and use cases for on-demand aviation in urban, suburban, and rural communities. AAM includes local use cases of about a 50-mile radius in rural or urban areas and intraregional use cases of up to a few hundred miles within or between urban and rural areas. AAM enables consumers' access to air mobility, logistics, and emergency services by dispatching or using innovative aircraft and enabling technologies through an integrated and connected multimodal network across the ground, waterways, and skies.

As envisioned, AAM will feature innovative technologies, such as vertical takeoff and landing (VTOL) aircraft powered by electric batteries or hydrogen, and it will use both existing and new infrastructure, including airports, heliports, and vertiports. It includes a variety of aircraft, use cases, and business models to meet the diverse needs of travelers, consumers, air carriers, infrastructure owners, and other stakeholders.

While AAM presents opportunities for communities, issues such as community impacts, public acceptance, safety, social equity, land use impacts, multimodal integration, and other considerations around planning and implementation could create challenges. To help communities prepare for the impacts of this emerging ecosystem, planners and policymakers should be actively involved in AAM planning and implementation. Planning addresses a range of cross-cutting policy and quality-of-life issues, such as mobility, land use, environmental protection, financing, economic development, and social equity. Because of their broad, diverse, and multidisciplinary roles, planners are well positioned to help communities understand, prepare for, and guide the growth and evolution of AAM. This PAS Report is intended to help.

THE STATE OF THE AAM INDUSTRY

The concept of using aviation for shorter-range use cases in a metropolitan region is not new. This PAS Report provides an overview of the history of AAM, beginning with "flying car" concepts of the early 20th century and continuing with helicopter-based air taxi services in operation from the 1950s to the 1980s. It describes how the growth of smartphone apps and on-demand access to goods and mobility has begun to change how consumers access aviation services.

In addition to commercial activity related to passenger mobility, there are an increasing number of aviation industry developments for goods delivery and humanitarian use cases. Globally, the use of uncrewed aircraft systems (UAS), or drones, for goods delivery, transporting medical samples and emergency supplies, mapping, and other professional use cases has grown rapidly. In recent years, there has been

an increasing number of developments associated with AAM passenger services using innovative aircraft designs. This PAS Report offers a snapshot of the state of industry today, including an overview of market studies forecasting the potential for AAM growth.

POTENTIAL CHALLENGES

As an emerging concept, AAM may face many barriers. This PAS Report provides an overview of the potential impacts of AAM on communities. These include potential operational concerns about safety, security, air traffic management, and weather. While local planners do not have a direct role in preparing for and managing many of these risks, it is important for them to understand the role of state and federal agencies and what is being done to address these challenges.

Additional concerns about AAM include community impacts of noise, privacy, visual pollution, energy use and emissions, and land use compatibility. These issues could affect public perceptions of AAM and have an array of effects on communities and planning practices. The report offers information on these potential impacts and how land use, zoning, infrastructure siting, and other planning and policy levers may serve as mitigation strategies.

While AAM presents potential opportunities for localities, negative community perceptions could pose challenges to AAM adoption and mainstreaming. Public perception and community acceptance will likely be influenced by its operational and community impacts. The report emphasizes the importance of social equity issues associated with AAM, such as affordability and who benefits from or bears the impacts of AAM, and the need to integrate AAM into existing multimodal transportation networks.

SOCIAL EQUITY CONSIDERATIONS FOR AAM

Considering social equity as part of AAM planning and implementation is key to ensuring broader access to its potential benefits for all, such as aeromedical services, employment opportunities and access, and economic development. This PAS Report explores the complex social equity issues related to AAM. These include the impacts associated with vertiport development and AAM operations on their immediate vicinity, concerns about affordability and accessibility of AAM flights, environmental impacts on underserved communities, and the allocation of public resources. All will be important for planners to address when considering AAM in their communities.

Identifying and understanding the social equity challenges related to AAM is critical in preventing discrimina-

tion in both processes and outcomes and ensuring access to potential AAM benefits. This PAS Report employs an evaluation framework to analyze the potential spatial, temporal, economic, physiological, and social barriers of AAM. It demonstrates how planners can evaluate the opportunities and challenges that AAM presents in the context of these five areas and envisions potential policy strategies to leverage possible opportunities and overcome key challenges.

AAM presents new challenges for planners. Historically, aviation planning processes have generally focused on aviation stakeholders and communities adjacent to airports. Because AAM has the potential to decentralize aviation impacts that have historically been limited to airport facilities and their immediate surroundings, planners will need to expand their understanding of these issues and engage diverse community and aviation stakeholders that likely have limited experience working with one another. This PAS Report explains how early and intentional stakeholder and community engagement will be important to help understand and address potential community concerns.

VERTIPORT INFRASTRUCTURE AND MULTIMODAL INTEGRATION

Deployment of AAM will require an extensive network of takeoff and landing facilities and energy infrastructure. Both the public and private sectors may need to identify how infrastructure can be repurposed with minimal physical modification, renovated and adapted, or replaced and redeveloped for AAM. However, constructing new and adapting existing infrastructure for AAM could present planning challenges, such as local concerns, high costs, and multimodal integration with other transportation modes.

This PAS Report explores a range of issues related to these concerns. It presents a taxonomy and definitions of AAM takeoff and landing infrastructure and outlines potential business models. It also discusses vertiport planning and design considerations, including forecasting and modeling, design and siting considerations, and the role of vertiport-oriented and joint development in achieving multimodal integration.

As the AAM ecosystem evolves, planners and policymakers will play important roles in the allocation of public resources, such as who can build or operate vertiports, or what service providers can have access to takeoff and landing infrastructure. As with curbside access, vertiport takeoff and landing slots and parking stalls could be a finite resource in some locations. This report describes potential options for managing competition among service providers.

INTEGRATING AAM INTO PLANNING PRACTICE

Comprehensive plans—known as general plans in several states—establish the vision, goals, and policies that communities use to guide development decisions. These longer-term planning efforts offer planners and policymakers an opportunity to initiate community discussions around emerging transportation technologies that could help guide future AAM decision-making.

This PAS Report underscores the need for communities to consider AAM in the context of their long-range planning efforts. It discusses potential opportunities for integrating AAM into local and regional planning processes. Discussions from planners in Los Angeles; Orlando, Florida; and the North Central Texas Council of Governments demonstrate how planners can help to guide planning outcomes by addressing key local policy issues affecting AAM.

Local policy and regulatory considerations for AAM predominantly relate to vertiport land use compatibility issues, as addressed through local zoning, vertiport approvals and permitting, funding for AAM infrastructure, and public-private partnerships. As with comprehensive planning, ensuring that land uses adjacent to vertiports are compatible with this aviation use is important for maintaining a community’s quality of life, minimizing adverse environmental and social equity impacts, and supporting the safe operations of a vertiport and its users.

LOOKING AHEAD

AAM is a transportation strategy that has the potential to serve a variety of mobility, logistics, emergency response, aeromedical, and other use cases. Numerous studies have documented the industry’s forecasted growth, and emerging research is beginning to examine the potential environmental, social, and transportation-related impacts of AAM. This highlights the need for greater awareness about AAM and its potential impacts among communities, which may have limited or no experience with aviation planning issues.

This PAS Report concludes with a summary of what is currently known and unknown about AAM. While the impacts of AAM are uncertain at present, AAM could potentially have transformational effects on the planning practice, built environment, and travel behavior. As the sector is expected to evolve over the coming decades, planners can help to prepare communities for the potential opportunities and challenges of AAM.

How planners plan and manage the physical, energy, and digital infrastructure needed for AAM deployment will likely be a key topic of conversation in the coming years.

Planners and policymakers will need to decide what level of support and influence over AAM-related issues is desired by—and appropriate for—the public sector. Planning and policy are needed to guide use cases that provide broad societal benefit. Institutional capacity building, community engagement, and ongoing research will be needed to guide sustainable and equitable outcomes.

CHAPTER 1

AN INTRODUCTION TO ADVANCED AIR MOBILITY

Technology is transforming how people travel and access goods and services. Shared transportation services—such as shared micromobility and transportation network companies—are impacting urban mobility. Electrification and automation are also poised to change ground transportation. Around the world, these converging technological innovations, along with advancements in app-based mobility services and vertical lift, are contributing to the concept of advanced air mobility (AAM).

AAM could result in fundamental changes to the built environment and land use and transform how people access essential services, goods, and mobility. While the impacts of these innovations remain to be seen, as such technologies come online, planners and policymakers will need to prepare for these changes to minimize the potential for adverse impacts and maximize the likelihood of sustainable and equitable outcomes.

This PAS Report presents planners and policymakers with the foundational knowledge necessary to understand the potential impacts of AAM on communities and provides information for the public sector to integrate AAM into planning and policymaking at the local and regional levels of government.

This chapter introduces the concept of AAM and explores its potential applications. To establish a common understanding among readers, it defines and explains key concepts such as aircraft types, business models, and air-space, which are integral to the discussion of how to plan for AAM. The chapter concludes with a roadmap for readers to the rest of the report.

WHAT IS ADVANCED AIR MOBILITY?

Advanced air mobility (AAM) is a broad concept focusing on emerging markets for on-demand aviation in urban, suburban, and rural communities. As envisioned, AAM will feature innovative aircraft technologies, such as vertical takeoff and landing (VTOL) aircraft powered by electricity or hydrogen, and will use both existing and new infrastructure, including airports, heliports, and vertiports.

AAM typically serves routes within about a 50-mile radius in rural or urban areas and intraregional routes of up to a few hundred miles that occur within or between urban and rural areas. It is part of a broader ecosystem of on-demand mobility through which consumers can access mobility and goods delivery services by using urban aviation services, courier services, shared automated vehicles, shared mobility, public transportation, and other innovative services through a connected and multimodal transportation network (Cohen and Shaheen 2016, 2021; Shaheen, Cohen et al. 2017; NASEM 2020).

AAM encompasses different services tailored to specific built environments, commonly referred to as urban, rural, and regional air mobility.

- **Urban air mobility** (sometimes referred to as UAM) envisions a safe, sustainable, affordable, and accessible air transportation system for passenger mobility, goods delivery, and emergency services within or traversing metropolitan areas (Reiche et al. 2018). UAM typically includes services within or between edge cities and urban, suburban, and exurban areas.
- **Rural air mobility** envisions a safe, sustainable, affordable, and accessible air transportation system for passenger mobility, goods delivery, emergency services, and other applications within or traversing rural and exurban areas. This might include passenger mobility and logistics between rural communities and urban centers, delivery of health care and other critical services in rural communities, agriculture crop dusting using uncrewed aircraft, and other applications. Rural air mobility may overlap with UAM when services cross different built environments.

- **Regional air mobility** (sometimes referred to as RAM) envisions a safe, sustainable, affordable, and accessible air transportation system for passenger mobility, goods delivery, and emergency services for intra- and interregional trips of about 50–500 miles. RAM includes scheduled and on-demand flights, typically between smaller airports, using small aircraft with less than 20 passengers or an equivalent weight in cargo (Antcliff et al. 2021).

This PAS Report primarily focuses on urban and regional air mobility.

KEY AAM CONCEPTS

AAM includes a variety of aircraft, applications, and business models to meet the diverse needs of travelers, consumers, air carriers, aircraft owners, and other stakeholders that are part of the supply and demand sides of the ecosystem.

Planning for AAM requires a broad understanding of these concepts and how airspace is both impacted by and impacts land use and built environments. The following sections provide a basic orientation for planners on the various types of AAM aircraft and different use cases and busi-

ness models for the industry, as well as an overview of U.S. airspace as defined and regulated by the Federal Aviation Administration (FAA).

Aircraft

Recent innovations in technology and aerospace engineering are contributing to the development of innovative and advanced aircraft. The AAM ecosystem includes an array of aircraft with variations in propulsion, including battery electric, hydrogen electric, hybrid, or gas powered; design; technology; capacity; range; autonomy, from piloted to remotely piloted or fully autonomous; and compatibility with existing infrastructure (Cohen, Shaheen, and Farrar 2021). Table 1.1 presents commonly used aircraft terms and definitions commonly discussed as part of the AAM ecosystem.

Use Cases

AAM applications, or use cases, include passenger mobility, logistics and goods delivery, emergency response or disaster relief operations, and other professional and industrial uses. Each of these use cases is described in Table 1.2 (p. 12).

Business Models

The broad AAM ecosystem includes a combination of commercial and noncommercial operations. These can be categorized in the following ways.

- **Personally owned aircraft:** Private aircraft owned and used by a single individual.
- **Fractional and shared ownership models:** Individuals co-own or sublease aircraft or subscribe to aircraft access.
- **Business-to-consumer (B2C) service:** Customers access aircraft for travel or package delivery through a company that owns or leases a fleet of aircraft.
- **Peer-to-peer (P2P) service:** Customers access privately owned aircraft for shared-use travel or package delivery through a P2P provider.
- **Air charter on-demand service:** Customers purchase access to aircraft from air charter brokers selling on-demand capacity using strategies such as crowdsourcing, membership programs, and smartphone apps.

The sale of on-demand capacity could theoretically help reduce costs by reducing the amount of unpaid surplus capacity, similar to the manner in which transportation network companies (TNCs) can reduce traveler costs for pooled trips with higher occupancies (Cohen, Shaheen, and Farrar 2021). The types of business models and use cases

TABLE 1.1. AAM AIRCRAFT AND AERIAL SYSTEMS TERMS AND DEFINITIONS

Term	Definition
Conventional takeoff and landing (CTOL)	A fixed-wing aircraft with runway requirements for takeoff and landing.
Short takeoff and landing (STOL)	An aircraft with short runway requirements for takeoff and landing.
Vertical takeoff and landing (VTOL)	An aircraft that can take off, hover, and land vertically. VTOL aircraft powered by battery electric propulsion are commonly referred to as eVTOLs.
Rotorcraft	A rotary-wing aircraft, such as a helicopter or gyroplane.
Uncrewed aircraft systems (UAS)	Uncrewed aircraft and its associated elements (including communication links and control components) that are required for the safe and efficient operation of the uncrewed aircraft in the national airspace system (also called unmanned aircraft systems or drones). In the United States, small drones weighing less than 55 pounds are referred to as sUAS.

TABLE 1.2 TAXONOMY OF AAM USE CASES

Use Case	Service Description
Passenger mobility	Personal flight: A model in which aircraft are owned and used by an individual or group for private use. Examples of this operational model include private aircraft ownership, fractional ownership, and rental.
	Air pooling: An on-demand service in which multiple users share an aircraft.
	Air taxi: An on-demand service for a single user or group of users that reserve an entire aircraft for a flight and determine the flight's origin, destination, and timing.
	Semischeduled service: A model with semiflexible scheduling that can be modified to meet a customer's preferences (e.g., a flight scheduled to depart within a two-hour window).
Logistics and cargo/ package delivery	Scheduled service: A model offering frequent flights along a route with regularly scheduled service, similar to the types of operations performed by commercial airlines.
	Small package delivery: Providing consumer or business delivery of one or more packages by a small uncrewed aircraft (i.e., drone) that weighs less than 55 pounds on takeoff, including everything that is on board or otherwise attached.
	Cargo delivery and logistics: Transporting cargo (goods, supplies, or other freight) to businesses or consumers using aircraft.
Emergency response, disaster relief, and humanitarian operations	Medical response, evacuation, and transport: Providing medical care, evacuating patients from an incident scene, and transporting them to medical facilities.
	Emergency and disaster response: An array of missions ranging from small incidents to mass casualty events that could include warning/evacuation, search and rescue, firefighting, assessing damage, providing immediate assistance, and restoring critical infrastructure.
	Disaster relief: An array of missions to help provide relief to return a community back to normal following an incident or disaster (e.g., distributing food and supplies).
	Other humanitarian uses: Other humanitarian, charitable, or philanthropic use cases, such as organ transport and the distribution of supplies, vaccines, food, clothing, and other items to underserved populations.
Other professional and industrial uses	A broad category that includes the use of uncrewed or other novel aircraft for a variety of professional, industrial, and other uses, such as crop dusting, aerial photography, news reporting, or infrastructure inspections.

Source: Adapted from Cohen, Shaheen, and Farrar 2021; Patterson, Antcliff, and Kohlman 2018; Cohen and Shaheen 2021

available will likely evolve based on the business climate and regulatory environment.

Airspace

AAM operations are anticipated to take place at relatively low altitudes and, in many cases, in urban environments. While airspace management is regulated by the Federal Aviation Administration (FAA), community policymakers and planners should be aware of key airspace concepts because the siting of AAM infrastructure and surrounding land uses may be impacted by FAA airspace designations.

The FAA has six airspace classifications (denoted by letters A to E and G). These classes are depicted in Figure 1.1 (p. 13) and summarized below:

- Class A: Airspace of 18,000 feet and above (up to Flight Level 600, approximately 60,000 feet).

- Class B: Airspace (generally up to 10,000 feet) around the largest airports with high levels of commercial traffic. All aircraft are subject to air traffic control.
- Class C: Airspace (typically 1,200 feet up to 4,000 feet) around large airports with lower levels of traffic. All aircraft are subject to air traffic control.
- Class D: Airspace (generally up to 2,500 feet) around smaller and regional airports with control towers.
- Class E: All controlled airspace other than Class A to D. Typically, Class E extends from 700 feet to 1,200 feet above ground level (AGL) up to the beginning of Class A. In some areas, Class E may begin at the surface instead.
- Class G: Uncontrolled airspace; the only airspace where operators do not need air traffic control permission to fly.

Airspace heights may vary by location. In many cases, drones will operate below 400 feet above ground level (AGL),

as an FAA waiver is required to allow them to fly above this altitude. Typically, AAM aircraft with passengers will have a service ceiling of approximately 5,000 feet AGL, but this will vary by aircraft capability.

In 2023, the FAA released the [UAM Concept of Operations \(ConOps\) v2.0](#). The ConOps describes FAA's air traffic management vision to support initial and future AAM operations in and around metropolitan areas (FAA 2023b). It envisions that as AAM scales, the FAA may establish "UAM corridors" to manage more aircraft and complex operations. These corridors could also allow AAM aircraft to traverse protected classes of airspace (e.g., Classes B, C, and D) in a more systematic manner. Other [FAA ConOps](#) envision that drones will continue to operate below 400 feet AGL and AAM will have dedicated corridors at various altitudes that allow aircraft to safely traverse different classes of controlled and uncontrolled airspace (FAA 2020), as depicted in Figure 1.2 (p. 14).

PLANNING FOR AAM IMPACTS

While AAM presents opportunities for communities, issues such as community impacts, public acceptance, safety, social equity, land use impacts, multimodal integration, and other issues around planning and implementation could create challenges for planners and policymakers.

For example, increased aviation activity at low altitudes over urban areas could raise several planning considerations associated with noise, privacy, and aesthetics. Planners may consider siting decisions regarding AAM takeoff and landing locations to discourage operations near sensitive land

uses, like residential development, open space, or historic communities, to minimize the auditory, aesthetic, or environmental impacts of low-level aviation activity on views and the natural environment. Similarly, the integration of AAM with other modes such as public transportation, shared mobility, and automated vehicles will likely influence street design, first- and last-mile connections, and surface congestion around takeoff and landing locations. Subsequent chapters in this PAS Report explore in more detail the potential impacts of AAM on communities and considerations for its implementation.

To protect communities from the potential impacts of this emerging transportation sector, planners and policy-makers should be actively involved in AAM planning and implementation to:

- Evaluate the equity, social, environmental, economic development, and workforce impacts of AAM on communities and develop local and regional policies to mitigate adverse impacts and maximize potential benefits.
- Identify local and regional government data needs, such as metrics, formats, and standards for data sharing.
- Review and update the current list of tall structures within a community or region where AAM might be implemented.
- Develop and use modeling tools to understand the potential traffic and land use impacts of AAM on communities.
- Implement best practices for multimodal integration.
- Work with regional, state, and federal agencies and other key stakeholders to understand the impacts of AAM on various land uses and collaborate on strategies to support sustainable and equitable outcomes.

Figure 1.1. Airspace classification (Federal Aviation Administration)

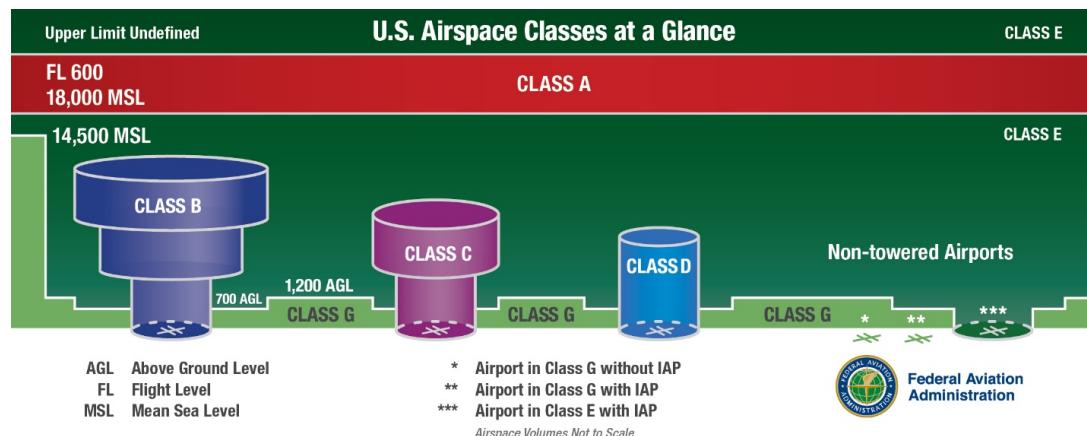
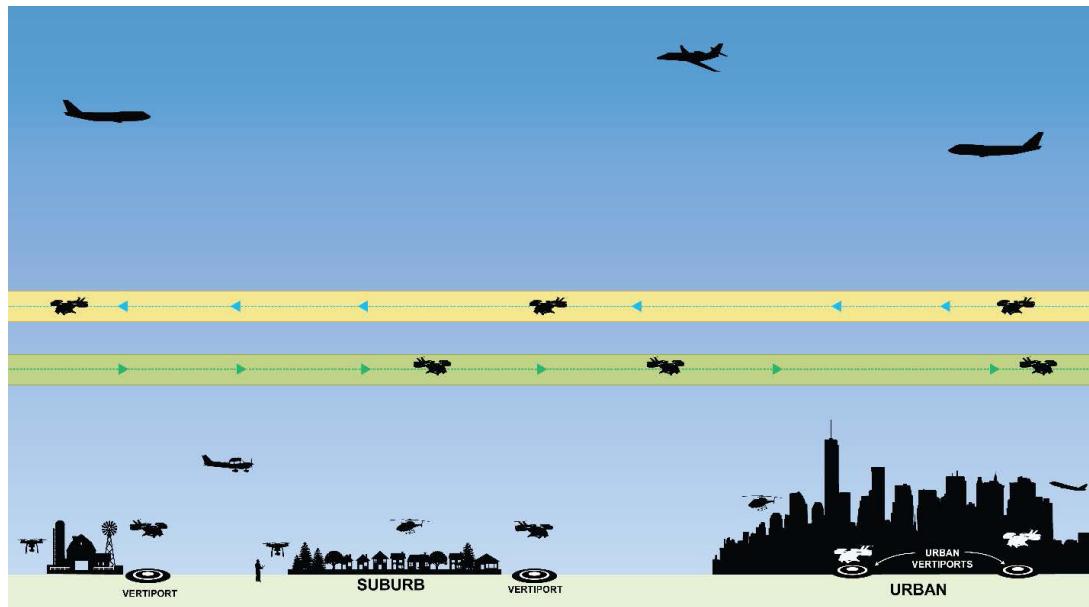


Figure 1.2. FAA's envisioned operating environment for AAM (FAA 2023b)



- Engage communities to understand needs and concerns of the public pertaining to AAM.

Planning addresses a range of cross-cutting policy and quality-of-life issues, such as mobility, land use, environmental protection, financing, economic development, and social equity. Because of their broad, diverse, and multidisciplinary roles, planners are well positioned to help communities understand, prepare for, and guide the evolution of AAM.

ABOUT THIS REPORT

The purpose of this PAS Report is to provide planners and policymakers with information on how to incorporate advanced air mobility into local and regional planning. The implementation of AAM has potential implications for nearly every aspect of planning: land use, environmental policy, transportation, economic development, urban design, and others. While AAM has the potential to provide additional access to mobility, goods, and critical services, it could have unanticipated equity, environmental, social, and other impacts if not carefully planned and integrated into communities.

Additionally, AAM presents planners with new challenges. AAM has the potential to decentralize aviation impacts that have historically been limited to airports and their immediate vicinities, but most planners have little

or no experience with aviation planning. This PAS Report offers guidance that will help planners to better understand AAM and its potential impacts and to plan for these emerging innovations.

The report is organized into seven chapters. This chapter has provided a basic overview of AAM and explained why this topic should be on planners' radars.

[**Chapter 2, Background and State of the Industry**](#), offers an overview of AAM history, from early "flying car" concepts through helicopter-based air taxi services to the emergence of app-based aviation services. It then describes the current state of the industry and explores AAM's market potential for future growth.

[**Chapter 3, Potential Challenges of Advanced Air Mobility**](#), reviews potential operational and community impacts of AAM that planners may be able to influence through planning practice and considers how AAM impacts could influence public perceptions of AAM and community acceptance.

[**Chapter 4, Social Equity and Advanced Air Mobility**](#), offers an overview of the potential social equity impacts of AAM. It applies the STEPS (spatial, temporal, economic, physiological, and social) equity framework developed by Shaheen, Bell et al. (2017) to AAM to assess social equity issues, barriers, and potential policy strategies. Finally, it discusses the importance of stakeholder and community engagement necessary for equitable AAM planning and implementation.

Chapter 5, Vertiport Infrastructure and Multimodal

Integration, explores a range of issues related to AAM infrastructure and multimodal integration. It presents a taxonomy and definitions of AAM takeoff and landing infrastructure, outlines potential infrastructure business models, discusses vertiport planning and design considerations, and addresses planning for the complete AAM trip, including connections with other modes of transportation.

Chapter 6, Integrating Advanced Air Mobility into

Planning Practice, underscores the need for communities to consider AAM in the context of their long-range planning efforts. It discusses potential opportunities for integrating AAM into local and regional planning processes. It also explores how planners may be able to use policy and regulatory approaches to address land use compatibility of vertiports with their surroundings, and it examines how AAM intersects with other strategic points of planning intervention, such as public investments and partnerships.

Chapter 7, Looking Ahead, concludes the report with a discussion of what is known and unknown about AAM and how planners can help their communities plan and prepare for the future of AAM.

The appendices to the report provide a [glossary](#) of key terms, a list of [acronyms](#) used in the report, a list of [additional AAM resources](#) planners can use to increase their knowledge about AAM, and documentation of the [methodology](#) used by the authors in developing this report.

CHAPTER 2

BACKGROUND AND STATE OF THE INDUSTRY

The concept of using aviation for shorter-range use cases in a metropolitan region is not new. Over many decades, inventors and entrepreneurs have created innovative aircraft concepts for a variety of applications.

This chapter offers an overview of the history of urban flight, from “flying car” concepts of the early 20th century through the helicopter-based air taxi services in operation from the 1950s to the 1980s to the modern concept of advanced air mobility (AAM). Figure 2.1 summarizes this history in a timeline. The chapter then describes the current state of the industry and explores AAM’s market potential for future growth, noting the potential impacts of the global COVID-19 pandemic on the trajectory of the industry and the use cases that are envisioned for AAM.

FLYING CAR CONCEPTS

Beginning in the late 1910s and early 1920s, automakers and inventors began envisioning a variety of “flying car” concepts. Early concepts were developed by Glenn Curtiss around 1917 and Henry Ford in the 1920s (Trex 2014). In the late 1930s, inventor Waldo Waterman developed the Arrowbile, a hybrid Studebaker-aircraft with detachable wings, but the project did not advance due to a lack of funding (Patches 2015).

In the 1940s, attempts were made to develop flying cars or “roadable aircraft” (an aircraft that could both be flown and driven on a roadway). The Airphibian (Figure 2.2, p. 18) was the first flying car approved by the Civil Aeronautics Administration (CAA), the predecessor to the Federal Aviation Administration (FAA). The Airphibian was followed by the ConvAirCar (Figure 2.3, p. 18), a two-door sedan equipped with a detachable airplane unit (Bonsor 2023). Neither of them achieved commercial viability.

The first concepts of vertical takeoff and landing (VTOL) aircraft were designed for military use by the Canadian and U.S. armed forces. One concept, the flying-saucer-shaped Avrocar, was ultimately cancelled in 1961 due to thrust and stability problems (U.S. Air Force 2015). Inventors and engineers continued developing various VTOL and flying car prototypes in the 1960s and 1970s, with limited technical and commercial success.

Several factors have made flying car development difficult to achieve (Cohen, Shaheen, and Farrar 2021). The addition of wings to a traditional automobile chassis can block driver sight lines and make a vehicle difficult to drive

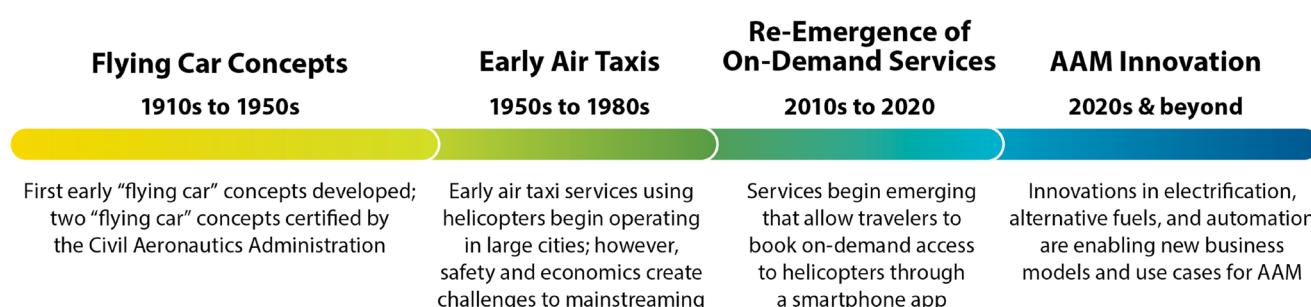


Figure 2.1. Timeline of the vision and evolution of urban aviation concepts (Authors)



Figure 2.2. The Airphibian, an early flying car concept (Smithsonian Institution National Air and Space Museum)



Figure 2.3. Another early flying car concept, the ConvAirCar (San Diego Air and Space Museum)

and park on roadways. Size, shape, and weight distribution requirements are very different for automobiles and aircraft. Automobiles and aircraft also have very different regulatory, technical, and safety design considerations, which makes it challenging to design one vehicle that can be both driven and flown. Additionally, high capital and operational costs for both aircraft and fuel created financial challenges to mainstreaming. Because of these issues, over the years the industry has evolved to focus on improving safety and enhancing operational efficiency to make a business case for urban aviation and VTOL concepts (Cohen, Shaheen, and Farrar 2021).

EARLY AIR TAXI SERVICES

Between the 1950s and 1980s, operators began providing passenger services using helicopters in metropolitan regions such as Los Angeles, New York City, and San Francisco (Figure 2.4, p. 19) (Cohen, Shaheen, and Farrar 2021). These early U.S. passenger helicopter services were typically enabled through a combination of airmail revenue and federal helicopter subsidies, the latter of which were discontinued in 1966 (Scott and Farris 1974; Congressional Quarterly 1965). In response to early interest in passenger helicopter services, the American Planning Association published the PAS Reports *Heliports in the City Plan* and *Helicopters* in 1953 and 1965, respectively.

Between 1965 and 1968, and again in 1977, Pan Am offered hourly connections via helicopter flight between Midtown Manhattan and John F. Kennedy International Airport, allowing passengers to check in at the Pan Ameri-

can building in Manhattan 40 minutes prior to their flight departure at Pan Am's Worldport terminal (Figure 2.5, p. 19). In 1977, the service was discontinued when metal fatigue of the helicopter's landing gear caused a rooftop crash, killing four people on the roof and one person on the ground 59 stories below (Carlson 2019).

Manhattan passenger helicopter services began to slowly re-emerge in the 1980s. Trump Air began offering scheduled passenger service connecting Wall Street to Trump Shuttle flights at LaGuardia airport. The service was discontinued in the early 1990s when Trump Shuttle was acquired by US Airways (Larsson and Zekria 2021).

TODAY'S STATE OF THE INDUSTRY

The growth of smartphone apps and on-demand access to goods and mobility has begun to change how consumers access aviation services. In the early 2010s, on-demand, app-based aviation services began entering the marketplace. In New York City, BLADE launched in 2014, providing helicopter services booked through a smartphone app. BLADE uses third-party operators that own, manage, and maintain their aircraft under FAR Part 135, the FAA operating regulations that govern commuter and on-demand operations.

In addition to commercial activity related to passenger mobility, there are also an increasing number of aviation industry developments for goods delivery and humanitarian use cases. Globally, the use of uncrewed air-

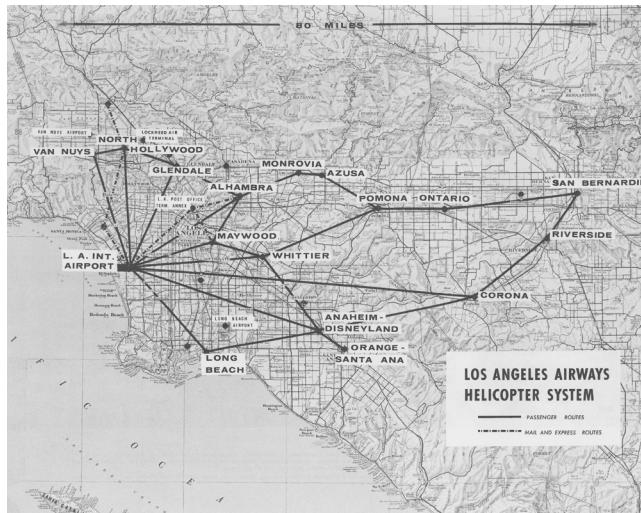


Figure 2.4. Helicopter passenger and mail routes offered by Los Angeles Airways in the 1960s (Los Angeles Airways)

craft systems (UAS), or drones, for goods delivery, transport of medical samples and emergency supplies, mapping, surveillance, and other professional use cases has grown rapidly. Drones are also being incorporated into planning in a variety of ways, such as traffic planning, resilience planning, asset management, surveying, and environmental planning (Veraart, Reel, and McConnell 2020). More information on the use of drones in the planning profession can be found in PAS Report 597, [Using Drones in Planning Practice](#).

The use of drones for consumer goods delivery is increasing worldwide, with a variety of small-scale planned, operational, and concluded demonstrations. In the United States, many of these early demonstrations have received FAA exemptions, such as approval for beyond visual line of sight (BVLOS) operations, operations over people, and the ability to operate as small UAS air carriers or “drone delivery airlines” (Cohen, Shaheen, and Farrar 2021).

Between 2017 and 2020, the FAA’s [UAS Integration Pilot Program \(IPP\)](#) brought state, local, and tribal governments together with private-sector entities, such as UAS operators and manufacturers, to accelerate safe drone integration (FAA 2021). The IPP demonstrated three core success areas: (1) safely integrating UAS into the National Airspace System (NAS); (2) understanding societal and community considerations; and (3) informing FAA policy and decision-making. The program funded nine lead participants that evaluated a host of operational concepts:



Figure 2.5. Pan Am's Manhattan passenger service (Pan Am/WikiArquitectura)

- Package delivery for consumer goods and medical supplies
- Flights over people and beyond the pilot's line of sight
- Night operations
- Detect-and-avoid technologies
- Reliability and security of data links between pilot and aircraft

Broadly, the IPP demonstrated diverse emergency, delivery, professional, and other drone use cases, including infrastructure inspections, social distance monitoring, medical specimen delivery, natural disaster damage assessments, agricultural monitoring, weather research, law enforcement operations, and food and package delivery.

There have also been notable international developments in delivery drone use. In the United Kingdom, Royal Mail has tested the use of drones to deliver parcels, personal protective equipment, and COVID-19 tests between the mainland and the Isles of Scilly near Cornwall, England. In parts of Africa, the use of drones has become an integral tool for rural health care delivery. Drones have been deployed for medical supply delivery since 2016 in Rwanda and since 2019 in Ghana. In addition to delivering medical supplies, drones were used during the pandemic to deliver COVID-19 test samples from remote areas that do not have testing facilities to laboratories in urban centers. Drones have also been used to expand access to medical care for patients who were unable to travel due to COVID-19 quarantines, such as delivering cancer drugs to patients in remote villages who were unable to travel to oncology centers during the pandemic (Cohen and Shaheen 2020).

Recent years have seen a flurry of activity around expanding AAM passenger services using innovative aircraft

designs. In 2021, several VTOL manufacturers and service providers became publicly listed companies on global stock exchanges:

- In May, BLADE Urban Air Mobility began trading on the National Association of Securities Dealers Automated Quotations (NASDAQ) following a merger with KSL Capital Partners.
- In August, Joby Aviation went public through a merger with Reinvent Technology Partners and listed on the New York Stock Exchange (NYSE).
- In September, Lilium went public through a merger with Qell Acquisition Corporation and listed on the NASDAQ. That same month, Archer Aviation listed on the NYSE following a merger with Atlas Crest Investment Corporation.
- In December, Vertical Aerospace went public and listed on the NYSE following a merger with Broadstone Acquisition Corporation.

These transactions have been conducted through special purpose acquisition companies (SPACs) that typically have no commercial operations and are formed to raise capital through an initial public offering (IPO) for the purpose of acquiring or merging with an existing company.

In addition, several automakers have announced investments in AAM, including Aston Martin, Audi, Daimler, Geely, General Motors, Hyundai, Porsche, Stellantis, and Toyota (Cohen, Shaheen, and Farrar 2021). And passenger airlines have announced investments in AAM. For example, both United and Mesa have invested in Archer Aviation, announcing plans to acquire up to 200 aircraft to provide airport shuttle service between smaller communities and hub airports (Sider 2021).

Several AAM services anticipate launching in the mid-to-late 2020s with aircraft certified by the FAA. Many of these aircraft will employ novel technologies and features, such as alternative fuels, VTOL, autonomous operation hardware and software, optionally piloted configurations, electric energy storage, and other innovations. As of February 2024, the Vertical Flight Society [lists](#) more than 950 electric VTOL aircraft under development (VFS 2024).

Some AAM business models involve a transition period to full autonomy that may include operations centers with remote operators controlling multiple aircraft. While the safety and operational risks need to be considered, the use of autonomy and remote pilots could reduce labor costs associated with AAM operations and help make services more affordable and financially sustainable.

AAM MARKET POTENTIAL

Several pre-pandemic market studies forecasted the global market potential for AAM to be between \$74 and \$641 billion in 2035 (Hasan 2018; Reiche et al. 2018; Porsche Consulting 2018; Morgan Stanley 2019). These studies also estimated a market potential of between \$2.8 and \$4 billion for the passenger service market segment and between \$3.1 and \$8 billion for the goods delivery market in 2030 (Cohen, Shaheen, and Farrar 2021).

Researchers have also attempted to estimate the market potential of AAM at the local and state levels. One study used geographic information systems (GIS) and a variety of data metrics to study the market potential for urban air mobility (UAM) in 84 global cities between 2020 and 2040 (Herman 2021). It identified more than 4,300 heliports valued at \$4 billion across all 84 cities and concluded that the availability of existing infrastructure will be a key factor in determining which metropolitan regions are early adopters of UAM. Another study used a mixed-method qualitative and quantitative approach comprising interviews, surveys, and GIS analysis to estimate the market potential of AAM in Ohio (Del Rosario et al. 2021). That study estimated that AAM will generate \$13 billion in commercial business activities between 2021 and 2045 for six uses cases involving passenger service, cargo logistics, and emergency services.

Though many of these studies suggest the potential for scaled operations and profitable services by the late 2020s and early 2030s, market forecasts vary considerably due to differences in assumptions (e.g., geographic region, timeline, autonomy), methodologies, and use cases examined. Additionally, changing economic conditions could cause original equipment manufacturers (OEMs), air carriers, and venture capitalists to change business models, capital expenditures, and investments in research and development. Longer-term modal shifts due to the growth of e-commerce, telework, and potential shifts to suburban and exurban lifestyles could also change the type of uses cases envisioned for AAM (e.g., rural health care delivery).

CONCLUSION

The concept of urban aviation is not new. But in recent years, new technologies have made new advances in air mobility possible, enabling on-demand aviation services similar to taxis and transportation network companies (TNCs) dispatched through a smartphone app.

While these innovations are beginning to serve a range of different use cases, the potential for a growing number of new users of low-altitude airspace in metropolitan areas is poised to impact communities in many ways. Planners need to understand how AAM may impact communities, how to engage stakeholders and the public, and how to plan and prepare for these innovations to guide sustainable and socially equitable outcomes.

The next chapter discusses the potential impacts and challenges of AAM and sets the stage for broader discussions in subsequent chapters of how community stakeholders and policymakers can guide sustainable and equitable outcomes through policy and community engagement.

CHAPTER 3

POTENTIAL CHALLENGES OF ADVANCED AIR MOBILITY

As an emerging concept, advanced air mobility (AAM) may face many barriers. These include concerns about safety and security, air traffic management, weather, noise, privacy, visual pollution, energy and environmental impacts, and land use compatibility. All of these issues could affect public perceptions and have an array of impacts on communities and planning practice.

This chapter provides an overview of these potential impacts of AAM on communities. First, the chapter reviews operational impacts that planners should be aware of today. It then explores potential community impacts that planners may be able to influence through planning practice. The chapter concludes with a discussion of how the impacts of AAM could influence public perceptions of AAM and community acceptance. Other related planning topics, such as concerns associated with social equity, multimodal integration, and community engagement, are discussed in Chapters 4 through 6.

OPERATIONAL CHALLENGES

There are four main potential operational challenges of AAM that planners should be aware of:

- Safety
- Security
- Air traffic management
- Weather

While planners do not have a direct role in preparing for and managing many of these risks, it is important for them to understand the role of state and federal agencies and what is being done to address these operational challenges.

In addition, there will be challenges associated with integrating AAM into existing transportation networks, societal systems, and the built environment. These integration topics are covered in greater detail in subsequent chapters of this report.

Safety

Concerns about the safety of AAM users, other airspace users, and bystanders (i.e., people on the ground being flown over by aircraft) represent challenges to growth, scaling, and mainstreaming of services. It is important for local and regional governments to understand that aviation safety is supported by a robust federal policy and regulatory environment governing aircraft and airworthiness; operations, including crew requirements; and access to airspace (Graydon, Neogi, and Wasson 2020; Thipphavong et al. 2018; Cohen, Shaheen, and Farrar 2021).

The Federal Aviation Administration (FAA) and other international civil aviation authorities work to promote the safety of all stakeholders by issuing and enforcing regulations, advisories, guidance, means of compliance, and minimum standards that address the following key areas:

- Aircraft manufacturing, operation, and maintenance
- Certification of pilots, aircrew, maintenance, and other personnel
- Certification of aviation facilities
- Operation of the network of air navigation, airspace, and air traffic management facilities, including developing air traffic rules and assigning the use of airspace

Additionally, state and local governments can promote safety for aviation facilities and operations through land use and zoning, building and fire codes, and law enforcement operations (Cohen, Shaheen, and Farrar 2021).

Significant safety risks for AAM related to aircraft and the operational environment that public agencies should be aware of include the following (Connors 2020):

- Ground safety, including aircraft access/egress and ground operations
- Flight outside approved airspace
- Unsafe proximity to people or property
- Critical system failure, including degraded or loss of command and control/GPS, or engine failure
- Loss of control, or flight control system failure
- Fires associated with fueling, charging, and energy systems
- Cybersecurity risks
- Hull loss
- Other potential hazards, such as weather, bird strikes, air and ground crew human factors (e.g., loss of situational awareness, task saturation), and passenger interference (e.g., disruptions, hijacking, sabotage)

Current legal, policy, and regulatory environments may present challenges for certifying and authorizing the use of some novel technologies and combinations of features that could be found in AAM aircraft (Coudert et al. 2019; Reiche et al. 2018; Connors 2020). These novel technologies include new aircraft designs and propulsion types, short and vertical takeoff and landing configurations (STOL/VTOL), autonomy hardware and software, optionally piloted configurations, electrification, alternative fuels, and others (Reiche et al. 2018; Coudert et al. 2019).

Existing regulatory frameworks and standards only address on-board piloted operations; they have not yet been developed for remotely piloted or autonomous flight. As noted in Chapter 2, however, some AAM business models involve a transition period to full autonomy that may include operations centers with remote operators controlling multiple aircraft. This will require the development of digital flight rules (Wing et al. 2022), and the role of autonomy will need to be considered as part of airworthiness certification, airspace access, crew training, certifications, and operational approvals (Reiche et al. 2018).

Security

Ensuring personal, personnel, and physical security, as well as cybersecurity, will be critical to managing risk, maintaining safety, and building public confidence in AAM. Air carriers, vertiport operators, and law enforcement at the local, state, and federal levels will play important roles in ensuring the security of AAM.

Exploratory focus groups convened in Los Angeles and Washington, D.C., have raised numerous concerns about the personal security of the passengers during booking, board-

ing, and traveling on the aircraft from departure to arrival (Shaheen, Cohen, and Farrar 2018). Key security concerns included hijacking, terrorism and aircraft sabotage, people pointing lasers at passengers and aircrew on takeoff and final approach, and unruly passengers and incidents involving passenger violence, particularly in an autonomous scenario without any aircrew on board.

Strategies to enhance personal safety and security for AAM include passenger background checks, no-fly lists for people convicted of certain criminal offenses, passenger rating systems, emergency dispatch buttons, and individual passenger compartments within an aircraft. The use of biometrics and trusted traveler programs like the Transportation Security Administration's PreCheck, which offers expedited security screening for passengers that have completed a vetting process, could also enhance AAM security, though these strategies present some additional risks that may also need to be considered. Further, there could be operational scenarios in which some AAM services or routes screen passengers and personnel, while others do not. The potential for these variations may need to be considered by practitioners planning vertiports for AAM.

The public sector will need policies and procedures to mitigate the risk of insiders (i.e., workers, contractors, vendors) from exploiting legitimate access to AAM infrastructure and services for unauthorized purposes. Moreover, strategies will be needed to ensure the physical security of takeoff and landing infrastructure, aircraft, charging/refueling facilities, other physical infrastructure, and cargo. Finally, ensuring the cybersecurity of all information technology systems, including but not limited to ticketing and booking, air traffic management, communications, navigation, surveillance, and autonomous aircraft systems will be critical.

In the future, close coordination among local and regional governments, law enforcement, state departments of transportation (DOTs), national security agencies, and private-sector stakeholders will be necessary to establish security standards and emergency plans for an array of scenarios.

Air Traffic Management

Under existing laws and regulations, the FAA has exclusive authority over the National Airspace System, but it will be helpful for planners to understand potential AAM airspace conflicts and how they may be regulated by the FAA (Serrao, Nilsson, and Kimmel 2018).

AAM operations will likely occur at relatively low altitudes and in dense urban environments (Cohen, Shaheen, and Farrar 2021). One of the principal challenges with AAM

is that it will likely have to interact with existing commercial aviation and small uncrewed aircraft system (sUAS)/small drone ecosystems in a variety of contexts.

Commercial airlines operate with experienced pilots in controlled airspace in which air traffic controllers have the authority to direct air traffic. In contrast, small drones have generally evolved in low-level and uncontrolled airspace using a different set of regulations, often with relatively inexperienced operators. AAM services operating in urban areas—especially at or near large and medium-sized airports with commercial airline activity—will have to interact with both of these operational environments and likely traverse controlled as well as uncontrolled airspace. AAM will need to ensure safe takeoff, approach, and landing alongside small drones, which typically operate below 400 feet, and it will need to avoid collisions with commercial aircraft (FAA 2018). This will require deconflicting and prioritizing users of shared airspace and managing air traffic congestion as the volume and frequency of AAM activity increases (Graydon, Neogi, and Wasson 2020; Neogi and Sen 2017).

In recent years, the FAA has begun taking steps to manage risks related to AAM air traffic management. The FAA's [Urban Air Mobility \(UAM\) Concept of Operations \(ConOps\) v2.0](#) anticipates that initial AAM operations will

comprise a small number of low-complexity operations and will evolve to mature-state operations with a high density and high rate of complex operations. As the operational tempo of AAM increases, the ConOps envisions the establishment of “urban air mobility/UAM corridors” (see Figure 1.2, p. 14) in which piloted aircraft will have the capability to exchange information with other corridor users to deconflict traffic without relying on air traffic control (FAA 2023b).

Due to federal preemption in airspace management, the best approach for local governments, metropolitan planning organizations (MPOs), and state DOTs is to monitor the growth and complexity of AAM operations and work with the FAA on strategies to manage airspace risks, as appropriate.

Weather

As with other small aircraft, weather will pose safety and operational challenges for AAM (Reiche, Cohen, and Fernando 2021). Weather-related risk conditions include low visibility, snow or ice accumulation, wind shear, and lightning. Knowing how weather conditions impact AAM can help planners better understand the potential feasibility of AAM in communities and regions.

Table 3.1 describes some of the common weather conditions that could impact AAM. Weather-related risks may

TABLE 3.1. COMMON ATMOSPHERIC CONDITIONS THAT MAY IMPACT AAM

Condition	Description
High winds	High winds and wind gusts can create safety, reliability, and passenger comfort challenges for AAM operating at low altitude and high-density built environments. High-rise buildings can create canyon effects that produce unpredictable wind environments in urban centers.
Ice	Snow and ice can stick to critical aircraft surfaces (e.g., wings and rotors). De-icing systems and icephobic surfaces may be able to help mitigate some of these risks.
Low temperatures	Air temperatures below freezing can decrease the range and longevity of batteries for electric propulsion, which many AAM aircraft are anticipated to use.
Precipitation	Rain, snow, sleet, and hail can create a variety of hazards for aircraft, which can include turbulence, tornados, icing, lightning, hail, heavy rain, downdrafts/microbursts, and other hazardous conditions.
Turbulence	Turbulence is an irregular motion of the air resulting from the air currents. Smaller aircraft are typically more susceptible to turbulence.
Visibility	Low visibility can limit a pilot's ability to safely fly, particularly during critical phases of flight such as takeoff and landing. Under instrument flight rules (IFR), which govern aircraft when flight by outside visual reference is not safe, pilots are still required to visually observe the landing environment. In the future, autonomous aircraft may be able to land in a greater variety of low-visibility conditions; however, minimum visibility requirements may still be needed given potential technological limitations of landing systems.
Wind shear	This sudden change in wind speed or direction can be particularly hazardous during critical phases of flight.

be exacerbated for AAM due to low-altitude operations over urbanized areas and the transition from vertical to horizontal flight required for VTOL operations. Strategies used in commercial aviation to overcome adverse weather conditions, such as delaying or rerouting flights to alternate airports, are not viable strategies for AAM because its value proposition is premised on convenience and time savings over other transportation modes. Additionally, proposed technologies for autonomous flight operations, such as lidar (light detection and ranging), may be degraded in low visibility conditions.

One exploratory study of AAM found that no more than 16 percent of aggregate operational time will be impacted by weather. However, the study also notes that certain markets, such as New York City and London, could have greater weather constraints (Holden and Goel 2016). A key limitation of this study is that it focuses on case studies of specific locations rather than large multicity analyses.

Another exploratory AAM climatology analysis of 10 U.S. cities with a variety of weather patterns found the most favorable weather in the Pacific region. Average weather conditions were found to be less favorable for AAM in most seasons along the East Coast and in the Southwest due to higher frequencies of nonvisual flight rules conditions, high winds, and vertical wind shear, while critical weather challenges in the Rocky Mountain region included lower temperatures, strong winds, and thunderstorms (Reiche, Cohen, and Fernando 2021). However, it is difficult to precisely estimate the impacts of weather on AAM operations due to the variety of aircraft under development, each with different design characteristics and performance limitations. Additionally, the proprietary nature of these aircraft concepts results in limited publicly available information about their performance. While aircraft design and technology may be able to expand performance limits, some weather challenges are likely to remain (Reiche, Cohen, and Fernando 2021).

As AAM scales and employs greater levels of autonomy, there will likely be a need for more granular weather data for AAM and other modes of transportation, such as automated ground vehicles. Local and regional governments, state DOTs, the private sector, and other stakeholders may play an important role in collecting, analyzing, and sharing this information. Additionally, the scalability of AAM may depend on the ability to provide dependable service with minimal delays. The integration of AAM into mobility on demand (MOD) and mobility as a service (MaaS) platforms could help improve traveler reliability and minimize delays by automatically routing a traveler's journey around travel dis-

ruptions, such as shifting trips from AAM to other modes at the onset of adverse weather (Shaheen et al. 2020). Additionally, AAM service providers may be able to use mixed fleets of aircraft with different performance capabilities suited for a variety of seasons, weather conditions, and climates.

COMMUNITY IMPACTS

Potential impacts of AAM on community members include the following:

- Noise
- Privacy
- Visual pollution
- Energy use and emissions
- Infrastructure siting and land use compatibility

Planners should better understand these potential impacts and how land use, zoning, infrastructure siting, and other planning and policy levers may serve as mitigation strategies. Chapters 4 and 5 discuss the potential impacts of AAM on social equity and multimodal integration, as well as the role planners can play in guiding sustainable and equitable outcomes. The full range and intensity of AAM impacts will become clearer as AAM deployments begin to occur, but demonstrations and field tests can help communities and planners better understand the potential for disruption, as discussed in the sidebar on [p. 27](#).

Noise

Aircraft and helicopter noise are a common concern in neighborhoods around airports and heliports (FAA 2023a). The high level of rotorcraft noise will likely continue to limit the use of helicopters for nonemergency use cases in many urban areas. One study estimates that electric vertical takeoff and landing (eVTOL) aircraft should be one-half as loud as a medium-sized truck passing by a house (75 to 80 decibels (dB) at 50 feet, approximately 62 dB at 500 feet altitude)—about one-quarter as loud as the smallest four-seat helicopter on the market (Holden and Goel 2016).

Although research on AAM noise and planning is limited, a few emerging studies on the public perception of AAM noise provide insights on the topic. A 2018 general population survey (N=1,540) conducted in Los Angeles, Mexico City, Switzerland, and New Zealand found that the second- and third-highest factors impacting the public perception of AAM are the type of sound generated by eVTOL aircraft,

DOCUMENTING THE IMPACTS OF AAM ON COMMUNITIES

Insight into the impacts of AAM can help planners understand the effects of early deployments and aid planners in guiding sustainable and equitable outcomes to achieve planning and public policy goals. However, this can be difficult to achieve due to limited research on early AAM demonstrations.

While some exploratory studies have attempted to provide early insights into community impacts and willingness to use AAM through surveys, the lack of personal experience using or observing AAM in communities makes it difficult for survey respondents to accurately respond to these types of questions. To enhance understanding and improve data validity, more research is needed to understand the impacts of AAM and the perceptions of users and nonusers of these services through experiential methods such as flight simulations, augmented reality, virtual reality, field operational tests, and other immersive experiences.

Field operational tests and demonstrations are key tools that can help both public- and private-sector stakeholders study AAM pilot deployments and test policies, use cases, and processes. These demonstrations can play a key role in helping communities to prepare for and implement AAM, validating technical and institutional feasibility, measuring the impacts of program deployments, and serving as venues for evaluating public policies and regulations that can either support or hinder AAM use and community acceptance. Demonstrations also can enable stakeholders to explore AAM innovations, monitor successes, adapt strategies, mitigate risks, and maximize the potential for successful deployments.

followed by the volume of sound generated from the aircraft (Yedavalli and Mooberry 2019). Similarly, an exploratory 2018 study ($N=1,700$) using focus groups in Los Angeles and Washington, D.C., and a general population survey in five U.S. cities found that noise levels could impact support for AAM by the public (Shaheen, Cohen, and Farrar 2018).

Unfortunately, it is difficult to estimate the precise likelihood or magnitude of noise from AAM operations. The effect of factors such as aircraft and propulsion type, noise characteristics, time of day, takeoff and landing procedures, and even use case means that similar aircraft types and sizes may have very different sound profiles. Context can also play

AAM demonstrations can focus on three types of impacts:

- Neighborhood impacts, such as the environmental, economic, or quality-of-life impacts of AAM on areas adjacent to takeoff and landing infrastructure
- City impacts, such as the effects of AAM on community economic development
- Regional impacts, such as the effects of AAM on regional mobility, logistics, and emergency response

As part of any demonstration, it is important for stakeholders to determine the type of scale at which they are seeking to understand impacts and target their field operational tests accordingly.

When demonstrating or evaluating any AAM deployment, stakeholders should do the following:

1. Define their demonstration objectives
2. Identify hypotheses that can be tested
3. Develop performance metrics for assessing demonstration impacts
4. Identify data sources needed to evaluate performance metrics
5. Define methodologies (quantitative, qualitative, or both) to guide data analysis

After these steps are completed, stakeholders can implement an evaluation of the demonstration/field operational test.

a role; for example, the public may perceive noise from air ambulances to be highly disruptive, but they may be willing to accept the noise because the use case is less frequent and serves a broader societal benefit.

Planners should be aware of the following AAM noise considerations:

- Volume of AAM noise (e.g., dB level)
- Length of time AAM noise occurs
- Time of day AAM noise occurs
- Type or frequency of AAM noise
- Number of people affected by AAM noise

- Location of AAM noise and proximity to sensitive land uses
- Number and location of takeoff and landing infrastructure
- Comparison of AAM noise to other ambient noise
- Differences between individual AAM aircraft noise compared to noise from scaled AAM operations

The Airport Noise and Capacity Act (ANCA) of 1990 prohibits local governments from implementing noise restrictions on aircraft; failure to comply can result in an airport losing access to FAA Airport Improvement Program funds. ANCA was intended to standardize how airport stakeholders approach noise issues, resulting in less litigation and more collaboration (Castagna 2020). It is important to note that the FAA does not specify aircraft noise exposure limits for communities near airports, but instead regulates noise emissions from types of aircraft permitted to operate at U.S. airports. Although airports can apply to the FAA to impose additional noise restrictions, such as curfews under FAR Part 161, as of April 2020 no airports had received approval (Castagna 2020).

Instead, local governments can plan for and mitigate aviation noise primarily by promoting land use compatibility and requiring real estate disclosures for properties subject to aviation noise impacts. At present, the primary mechanism for local, regional, and state agencies to influence noise impacts may be through land use planning and zoning for takeoff and landing infrastructure, such as vertiports. In some cases, noise risk could be mitigated through minimum distance requirements between vertiports and sensitive land uses, such as residential zoning and open space. During the vertiport planning process, a public agency may approve a private vertiport conditionally if the owner or operator prohibits flight operations during late night and early morning hours. Local governments can also negotiate with AAM operators to reach voluntary agreements that mitigate noise impacts on the community, and they can reach out to the FAA and request a re-evaluation of flight paths. Owning, operating, or funding vertiports may allow local governments to have greater influence on AAM operations. In other cases, local agencies may be able to reduce the impacts of AAM noise through building codes, grant programs, and other practices requiring or incentivizing the use of sound-deadening material in structures near vertiports and along key flight paths (USDOT Volpe Center 2017). Other noise mitigation measures, such as reducing noise through aircraft design, may be more appropriate for the FAA and private industry.

Planners can also take note of efforts by some airports to proactively reduce noise to be good neighbors, reduce

noise complaints, engage community stakeholders, and support airport growth. Seattle-Tacoma International Airport has implemented a voluntary program designed to reduce late-night noise by increasing airline awareness of noise impacts on local communities. The airport uses noise monitors to track overnight aircraft noise that exceeds certain decibel levels and publishes a quarterly report disclosing airline performance. San Francisco International Airport has implemented policies intended to reduce noise exposure, such as restricting the use of auxiliary power units and prohibiting engine tests and run-ups overnight; using preferred runways that minimize flight activity at night over populated areas whenever possible; and requiring helicopters to hold over water, industrial land uses, and highways. The Van Nuys, California, airport has a history of adopting noise mitigation measures ahead of the general aviation industry, such as a residential soundproofing program and other voluntary programs (Castagna 2020). These approaches could be applied by vertiports to voluntarily minimize AAM noise and maintain positive relationships with their surrounding communities. These examples stand in contrast to other cases in which smaller airports are being closed in response to community complaints about noise and quality of life; the Santa Monica, California, airport is scheduled to close in 2028 for this reason (Santa Monica 2020).

While some airports have set recommended thresholds for noise around their facilities, AAM may need to meet a stricter noise standard due to the nature of low-level flight over highly populated urban areas, coupled with scaled operations (Holden and Goel 2016). Noise concerns could be mitigated through technological improvements in aircraft design and electrification, or they could persist as the market matures into larger-scale operations, increasing the total ambient aircraft noise from multiple aircraft operating in close proximity. Additionally, a future reduction in ambient urban noise as surface transportation transitions from internal combustion engines to electric and hydrogen power could make aircraft noise more perceptible than it is today. In the future, legislative and regulatory changes also could expand policy mechanisms for noise abatement by local communities, MPOs, and state DOTs.

Privacy

Privacy represents another potential AAM planning challenge. This encompasses both physical privacy—for example, residential communities concerned about the privacy impacts of low-altitude aircraft—and data privacy, including protection of personally identifiable information. Privacy

concerns associated with AAM data collection, sharing, and management center on traveler or user privacy. With respect to data privacy, state and federal legislation may be needed to protect the sharing, storage, and maintenance of consumer data. It is important to note that this type of legislation may not be specific to AAM.

While studies on the potential physical privacy impacts of AAM are limited, some emerging research on the privacy issues related to small drones may provide some insight. Several qualitative and quantitative studies examining the perception of bystanders about drone privacy have found that the public has notable concerns relating to stalking, photo/video recording, the sharing of recorded information, and the use of small drones near residential land uses (Wang et al. 2016; Rice et al. 2018; Winter et al. 2016; Uchidiuno, Manweiler, and Weisz 2018; Bajde et al. 2017).

Regulation has not kept pace with the potential technological and privacy concerns associated with small drones (Winkler, Zeadally, and Evans 2018; Jenkins 2013; Popescu Ljungholm 2019), although some states have begun to pass legislation intended to protect the privacy rights of individuals from aerial surveillance. In 2015, California ratified Assembly Bill 856, which allows a person to be liable for the physical invasion of privacy when they knowingly enter the land or airspace above the land of another person without permission to capture a visual image or sound recording. Other concerns have been raised about governmental use of small drones and potential civil liberty and privacy concerns. Planners may be able to help mitigate some privacy risks through zoning and the placement of takeoff and landing locations.

Visual Pollution

An overcrowding of low-altitude aircraft in urbanized areas could create unwanted visual disturbances (Cohen and Shaheen 2021). The risks associated with visual pollution from AAM are difficult to ascertain because aesthetic impacts can vary based on a combination of quantitative and qualitative factors. These include frequency of operations, location of operations relative to surrounding land uses, aircraft size, and other characteristics. For example, the public may be more sensitive to the presence of an air taxi flying over an historic neighborhood or greenspace than over the parking lot of a shopping mall. Similarly, the public may be more concerned with multiple aircraft in close proximity to one another, such as near a vertiport with a high volume of air traffic. The public also could be concerned by the size of an aircraft in the sky or by the color or materials, such as if the

aircraft is reflective and creates glare. For these reasons, the potential impacts of visual pollution are diverse and difficult to quantify.

A few studies have attempted to understand the potential aesthetic impacts of AAM and small drones through exploratory user surveys. However, the lack of personal experience observing AAM in a real-world environment can make it challenging for survey respondents to accurately respond to these types of survey questions.

Research on the aesthetic impacts of small drones may be able to provide some insight. In June 2016, a survey ($N=1,465$) administered by the U.S. Postal Service focused on potential public concerns on the use of drones. The study found that approximately one in five respondents raised concerns about the visual pollution associated with drone use. Interestingly, the findings were consistent across respondents in urban, suburban, and rural communities (USPS Office of the Inspector General 2016). More recently, a six-city survey representing Barcelona, Budapest, Hamburg, Milan, Paris, and Öresund ($N=3,690$) conducted by the European Union Safety Agency in November 2020 on the potential societal barriers associated with AAM found that 19 percent and 16 percent of survey respondents raised concerns about visual pollution from small drones and air taxis, respectively (European Union Aviation Safety Agency 2021). Collectively, emerging research suggests that visual pollution from AAM could be perceived as an environmental concern; however, more research is needed.

Energy Use and Emissions

Energy consumption, emissions, and energy infrastructure could represent another potential challenge of AAM. Interest in AAM has closely been linked to developments in propulsion technologies, such as electric-powered aircraft. Some proponents of AAM argue that the shared use of electric aircraft could result in emission reductions relative to gas-powered ground vehicles, small aircraft, and helicopters.

A 2019 study modelled the environmental impact of eVTOLs using estimates for average U.S. electricity generation emissions. The model's outputs suggest that an eVTOL aircraft with one occupant (i.e., a pilot and no other passengers) would result in 35 percent lower greenhouse gas emissions than a single occupant gas-powered ground vehicle, but 28 percent higher emissions than a battery electric ground vehicle (BEV) with the same occupancy. An eVTOL carrying three passengers would result in lower emissions than conventional ground vehicles and BEVs with an average occupancy of 1.54 (Kasliwal et al. 2019).

However, limitations in aircraft range and charge times could present challenges to electric aviation growth. As suggested by the study cited above, pooled flights with multiple passengers will be important to the extent to which reductions in energy consumption and emissions may be achieved. Finally, lifecycle emissions and the potential for induced demand—when improvements in transportation contribute to increased travel behavior—will need to be considered as part of energy and environmental planning.

Ensuring a network of refueling facilities (e.g., aviation fuel, hydrogen, and other alternative or biofuels), charging infrastructure, and battery swapping could create a variety of logistical, operational, and technical challenges, though infrastructure such as ground battery storage could help manage peak AAM electricity use and flatten demand on the power grid. AAM will most likely require new electric charging infrastructure and power grid improvements, which require significant lead times for planning, budgeting, permitting, and construction. AAM infrastructure needs are addressed in greater detail in Chapter 5.

Infrastructure Siting and Land Use Compatibility

The deployment of AAM will require an extensive network of takeoff and landing, energy, and digital infrastructure. While AAM may be able to use existing airports and heliports initially, its growth and evolution will likely require repurposing, renovating, adapting, replacing, redeveloping, or constructing infrastructure.

New infrastructure close to origin and destination pairs will likely be needed to reduce the number of modal connections and travel times associated with first- and last-mile connections to takeoff and landing locations (Yedavalli and Cohen 2022). In urban areas, this can present challenges due to limited land for new infrastructure; heights of existing buildings and structures that could impact airspace to and from new takeoff and landing locations; availability of enabling infrastructure, such as for charging or fueling and information technology; and the impacts of AAM operations on surrounding communities (Yedavalli and Cohen 2022). These issues could be magnified if infrastructure is available only as exclusive use to one service provider in markets with multiple operators.

Adapting existing facilities or constructing new infrastructure could face a variety of difficulties, such as local concerns, cost, and multimodal integration. Because AAM has the potential to decentralize the impacts of aviation that have typically been limited to airport facilities and their immediate surroundings, understanding the relationship

of the built environment and infrastructure siting will be important to integrating AAM with adjacent land uses and prioritizing sustainable ground connections to and from takeoff and landing locations. Although existing studies are limited, planners will need to assess a variety of factors when considering infrastructure siting, such as the myriad of potential impacts on nearby land uses and vertiport access for emergency services. Chapters 5 and 6 discuss infrastructure planning and land use compatibility issues in greater detail.

PUBLIC PERCEPTION AND COMMUNITY ACCEPTANCE

While AAM presents potential opportunities for localities, negative community perceptions could pose challenges to AAM adoption and mainstreaming. Public perception and community acceptance will likely be influenced by the following operational and community impacts, most of which have been discussed previously in this chapter:

- Noise and visual pollution
- Privacy, particularly for flights over residential land uses
- Social equity (perceptions that AAM is a mode for wealthy households to buy their way out of traffic congestion)
- Personal safety, with other passengers in a small space
- Safety and airworthiness of both small and new aircraft designs
- Infrastructure locations
- Flight paths over particular land uses or during particular times
- Range anxiety (fear of electric aircraft batteries running out of power before arrival at the destination)
- Apprehension regarding autonomous flight

The 2018 general population survey conducted in Los Angeles, Mexico City, Switzerland, and New Zealand mentioned earlier in this chapter found around 45 percent of respondents' initial reactions were in support of AAM (Yedavalli and Mooberry 2019). Similarly, the 2018 general population survey conducted across five U.S. cities found neutral to positive initial reactions to AAM, although around 20 percent were skeptical. Respondents felt safer about piloted AAM aircraft flying overhead (41 percent) compared to automated aircraft with no attendants (23 percent) (Shaheen, Cohen, and Farrar 2018).

Results from stated preference questions in this study indicated that age, gender, and familiarity with the concept

of AAM were statistically significant predictors of whether a person would consider using AAM. These and other exploratory studies suggest that AAM adoption may vary by sociodemographics, with adoption higher among younger individuals, males, those with high household income, and those with higher educational attainment (Yedavalli and Mooberry 2019; Shaheen, Cohen and Farrar 2018; Fu, Rothfeld, and Antoniou 2019). The lack of public experience with AAM aircraft and scaled operations represents notable limitations to these studies, as it is difficult for respondents to accurately comment on something they have no direct experience with. More research is needed to advance understanding of potential challenges in this area.

Ongoing community engagement and research are needed to further advance understanding of societal barriers and explore policies that can maximize the public good. In July 2019, the nonprofit [Community Air Mobility Initiative](#) (CAMI) was established to educate and provide resources and collaboration opportunities to local, regional, and state decision-makers. Planners and public agency staff can access online resources, as well as in-person and online seminars, through the CAMI website. CAMI's [Urban Air Policy Collaborative](#) (UAPC) provides a structured forum for public agencies to discuss AAM issues and develop policies, strategies, and emerging practices. At the federal level, the FAA and NASA are both engaging with stakeholders and developing guidance to help communities understand and prepare for AAM, as discussed in the sidebars on [pp. 32–33](#) and [pp. 34–35](#). Planners can look to both agencies for additional resources on this emerging transportation technology.

CONCLUSION

There are a number of potential operational challenges to AAM, including safety, security, air traffic management, and weather. While planners typically do not have a direct role in the operational aspects of AAM, it is important for them to understand what different levels of governance are doing to mitigate potential risks. While safety is generally regulated by the FAA, state and local governments can promote safety through land use and zoning, building and fire codes, and law enforcement operations.

As an emerging mode of transportation, AAM may have a variety of potential community impacts, such as noise, privacy, visual pollution, energy use and emissions, and infrastructure siting and land use compatibility. At the local and regional level, planners can play an important role

in mitigating these impacts and guiding sustainable outcomes through land use, zoning, infrastructure siting, and other planning and policy strategies, such as stakeholder and community engagement.

Operational concerns, environmental impacts, and public perception of AAM could pose challenges to its adoption and mainstreaming in the future. Field operational tests and demonstrations have the potential to enable communities to explore AAM use cases and innovations, monitor impacts, adapt if necessary, reduce the risk of failures, and maximize the potential for success.

In addition to community impacts, social equity and environmental justice may be one of the largest barriers to community acceptance. The next chapter discusses potential social equity issues associated with AAM and how some of these concerns could be addressed through planning, policy, and prioritization of emergency response and humanitarian use cases.

THE FAA AND ADVANCED AIR MOBILITY

Colleen D'Alessandro, New England Regional Administrator, Federal Aviation Administration

The Federal Aviation Administration (FAA) is the safety regulator for the U.S. aviation industry, which includes the emerging advanced air mobility (AAM) sector. Our mission is to ensure the highest levels of safety in these new operations to protect the traveling public as well as people and property on the ground. Additionally, the FAA operates the National Airspace System 24/7/365, and AAM operations must be integrated safely and efficiently into this existing system. These two federal roles—regulatory and operational—are critical for the introduction of AAM technologies into cities and communities.

Our job is to ensure this new generation of aircraft maintains the high level of safety that defines commercial aviation today. This effort will involve the following responsibilities:

- Certifying the designs of these aircraft with the AAM manufacturers
- Finalizing the operating framework, such as pilot qualifications and training
- Integrating these new operations into the existing aviation system, which involves not just the airspace, but also vertiports, other industries, local communities, and the international community

The FAA does not promote or advocate for the adoption of any specific AAM technologies. Our primary role is to ensure safety as the AAM sector becomes part of the aviation system. That nuance is sometimes lost, but it's important to recognize. The innovative industries and the proposed operators are the ones leading the charge to bring these new technologies into the system and into communities. The FAA is doing its part to ensure safe integration when they are ready.

It is important to remember that the FAA is also a service provider. It manages air traffic on any given day based on what that day brings. The FAA does not decide what type of aircraft an operator decides to fly, what time of day an aircraft flies, or which routes operators fly. Those decisions are based on market demand and business decisions by the operator. That practice will remain true with AAM.

At the local level, the FAA's role intersects with AAM starting with a community's decision to build a vertiport. Once a community decides where they would like to build a vertiport, the FAA looks at where and when the operator wants to go. That information will help determine how to work them into the airspace operation. In most U.S. communities, airports

were constructed 50 to 100 years ago. The FAA developed flight paths based on the airport's layout and geometry of its runways. A similar process will be needed today when a community decides to plan for a vertiport.

Construction of on-airport vertiport facilities may require FAA notification under [14 CFR Part 77, Safety, Efficient Use, and Preservation of Navigable Airspace](#), and updates to an airport's FAA-approved airport layout plan (for federally obligated airports). Modifications to existing federally obligated infrastructure will also undergo FAA environmental review and associated public involvement requirements. Facilities that do not require FAA approval or funding may be responsible for community engagement consistent with local rules.

Communities, developers, and operators may also choose to establish new vertiports not co-located with an existing airport or heliport. State licensing and local zoning ordinances may require updates to accommodate these new types of landing facilities. Where no federal funding is used, FAA oversight and engagement with these new vertiports and their surrounding communities may be limited.

Communities are encouraged to plan for vertiports capable of accommodating multiple operators that will benefit passengers. They should also plan for equitable, multimodal placement of vertiports to connect transportation systems without creating new sources of traffic congestion and parking concerns. Construction of new infrastructure would trigger FAA notification under [14 CFR Part 157, Notice of Construction, Alteration, Activation and Deactivation of Airports](#).

Tribal, State, and Local Government Roles

Many critical roles and responsibilities are within the purview of tribal, state, and local governments that must be considered and implemented for successful AAM operations. Each state will likely have a slightly different approach, and tribal, state, and local government roles will likely be enhanced within the AAM ecosystem compared with other portions of aviation. Some of these enhanced roles include the following:

- Land use
- Zoning
- Funding
- System planning
- Vertiport siting
- Governance
- Construction permitting
- Building codes
- Licensing
- Oversight
- Multimodal considerations
- Utilities and electrification

- Community engagement and awareness
- Equity and accessibility
- Economic and community benefits
- Environmental review

Planners should be familiar with how their region is addressing all these topics to enable AAM operations in their area.

Engagement

Collaboration and early engagement at all levels of government is essential for the successful implementation of AAM operations. Engagement must be multidimensional: horizontally across the local jurisdictions in a metropolitan area, as well as vertically at local, state, tribal, and federal government levels.

If a city or local planner wants to engage with the FAA about AAM, the best place to start is with the local FAA regional administrator. Each of the FAA's nine regions (Figure 3.1) is led by a regional administrator responsible for horizontal integration across the agency at the local and regional level, community engagement efforts, and coordination of FAA activities with federal, tribal, state, and local government stakeholders. Click on [the map on this webpage](#) to find the regional administrator for your area.

FAA Resources for Planners

Beyond the regional administrator points of contact, the FAA has various resources and background materials that planners can use to inform their local efforts:

- The FAA's first [Engineering Brief on Vertiport Design](#) (August 2022) with interim safety guidance for planning, designing, and building a vertiport
- An [updated blueprint](#) (May 2023) for airspace and procedure changes to accommodate future AAM operations
- A proposed [comprehensive rule](#) (June 2023) for training and certifying pilots
- An [implementation plan](#) (July 2023) detailing the steps that the FAA and others will need to take to safely enable AAM operations in the near term

The FAA also has a formal advisory committee, the [Advanced Aviation Advisory Committee](#) (AAAC), that provides consensus recommendations on AAM topics. All meetings are open to the public and live streamed. You may also visit the [AAM informational webpage](#) to learn more about this emerging sector of aviation. The FAA is always here as a resource for you and ready to engage as a stakeholder in your early AAM community discussions.

Figure 3.1. The nine FAA regions (FAA)



ADVANCED AIR MOBILITY ECOSYSTEM WORKING GROUPS

Nancy Mendonca, Deputy AAM Mission Integration Manager, NASA

As National Aeronautics and Space Administration (NASA) began to pivot its research portfolio to include urban air mobility (UAM) and, later, advanced air mobility (AAM), the Aeronautics Research Mission Directorate (ARMD) looked across the nascent ecosystem to assess planning opportunities, barriers to adoption, and gaps in understanding. One of the gaps ARMD identified was a forum in which the ecosystem members could learn, exchange ideas, and provide perspectives on a variety of topics. In response, it created the [Advanced Air Mobility Ecosystem Working Groups](#) (AEWG) in 2020.

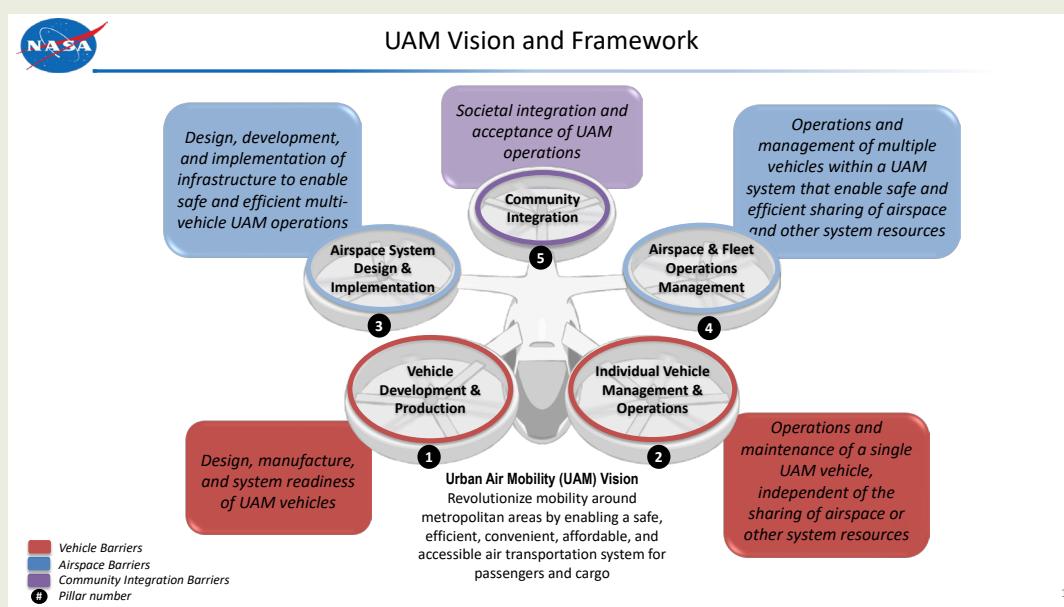
To address stakeholder needs and potential future gaps, the AEWG provides information on AAM-related topics with a variety of depth and breadth, ranging from planning and policy considerations to deep technical knowledge. It consists of four working groups—Aircraft, Airspace, Community Integration, and Crosscutting—reflecting the five pillars in the UAM framework depicted in Figure 3.2. Of particular interest to planners, the [Community Integration Working Group](#) seeks to provide information relevant to state, local, and tribal planners and policymakers.

Since 2020, more than 100 AEWG meetings have been held virtually, and NASA has made meeting [recordings and resources](#) accessible for planners and policymakers. In addition

to the AEWG resources, ARMD also maintains an [AAM portal](#) offering additional NASA resources. During the pandemic, each group typically met monthly, but as more in-person forums have become available, each group is now meeting approximately every other month.

The AEWG continues to provide a unique contribution to ecosystem members. It remains crosscutting, spanning information from foundational to deeply technical and readily available. Together with offerings by other ecosystem members—such as the American Institute of Aeronautics and Astronautics and the Vertical Flight Society for technical research; the Transportation Research Board and its National Aviation System Planning Symposium for multimodal transportation research; planning-focused efforts such as those hosted by the American Planning Association and the Association of Metropolitan Planning Organizations; state and tribal members' events held by the National Association of State Aviation Officials and National Transportation in Indian Country Conference; locally focused events hosted by the National League of Cities and the National Association of Counties; and smart cities and tailored sessions like those offered by the Community Air Mobility Initiative—there are multiple sources to meet the current and future needs for

Figure 3.2. NASA's Advanced Air Mobility Ecosystem Working Group addresses the five components of the UAM framework (NASA ARMD)



state, local, and tribal ecosystem members, whether they are just learning about AAM, planning for initial operations, or developing multidecade planning documents to guide future transportation investments.

Looking forward, the AEWG will continue to meet current and future needs of the ecosystem by providing a venue for ecosystem stakeholders to engage one another and discuss

topics that are timely and relevant to community integration partners and other ecosystem stakeholders. Local and regional planners and policymakers are encouraged to participate in the AEWG [Community Integration Working Group](#) and to engage in the conversations and provide input on potential future topics to be discussed within this working group.

CHAPTER 4

SOCIAL EQUITY AND ADVANCED AIR MOBILITY

Social equity is key to ensuring broad access to the potential benefits of advanced air mobility (AAM), which include aeromedical services, jobs access, and economic development. Social equity is “the state, quality, or ideal of being just, impartial, and fair” (Loper, Woo, and Metz 2021). It needs to be thought of as a structural and systemic concept to be achieved and sustained.

This chapter explores the complex social equity issues related to AAM: affordability and accessibility, gentrification and displacement around vertiports, the impacts of vertiports on neighborhoods and underserved populations, and the role of humanitarian use cases like emergency response in expanding AAM access and benefits to all communities.

The chapter begins by providing an overview of the potential social equity impacts of AAM. Next, it applies the STEPS (spatial, temporal, economic, physiological, and social) equity framework developed by Shaheen, Bell et al. (2017) to AAM, assessing equity issues, barriers, and potential policy strategies. Finally, this chapter discusses the role of stakeholder and community engagement to support equitable AAM planning and implementation.

POTENTIAL SOCIAL EQUITY IMPACTS OF AAM

Broadly, the social equity impacts of AAM can be organized into three categories: the impacts associated with vertiport development and AAM operations on their immediate vicinity; concerns about affordability and accessibility of AAM flights; and environmental justice and the allocation of public resources. All will be important for planners to address when considering AAM in their communities.

Vertiport Placement and Operations

The development of vertiports within a community will have impacts on surrounding neighborhoods that planners must consider. Transit-oriented development (TOD) is a well-established approach that increases density and use types around transit stations to create dense, walkable, mixed-use development that attracts people and adds to vibrant, connected

communities (Federal Transit Administration 2023). Similarly, vertiport-oriented development (VOD) has the potential to support mixed land uses, such as residential, retail, and office, in the vicinity of takeoff and landing locations. Local and regional governments can encourage VOD through land use planning, zoning laws, and changes to building codes and other policies. Chapter 5 discusses VOD, joint development, and multimodal integration in greater detail.

However, like TOD, VOD has the potential to cause gentrification and displacement. Gentrification is the upgrading of previously disinvested neighborhoods and is typically followed by displacement: the movement of people and businesses from their original neighborhood, often because they have been priced out of that location (Hansen 2021). Displacement also can occur in the absence of gentrification; for example, if the local government chose to use eminent domain to take previously developed land and construct a vertiport (Hansen 2021).

Tools that may be able to minimize gentrification and displacement from vertiport development include the following:

- **Affordable housing trust funds:** Funds managed by a public agency or nonprofit can assist in the financing, development, and preservation of affordable rental housing in the vicinity of vertiport development.
- **Neighborhood trust:** Neighborhood trusts managed by existing neighborhood organizations and accountable to the neighborhood’s priorities can develop, own, and operate rental housing and retail portfolios near vertiport locations in the interest of current residents.
- **Land banks:** A land bank can convert vacant, abandoned, and foreclosed property in the vicinity of the vertiport into productive use by acquiring titles to prop-

- **Inclusionary zoning:** Zoning provisions for VOD can require the inclusion of affordable units in residential development within the district.
- **Property tax reductions:** Local governments can reduce property taxes in the vicinity of vertiports to make building housing and operating businesses more affordable.
- **Home ownership assistance programs:** Public agencies or nonprofits can provide homeowners with assistance, such as funds to help owners of homes in the vicinity of a vertiport maintain and improve their homes or funds for foreclosure assistance.
- **Renter assistance programs:** Public agencies or nonprofits can provide renters in the vicinity of a vertiport with assistance, such as requirements to provide written explanation of evictions and rent control to limit rent increases.
- **Commercial ownership assistance programs:** Public agencies or nonprofits can provide businesses with assistance, such as ordinances requiring the first floor of a vertiport to be set aside for local businesses, small businesses, or other commercial uses; financial assistance programs to support the purchase of commercial condos or units in the vicinity of a vertiport; or providing facilities or spaces for displaced businesses.
- **Multimodal connection requirements:** Local governments can require AAM services to be integrated with public transportation and shared mobility, so that residents can carry out a complete trip and the vertiports do not increase single-occupancy vehicle traffic and parking in the neighborhoods where they are located.

As with all infrastructure investments that have the potential to increase property values and trigger gentrification and displacement, planners should consider how existing residents in areas of vertiport development can stay in their neighborhoods and will be impacted by such facilities. However, given the potential concerns about noise and visual pollution, it is unclear if locating near a vertiport will be considered positive or negative.

Another way in which vertiport placement could affect existing neighborhoods is by enabling remote workers who periodically travel to offices to live further away from these job centers. Like high-speed rail and automated vehicles, faster travel speeds and reduced stress from driving could expand a region's commute-shed and encourage some households to relocate to exurban and rural areas further from urban centers, potentially contributing to regional sprawl.

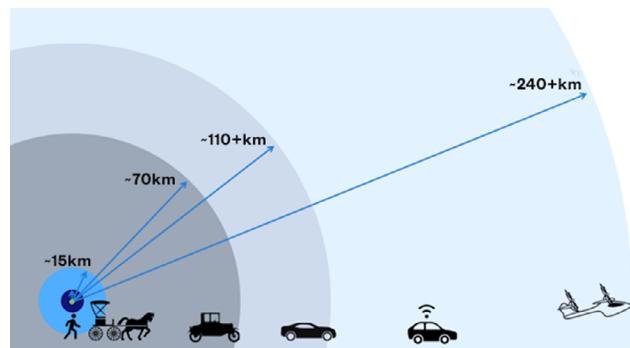


Figure 4.1. According to Marchetti's constant, as the speed of transportation innovations increases, the further the distance people can travel within an average one-hour travel time (Community Air Mobility Initiative)

One study argues that with the introduction of faster means of transportation, the radius of cities grows in proportion to the speed of transportation options (Marchetti 1994). The study posits that people are willing to spend about one hour per a day traveling to or from their destination, referred to as Marchetti's constant. The faster speeds of AAM could increase the distance a person can cover in that one-hour travel time, as illustrated in Figure 4.1.

Additional social equity issues can arise from the impacts of vertiport siting on surrounding communities, which include the challenges associated with AAM flight to and from takeoff and landing locations discussed in Chapter 3. Specific social equity concerns associated with the potential impacts of vertiport placement and AAM operations include the following:

- Flight operations over low-income and minority communities
- Temporal impacts of flight operations, such as noise impacts of late-night flights over residential communities
- Increased air traffic over sensitive land uses, including residential land uses, schools, and open space
- Noise, visual pollution, and other impacts associated with the flight paths of individual flights and scaled operations

Contextual variables such as vertiport design, location, surrounding land uses, connections with other modes of transportation, and other factors will need to be considered in planning for AAM. Planners may be able to employ digital modeling and scenario planning when considering vertiport placement so that the impacts of AAM operations on low-income households, minority communities, and

sensitive land uses are minimized. Planners will also need to consult the FAA to discuss any concerns about AAM flight paths, as airspace regulation is under its authority. More information about the role of the FAA in AAM regulation and the resources it provides to state, tribal, and local planners can be found in the sidebar on [pp. 32–33](#).

The placement of vertiports also offers potential social equity opportunities. Vertiports can provide opportunities for economic development and neighborhood revitalization. The deployment of AAM may create a wide range of new jobs to enable this industry. Local, regional, and state governments can play a critical role in the development of training and retraining programs that provide the job skills and technical expertise to enter AAM career fields (Del Rosario et al. 2021). These programs could be leveraged to expand technical training for underserved populations. More directly, vertiports and other AAM-related facilities may offer employment opportunities that can be leveraged to benefit community residents (Del Rosario et al. 2021).

Affordability and Access

The primary social equity concerns pertaining to AAM service are affordability and access for people with disabilities.

There is concern that AAM passenger services will be used by wealthy travelers to buy their way out of congestion. While proponents suggest that AAM will achieve mass market affordability over time, similar to the evolution of early commercial aviation, skeptics note that the business models of intra-urban, small aircraft operations are quite different. For example, the capital and operating costs of AAM are distributed among four to six passengers, in contrast to 150 to 400 passengers in commercial aviation.

Market forecasts estimate that AAM passenger services will cost U.S. consumers between \$6 and \$11 per mile, depending on aircraft occupancy. This is comparable to helicopter and limousine services that average \$9 and just under \$12 per mile, respectively (Goyal et al. 2021). While aircraft electrification and autonomous flight may be able to help reduce AAM costs, there is much uncertainty about how much AAM will ultimately cost, how long it will take to become affordable (if ever), and what type of public funding or policies (if any) should apply to AAM.

The ability for AAM to achieve mass market affordability will likely depend on a variety of factors, including technological improvements to enable larger aircraft, which could distribute costs among more passengers; the ability to reduce capital costs of both aircraft and infrastructure through a variety of means such as improvements to design,

materials, construction, and manufacturing; and the potential to reduce operational costs by achieving cost savings through autonomy, electrification, and alternative fuels.

Secondary factors that may impact affordability include decisions about vertiport placement and route planning based on anticipated use cases. As such, it is important that vertiport placement serves broad public benefit. Planners should seek to optimize locations for emergency response and aeromedical use cases and consider locating vertiports near the workforce required to support AAM operations.

Access for people with disabilities represents another important area of social equity for AAM. An AAM trip will include multiple links, including planning the trip, traveling to a vertiport, boarding the aircraft, spending time in flight, exiting aircraft and vertiports, transferring between modes, and traveling to a final destination after leaving a vertiport. The accessibility of AAM can be described in terms of the ability of individuals to go from their origin to a destination without breaks or interruptions. If one link in the trip is not accessible, then access to a subsequent link is unattainable and the trip cannot be completed using AAM (USDOT n.d.). As such, it will be imperative that the public and private sectors ensure that all AAM facilities are fully accessible, and that AAM is integrated with first- and last-mile connections using surface transportation modes to enable seamless door-to-door connectivity.

Environmental Justice and the Allocation of Public Resources

The cross-cutting issues of environmental justice and the allocation of limited public resources for AAM may raise additional social equity concerns.

Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (U.S. EPA 2024). *Fair treatment* means no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental, and commercial operations or policies (U.S. EPA 2024). *Meaningful involvement* entails providing people with an opportunity to participate in decisions about activities that may affect their environment or health, allowing the public's contribution to influence a regulatory agency's decision-making, considering community concerns in the decision-making process, and requiring decision-makers to seek out and facilitate the involvement of those potentially affected (U.S. EPA 2024). This is another

AAM AND DISPARATE IMPACTS

The emergence of AAM as an urban transportation sector has the potential to impact protected classes under [Title VI](#) of the Civil Rights Act of 1964. The purpose of Title VI is to protect against two types of inequities: (1) disparate treatment and (2) disparate impact (USDOT 2022).

Disparate treatment is intentional discrimination on the basis of race, color, or national origin (USDOT 2022). *Disparate impact* discrimination (sometimes referred to as an adverse impact) occurs when a recipient of federal funding adopts a procedure or engages in a practice that has a disproportionate, adverse impact on individuals who are distinguishable based on their race, color, or national origin, even if the recipient did not intend to discriminate. However, a disparate impact alone does not mean the policy or practice is prohibited.

If a policy or practice creates a disparate impact—for example, noise and air quality issues associated with vertiport placement or flight routing that affect a minority neighborhood—the federal funding agency and the funding recipient must consider whether there is a “substantial, legitimate justification” for the policy or practice and an alternative policy or practice that has less of a disparate, adverse impact (USDOT 2022).

If there is a substantial and legitimate justification for a policy or practice, then it may not constitute prohibited discrimination. If the funding recipient cannot establish a substantial, legitimate justification for the action or project, they must consider a feasible alternative policy or practice with a lesser adverse impact. If the recipient does not consider a feasible alternative nor establish a sufficient justification for their action, this could constitute prohibited disparate impact discrimination under Title VI (USDOT 2022). It is important that public agencies and recipients of federal funding prevent both disparate treatment and disparate impact discrimination in deploying AAM.

important concept to consider as part of AAM planning and implementation.

Applying environmental justice principles to AAM means that the public should have the opportunity to participate and influence a regulatory body’s environmental decisions, such as where a vertiport is placed or if a vertiport is constructed at all. It also means that no group of people should disproportionately bear the negative environmental impacts of AAM operations or policies, especially vulnerable

Planners should emphasize the importance of learning from historic inequities in both surface and aerial transportation when planning for a new mode of travel. Highway construction in the 1950s through the 1970s frequently resulted in disparate impacts on low-income, minority, and intercity neighborhoods. Recognition of these and other historic inequities led to President Bill Clinton’s [Executive Order \(EO\) 12898](#) of 1994, which directed federal agencies to identify and address disproportionately high and adverse human health or environmental effects on low-income and minority populations. Federal agencies must conduct their programs, policies, and activities that may substantially affect human health or the environment to avoid excluding persons or populations or subjecting persons or populations to discrimination because of their race, color, or national origin.

In response to EO 12898, the federal government has taken several actions designed to focus federal attention on human health and environmental conditions in minority and low-income communities. The USDOT established [DOT Order 5610.2\(a\)](#) to ensure that minority and low-income population groups are not disproportionately affected. Additionally, the FAA includes guidance on environmental impact analysis related to environmental justice, as well as other socioeconomic impacts, in [FAA Order 1050.1F](#) and the accompanying [1050.1 Desk Reference](#). From a planning perspective, it is important that local governments carefully consider the potential impacts of AAM implementation on low-income and minority communities, and that local, regional, and state agencies work collaboratively to address potential concerns associated with vertiport siting and its impacts. Collaboration with the FAA may also be helpful to engage communities and understand the needs of underserved communities.

groups that are protected under Title VI of the Civil Rights Act and federal environmental justice initiatives. The sidebar on this page takes a deeper dive into the importance of avoiding disparate impacts in planning for and deploying AAM.

Some equity advocates argue that allocating limited public resources for AAM may come at the expense of other investments that may have a broader impact, such as funding public transportation (Leclerc, McLay, and Mayorga 2012). However, some funding sources may be restricted to

certain transportation modes and not expendable on other modes. For example, aviation funding sources may not be usable for public transportation. For uses of funding that would divert resources from other transportation modes or facilities, planners and policymakers may consider prioritizing investments in AAM infrastructure and use cases with broad social benefits, such as aeromedical, firefighting, and emergency response.

ASSESSING AAM THROUGH THE STEPS EQUITY FRAMEWORK

Identifying and understanding the social equity challenges related to AAM is key to preventing discrimination both in processes and outcomes and ensuring access to the potential benefits of AAM for all. One way to do this is for the public and private sectors to analyze AAM services, programs, and policies by employing the STEPS framework.

In 2017, the U.S. Department of Transportation (USDOT) published the STEPS equity framework to categorize an array of transportation equity barriers facing transportation users (Shaheen, Bell et al. 2017). STEPS stands for spatial, temporal, economic, physiological, and social barriers.

- **Spatial barriers** create physical gaps in the transportation network, such as limited service availability in a particular area, excessively long distances between destinations, and lack of public transit within walking distance.
- **Temporal barriers** create gaps in the transportation network during particular travel times, such as the inability to complete trips during off-peak hours or late nights due to lack of services.
- **Economic barriers** include financial challenges, such as high direct costs of travel, such as airfares; indirect costs, such as smartphone access for booking flights; and structural barriers, such as banking access to pay for flights.
- **Physiological barriers** include physical and cognitive limitations that make using standard transportation modes or digital platforms difficult or impossible for certain individuals, such as people with disabilities or older adults.
- **Social barriers** include social, cultural, safety, and language challenges that may inhibit a potential rider's comfort with using transportation modes and services, such as poorly targeted marketing, a lack of multilingual information, or neighborhood crime.

Applying the STEPS equity framework to AAM entails considering the opportunities and challenges that AAM presents in the context of each of the five barriers listed above and brainstorming potential policy interventions to build on those opportunities and overcome those challenges. Table 4.1 ([p. 42](#)) summarizes an analysis of AAM using the STEPS framework.

When AAM is analyzed through this framework, potential policies that could address social equity challenges, such as expanding service availability and mitigating potential adverse impacts on underserved populations, may emerge. For example, in commercial aviation, the USDOT's Essential Air Service (EAS) program guarantees that small communities that were served by certificated air carriers before airline deregulation maintain a minimal level of scheduled air service. EAS is generally accomplished through a federal program that subsidizes flights between a small community and a medium or large hub airport.

Employing this same concept, a public agency at any level of government could establish an EAS-type program subsidizing the incorporation of AAM use cases in emerging markets or in those with an uncertain business case. The program could provide a direct subsidy per passenger or per flight. Alternatively, it could use a "subtraction model" drawn from the carsharing sector, in which an AAM service provider could value the break-even cost of providing service, subtract revenue from that collected value, and bill the shortfall to the risk partner (Shaheen, Cohen, and Roberts 2006).

In another example, the STEPS framework could be applied to identify policies to mitigate the potential adverse impacts of AAM on underserved communities. For example, if an AAM service operating overnight has a disparate impact on a low-income or minority community, the service provider may restrict late-night flight plans over residential communities or the infrastructure operator may restrict takeoffs and landings during late night times. The sidebar on [pp. 43–44](#) describes the proactive approach being taken by the City of Los Angeles in centering equity and thinking critically about the potential community impacts of this emerging sector.

STAKEHOLDER AND COMMUNITY ENGAGEMENT

State, regional, and local agencies may require or recommend meaningful opportunities for public participation to precede official decisions, including those regarding transportation planning. This can be done in ways that include publishing information in newspapers and online; sending direct mail-

TABLE 4.1. STEPS FRAMEWORK ANALYSIS FOR AAM

Elements	Opportunities	Challenges	Potential Policy Interventions
Spatial	AAM has the potential to bridge spatial, topographical, and built environment gaps (e.g., water, mountains, megaregions).	AAM could present spatial barriers if a service is unavailable in a particular neighborhood, city, or region. Additionally, AAM could encourage some households to live further from urban centers, contributing to exurbanization and the spatial growth of regions.	The public sector could provide incentives to support routes that have limited transportation connectivity (i.e., essential air service for AAM in rural areas).
Temporal	AAM could provide supplemental services at times when other forms of mobility are unavailable (e.g., late-night transportation).	AAM might present temporal challenges, such as services that are unavailable during particular times or services that impact underserved communities during particular times of day (e.g., late-night noise).	Policies that restrict late-night operations over low-income and minority residential communities could reduce the temporal impacts of AAM on underserved populations. However, this would also need to be balanced against limiting late-night AAM service.
Economic	AAM has the potential to create new direct and indirect employment opportunities and possibly reduce the mismatch between affordable housing and jobs. AAM also has the potential to revitalize neighborhoods around vertiports.	AAM could present economic challenges for users and nonusers, such as lack of affordable services and gentrification in neighborhoods around vertiports. Conversely, if a vertiport is viewed as a detractor due to noise or other impacts, vertiports might have an adverse impact on the economic development in their vicinity.	Special pricing or subsidy programs for underserved populations and socially desirable use cases (e.g., aeromedical and emergency response) could help to make AAM accessible for more people. There are also opportunities to create workforce training programs for underserved communities.
Physiological	AAM could provide additional mobility options for travelers who may not be able to travel long distances or times.	AAM might present physiological challenges if the infrastructure, aircraft, and services are not accessible for people with disabilities and older adults.	The incorporation of universal design principles (creating products and services that are accessible to people with a wide range of abilities, disabilities, and other characteristics) into aircraft, facilities and vertiports, and apps can help make AAM more accessible for all.
Social	AAM has the potential to expand access to employment and critical services, such as rural health care delivery and emergency response.	AAM could have social and environmental impacts, including noise and aesthetics, on underserved populations or disadvantaged communities.	Targeted stakeholder and community outreach may assist in identifying early impacts and identifying specific strategies that could help mitigate the adverse impacts of AAM on underserved populations.

ers; providing opportunities for public review and comment; engaging residents through social media; and holding workshops, meetings, conference calls, and public hearings.

AAM presents new challenges for stakeholder and community engagement. Historically, aviation planning processes have generally focused on aviation stakeholders and the immediate communities around airports. Because AAM has the potential to decentralize aviation impacts that have historically been limited to airport facilities and their immediate surroundings, it will require deep levels of engage-

ment of both community and aviation stakeholders, along with the cross-pollination of perspectives and expertise. This requires bringing together diverse community and aviation stakeholders that have limited experience working with one another. Figure 4.2 (p. 44) depicts the traditional silos of local and aviation planning stakeholders and the overlap between AAM planning and community integration.

Early and deep stakeholder and community engagement around proposed vertiport projects will be important to help understand and address potential community

CONSIDERING AAM IN LOS ANGELES

Gabriela Juárez, AICP, Urban Air Mobility Lead, City of Los Angeles, Department of City Planning

The City of Los Angeles' municipal priorities include affordable housing, equity, environmental justice, sustainability, and resiliency. As the region contemplates advanced air mobility (AAM), several questions and considerations have arisen for the city. For a planning department, the first questions to ask are what problems does AAM solve, and what municipal priorities does AAM help advance? As such, Los Angeles City Planning's approach to gain a greater understanding of this new mode was to assess the potential opportunities and challenges associated with AAM across five planning and policy areas: potential use cases, environmental justice, environmental impacts, social equity, and land use compatibility.

Opportunities for potential use cases. As part of City Planning's research, planners identified several AAM use cases using electric vertical takeoff and landing (eVTOL) aircraft: commercial drones, passenger movement (both piloted and unpiloted), and package delivery (including medical service). These use cases have the potential to offer a variety of benefits to the public and private sectors in both commercial and private operations and support economic development in the Los Angeles region.

- **Drones:** Commercial drone use has become more common in the film and television industry in Los Angeles for aerial videography. There has been increasing use of drones in the real estate industry to showcase properties for sale. Both the city and county public safety departments are increasingly using drones to support emergency response and law enforcement. State agencies like Caltrans are using drones in a variety of ways, from ecology (e.g., tracking invasive species in difficult-to-reach areas) and resiliency (e.g., tracking hazards such as wildfire and sea level rise) to studying marine life activity.
- **Package delivery:** Several original equipment manufacturers (OEMs) have been developing both drones and eVTOLs for package delivery. These package delivery use case operations range from delivery dropoff at a hub, similar to a locker, that is centrally located for individual pickup, to an envisioned direct home/front-door delivery. This use case could offer organ transport, medical supplies, and prescription delivery to those that have mobility or access limitations.
- **Passenger movement:** Passenger movement has been the most highlighted use case in recent news. This use

case is evolving and developing in several aspects, including the number of passengers that can be accommodated in one aircraft as well as the type of fuel being considered. This use case can also offer emergency and medical services, particularly to those areas with limited roadways or high congestion.

Environmental justice impacts. Communities of color and low-income communities have been adversely impacted by environmental injustices rooted in past land use decisions related to surface transportation and aviation decisions. Freeways, heavy rail, oil wells, and refineries, as well as heavy industrial uses abutting single-family and multifamily residential, have contributed to long-term health disparities in low-income neighborhoods and communities of color. The opportunity to develop and contribute toward a new mode while recognizing this context allows planners, policymakers, and decision-makers to assess past environmental injustice outcomes and make changes to policies that proactively account for potential externalities of emerging transportation modes such as AAM.

Environmental impacts. Existing regulations do not presently account for the frequency of eVTOL trips, which could be influenced by the hours of operations, location of approach and takeoff areas, and the proximity of eVTOL operations to nearby buildings, which could impact noise and vibration. Flight planning for AAM is still in the nascent stages and additional studies would be needed to assess a variety of potential AAM environmental impacts, such as those to wildlife and dark skies, in addition to these mentioned here.

Social equity. When considering equity for AAM, there is a significant potential to build in opportunities for STEM education, workforce development, recruitment, and direct local hire among Los Angeles' communities of color and low-income communities. The potential to create and grow positions in aircraft manufacturing and maintenance presents an opportunity to uplift equity in this new mode. From what has been shared by AAM operators, it is anticipated that this new modality will likely have a high cost and be limited to users with greater financial means. Including workforce opportunities for communities of color and low-income communities at the outset will help ensure that equity is prioritized.

Land use compatibility. The land use considerations for AAM will require a very careful and thoughtful approach to balancing compatible uses. Los Angeles has been very fortunate to receive state and federal investments for our public transit system's expansion. The introduction of any new mode in Los Angeles should be an extension of all this public investment. Vertiports co-locating within large employment centers and proximate to sports venues and facilities can offer options that extend the existing public transit network. Furthermore,

balancing housing density and vertiport locations will have to weigh the benefits and drawbacks of offering AAM where it is needed most and available to the most users.

When scooters came to Los Angeles, the city missed an opportunity to participate in the conversation and shape that mobility option. Planners should take advantage of opportunities to ask questions and learn as much as possible to consider policy and regulatory needs if and when AAM comes to their regions.

concerns, such as noise, aesthetics, traffic congestion, social equity impacts, safety, and others. Community engagement is an essential part of understanding and mitigating the adverse impacts of AAM on underrepresented populations and communities.

The International Association for Public Participation (IAP2) has developed a public participation framework describing a spectrum of five different types of participation, ranging from the least to the greatest influence over deci-

sion-making in public processes (Figure 4.3, p. 45). Applying these concepts to the AAM context, both the public and private sectors may consider embedding public participation and engagement at multiple stages of the planning process.

As part of long-range planning, stakeholder and community engagement could help communities understand if AAM is an appropriate strategy (Yedavalli and Cohen 2022). Communities could conduct exploratory scoping to better understand potential use cases, demand, and locations for

Figure 4.2. Overlap between local community and aviation stakeholders in AAM community integration

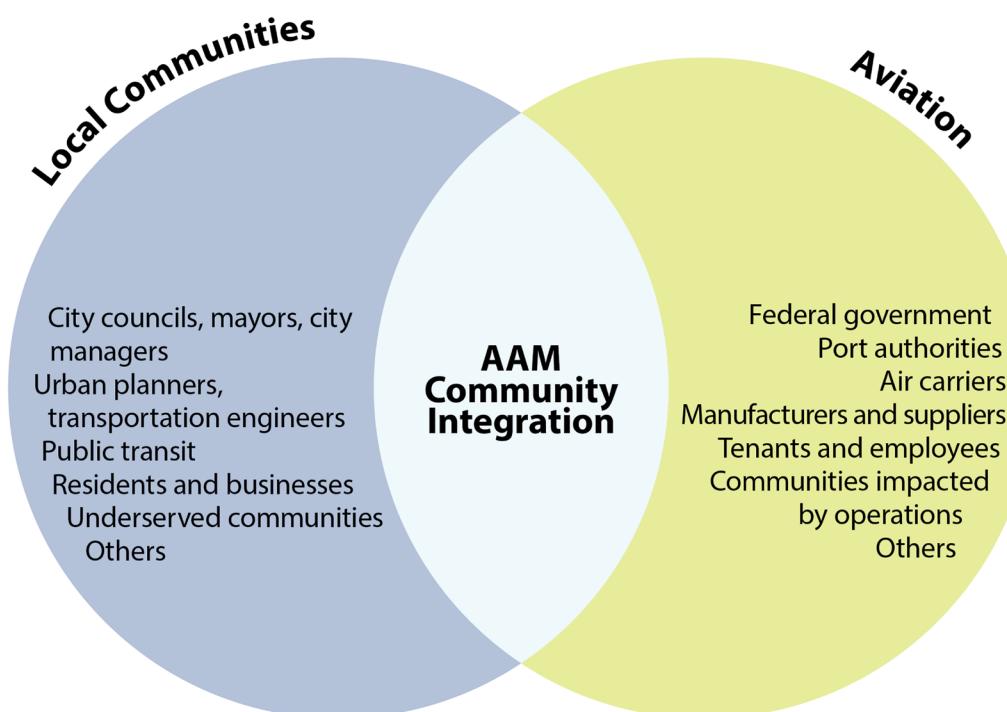
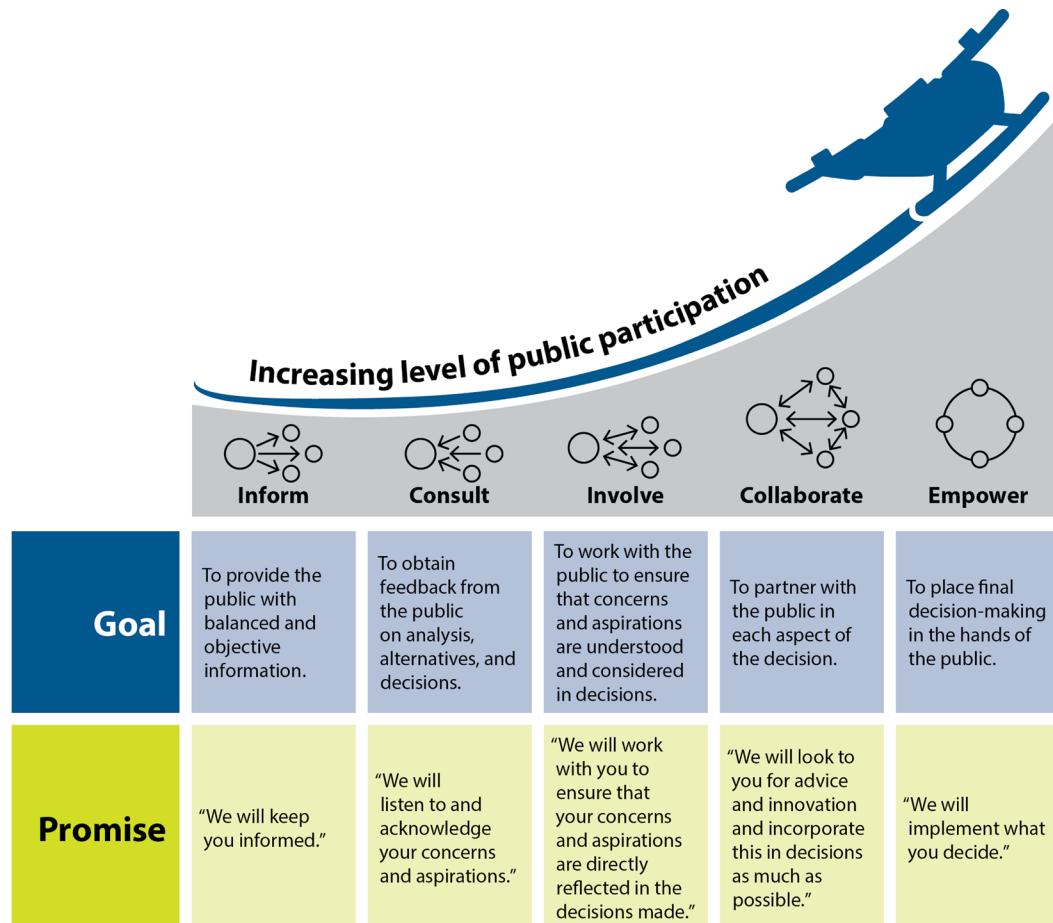


Figure 4.3. IAP2

Spectrum of Public Participation (adapted from ©International Association for Public Participation www.iap2.org)



AAM service. As the planning process progresses, communities may pivot toward more in-depth engagement that empowers stakeholders to better understand local concerns and employ a variety of techniques to vet vertiport concepts and alternatives. If or when a developer decides to build a vertiport, additional community engagement may be recommended and even statutorily required by local, state, and federal laws (Yedavalli and Cohen 2022).

CONCLUSION

AAM presents both social equity opportunities and challenges. It has the potential to create opportunities for economic development around vertiports and prospects for direct and indirect jobs. However, as discussed in Chapter 3, AAM also can have a variety of direct and indirect

negative environmental impacts associated with vertiports, flight paths, and operations, including noise and visual pollution. The distribution of these impacts and who benefits from AAM compared to who bears its burdens could raise significant equity concerns.

AAM also raises concerns regarding affordability and accessibility of services. Ensuring full and fair participation in the AAM decision-making process, engaging stakeholders, empowering the public through education and community engagement, and understanding the degree and distribution of AAM impacts, coupled with mitigation measures, is needed to ensure AAM is equitable in serving the public and all communities. Planners must keep all of these considerations top of mind when considering infrastructure development for AAM and its integration with other modes of transportation, which is the focus of the next chapter.

CHAPTER 5

VERTIPORT INFRASTRUCTURE AND MULTIMODAL INTEGRATION

The deployment of advanced air mobility (AAM) will require extensive infrastructure, including a network of takeoff and landing facilities and enabling energy infrastructure. It is envisioned that most off-airport AAM use cases will use vertical takeoff and landing (VTOL) aircraft. While VTOLs may be able to use existing aviation facilities such as airports and heliports, as AAM scales a variety of different-sized facilities could evolve based on frequency of flights, traveler demand, urban density, and the surrounding built environments.

Both the public and private sectors may need to identify how infrastructure can be repurposed with minimal physical modification, renovated and adapted, or replaced and redeveloped for AAM. However, constructing new and adapting existing infrastructure for AAM could present planning challenges, such as local concerns, cost, and multimodal integration.

This chapter explores a range of issues related to AAM infrastructure and multimodal integration. It presents a taxonomy and definitions of AAM takeoff and landing infrastructure, and it outlines potential infrastructure business models as well as potential strategies for managing competition among service providers for vertiport access. It then discusses vertiport planning and design considerations, including forecasting and modeling, design and siting

considerations, and the role of vertiport-oriented and joint development in achieving multimodal integration.

TYPES OF AAM TAKEOFF AND LANDING INFRASTRUCTURE

To the extent that vertical takeoff and landing infrastructure has been discussed in the literature or defined by the federal government or private sector to date, it can generally be categorized into three types of facilities, from smallest to largest: (1) vertipads/vertistations, (2) vertiports/vertibases, and (3) vertihubs.

Table 5.1 and Figure 5.1 (p. 48) provide additional information on the approximate sizes and construction

TABLE 5.1. EMERGING TAXONOMY AND DEFINITIONS OF AAM TAKEOFF AND LANDING INFRASTRUCTURE

Term	Description	Approximate Size	Construction Cost (USD)
Vertipad/vertistation	A single landing pad and parking stall intended to accommodate one or two parked aircraft	6,000 SF	\$200,000–\$400,000
Vertiport/vertibase	A medium-sized facility intended to accommodate up to three landing pads and up to six parked aircraft	23,000 SF	\$500,000–\$800,000
Vertihub	A larger facility, possibly with multiple floors, to accommodate numerous landing pads with parking for multiple aircraft	70,000 SF across multiple floors	\$6–7 million

Source: Johnston, Riedel, and Sahdev 2020

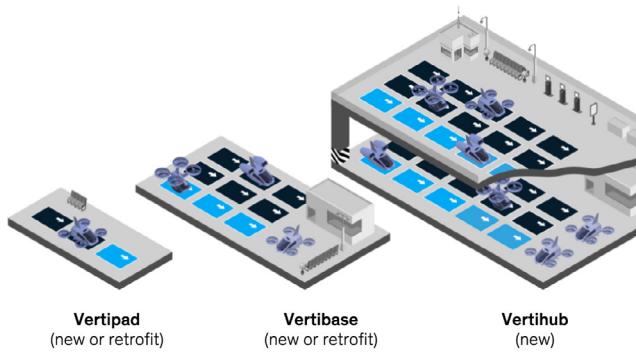


Figure 5.1. Three potential types of AAM infrastructure (McKinsey & Company)

costs of these facilities as estimated by the global consulting firm McKinsey & Co (Johnston, Riedel, and Sahdev 2020). Note that this chapter will refer to AAM takeoff and landing infrastructure generally as “vertiports” for consistency with the Federal Aviation Administration’s (FAA) [Engineering Brief on Vertiport Design](#) (FAA 2022b).

AAM also may be able to use existing infrastructure such as heliports and airports, as well as waterways for amphibious operations. The use of seaplanes and amphibi-

ous aircraft, where possible, could reduce the need for new infrastructure. While some studies have proposed the use of existing helipads on building rooftops, many of these facilities are designed for emergency use, are not intended for passenger access, and may have weight and other safety limitations. As such, the feasibility of converting an emergency use facility to a regularly used vertiport remains to be seen. Planners may also need to consider the location and availability of alternative or emergency landing areas for AAM. This could include locations on public or private land, such as parking lots or open spaces suitable for landing.

New vertiports close to the origins and destinations of AAM activity will likely be needed to reduce the number of modal connections and travel times associated with first- and last-mile connections to and from takeoff and landing facilities. In urban centers, this can present several notable challenges, including limited availability of land for new vertiports; heights of existing buildings that could impact airspace to and from new vertiports; availability of enabling infrastructure, such as charging/fueling facilities and digital infrastructure; and the impacts of vertiport operations on surrounding communities. The magnitude of these challenges in a given community will likely vary based on vertiport size, as well as the number of vertiports required to serve the local market.

TABLE 5.2. POTENTIAL BUSINESS AND OPERATIONAL MODELS FOR VERTIPORTS

Model	Description
Publicly owned and operated	A public entity owns and operates a vertiport through a port authority, transportation department, joint powers authority (for ownership and operation by two or more public agencies), or another public agency.
Publicly owned, contract/third-party operated	A public entity owns a vertiport, but vertiport operations are contracted or managed by a third-party vendor. The third-party entity may operate landside, airside, or both landside and airside operations. Different third-party vendors may operate landside or airside operations. Additionally, a public agency may manage one operation and contract another to a third party (e.g., a transportation department that owns a vertiport operates landside operations (curbside access) and contracts to a third party to manage airside operations).
Public-private partnership	A private-sector stakeholder funds, builds, and/or operates a vertiport in which a public agency has an ownership stake. For example, a developer may agree to build, fund, and maintain part of a publicly owned vertiport. A developer also may agree to build, fund, and maintain a vertiport on publicly owned land in exchange for a ground and/or air rights lease.
Privately owned and operated	A private entity owns and operates a vertiport. Such entities could include infrastructure owner/operators, original equipment manufacturers (OEMs), air carriers, or providers of services for urban air mobility (PSUs). PSUs support operations and flight planning, airspace management, and information exchange during operations, but in theory could also own and operate vertiports.
Privately owned, contract/third-party operated	A third-party vendor or contractor operates a privately owned vertiport.

AAM INFRASTRUCTURE BUSINESS MODELS

There are a variety of potential models for owning, operating, and financing AAM infrastructure involving the public and private sectors that could emerge as AAM evolves. Blended ownership and operational strategies could prioritize use for a particular operator or use case, while making infrastructure available for other operators or for lower-priority use cases during off-peak periods. Table 5.2 (p. 48) describes the potential business and operational models that could develop for AAM.

Crucial to this discussion is the potential role of the public sector in financing and operating AAM infrastructure and guiding how infrastructure is designed and used. Typically, when infrastructure owners or sponsors, planning agencies, and other entities accept FAA-administered funds, they must agree to certain obligations or assurances. These obligations often require that facilities are maintained and operated safely and within specified conditions. In some cases, assurances may be a requirement of accepting FAA funds or are attached to the grant deed of a property. The duration of these obligations can depend on the type of recipient, lifespan of a facility being developed, and other conditions (FAA 2022c).

Thus, the acceptance of public funds can have practical implications for vertiports. For example, a federally funded vertiport might have grant assurances that prohibit a facility from limiting takeoff and landing hours. To comply, a publicly funded vertiport might have to permit night and early morning takeoffs and landings, whereas a privately funded vertiport might be able to more readily limit activity during particular times of the day. Similarly, the acceptance of public funds could also impose additional airspace protection requirements that could impact adjacent parcels, including land uses and air rights.

Closely related to the concept of ownership and management of a vertiport is the concept of service provider access. If AAM grows into a mature network, planners and policymakers may need to decide whether AAM infrastructure should be exclusive to a single service provider, offer preferential use for some service providers with partial access to other users, provide prioritized use for specific use cases, or be open to multiple air carriers. Table 5.3 lists potential scenarios.

It is important for planners to remember that like other transportation-related land uses, such as parking, vertiport access scenarios can have notable impacts on the built environment. As with parking, multiple networks of exclusive-

use vertiports could lead to more takeoff and landing infrastructure than is needed to serve a community. In contrast, vertiports that provide open access to multiple services and use cases could help minimize unused and unneeded takeoff and landing capacity. In doing so, open-access vertiports can help right-size the infrastructure needed for a particular community and reduce the number of vertiports that would be required if each service provider had exclusive access to its own takeoff and landing facilities.

Each model of access described in Table 5.3 has pros and cons. Publicly funded infrastructure could ensure open takeoff and landing access for multiple air carriers and allow for a greater network of connections, whereas privately funded infrastructure may be faster to fund and construct. Planners also may be able to ensure open access for privately constructed takeoff and landing infrastructure through conditions added to zoning codes and approval processes for new vertiport facilities. Communities

TABLE 5.3. POTENTIAL SCENARIOS FOR VERTIPORT ACCESS

Scenario	Description
Exclusive access	An AAM service provider has the right to complete use of a vertiport facility. The service provider may own the facility or exclusively lease the facility from a vertiport owner/operator.
Preferential access	An AAM service provider has first choice over takeoff and landing slots, gates, parking locations, and other facilities at a vertiport. Preferential access may be granted because a service provider engaged in a partnership to construct or operate the facility (joint development) or has another type of business relationship with vertiport owners/operators (business partnership or alliance). Public entities owning/operating a vertiport also can grant preferential access to the vertiport.
Prioritized access	A particular use case receives vertiport access priority. For example, an infrastructure owner/operator may grant prioritized access for specific AAM use cases such as aeromedical, law enforcement operations, firefighting, or emergency management.
Public or open access	All service providers have access to vertiport facilities. This is similar to how public airports operate.

may consider requiring that a vertiport owner/operator record access requirements with a grant deed to ensure that these requirements run with the land, irrespective of future facility owners or operators.

Managing Competition Among AAM Service Providers

As with curbside access, vertiport takeoff and landing slots and parking stalls could represent a finite resource, particularly in an open-access facility. When demand for a facility shared by multiple service providers may exceed available capacity, an infrastructure owner/operator may need to manage competition between service providers.

When considering the allocation of public resources, such as who can build or operate vertiports, or what service providers can have access to takeoff and landing infrastructure, planners and policymakers may want to consider service characteristics and use cases, in addition to different options of procedures for managing competition among service providers. Table 5.4 summarizes these issues.

TABLE 5.4. CONSIDERATIONS FOR MANAGING AAM COMPETITION

Considerations	Criteria
Service characteristics and use cases	Business characteristics: operational history, safety record, on-demand vs. scheduled service Operational characteristics: routing, time of day/night, altitude of flights Fleet characteristics: zero emission, low noise Occupancy: air taxi, air pooling Use case: passenger mobility, goods delivery/logistics, aeromedical, emergency response Services that benefit nonusers: vehicle charging, intermodal connections, retail/services that benefit the local community, microgrid capacity
Procedures for allocating and valuing public resources	Jurisdiction: city staff, city council, port authority Process: first-come, first-served; lottery, auction; request for proposals Cost recovery of vertiport development, operations, and depreciation Value capture or revenue generation: permits, takeoff and landing fees, non-aeronautical revenue

Source: Adapted from Cohen and Shaheen 2016

In particular, the management of competition may include three key areas: (1) managing competition for take-off and landing facilities, such as if multiple infrastructure owner/operators want to establish vertiports on the same parcel or in close proximity to one another; (2) managing competition within a vertiport facility between operators, such as if multiple service providers request the same gate or takeoff and landing time; and (3) managing competition between use cases that might have conflicting facility needs or operational characteristics, such as air taxi, goods delivery/logistics, aeromedical, or emergency response.

Local governments may be able to manage competition for vertiport access by developing policies similar to those now used to manage curbside and on-street parking. Some of the methods that can be used to manage competition among infrastructure owner/operators, service providers, and different AAM use cases are shown in Table 5.5 (p. 51).

VERTIPORT PLANNING AND DESIGN

Key infrastructure planning issues and design considerations for vertiports include the components and characteristics of these facilities, as well as multimodal integration. When planning and designing for AAM, both equity considerations and community engagement are critical, as discussed in Chapter 4. Chapter 6 will explore planning and regulatory approaches for vertiport development, including land use compatibility and siting considerations.

Vertiport Design Considerations

In September 2022, the FAA released a [Vertiport Design Engineering Brief](#) that provides emerging practice to airport owner-operators and their support staff for the design of vertiports for VTOL aircraft that are piloted, electric powered, and weigh 7,000 pounds or less with a maximum length and width of 50 feet (FAA 2022b). The 2022 brief replaces an early 1990s FAA vertiport design advisory circular based on military aircraft technology that was canceled in 2010. The FAA plans to update the engineering brief as additional data and research becomes available and anticipates developing a vertiport design advisory circular in the future.

While the engineering brief covers vertiport design in detail, there are a few foundational terms and concepts planners should be familiar with. Understanding these concepts can help planners integrate AAM into policy and planning documents.

TABLE 5.5. METHODS USED TO ADDRESS COMPETITION AMONG AAM SERVICE PROVIDERS

Method	Policy Description	Advantages	Disadvantages
First-come, first-served	The public agency handles requests for access to vertiport takeoff and landing slots in the order in which they are made.	No need to develop more sophisticated policies, particularly when there is only one requester.	Policy may give preferential treatment to early market entrants; new service providers or use cases may have difficulty getting access to the same resources if taken by an earlier requester.
Lotteries	The public agency manages access to vertiport takeoff and landing slots by lottery to service providers meeting minimum requirements.	Generally perceived as fair.	Excludes other potentially mitigating factors that may warrant preferential or disadvantageous treatment to further the public good.
Auctions	The public agency holds auctions in which requests for access to vertiport takeoff and landing sites are granted to the highest bidder.	Raises money for municipal coffers and establishes market-rate pricing for vertiport access.	Equity issues if service providers with greater financial resources can outbid operators with fewer financial resources or pass costs onto consumers; may result in inequitable use cases that impact the community.
Preferential treatment	The public agency gives preferential treatment to a specific service provider or use case, such as expedited planning review and approval for new vertiports serving aeromedical and emergency response use cases.	Allows a public agency to incentivize certain behaviors or characteristics.	Requires careful planning and legal review to ensure that a policy is fairly implemented.
Collaborative approaches	The public agency employs collaborative processes among diverse stakeholders, such as negotiation or mediation, to reach a mutually beneficial outcome for decisions about vertiport establishment or access.	Brings all stakeholders together to possibly obtain a mutually beneficial outcome.	Not all parties may be willing to have an open dialogue; requires more time and resources on the part of the public agency to facilitate.
Requests for Proposal (RFP)	The public agency uses a solicitation/bidding process to procure an AAM service.	Gives public agencies and local governments the greatest control to select the service characteristics and requirements (e.g., equity, sustainability) they desire.	Potentially time consuming and susceptible to litigation if not properly executed.
Tandem policies	The public agency gives every AAM service provider an equal share of vertiport access.	Generally perceived as fair.	May not be appropriate for vastly different-sized AAM service providers to give large and small operators the same allocation.

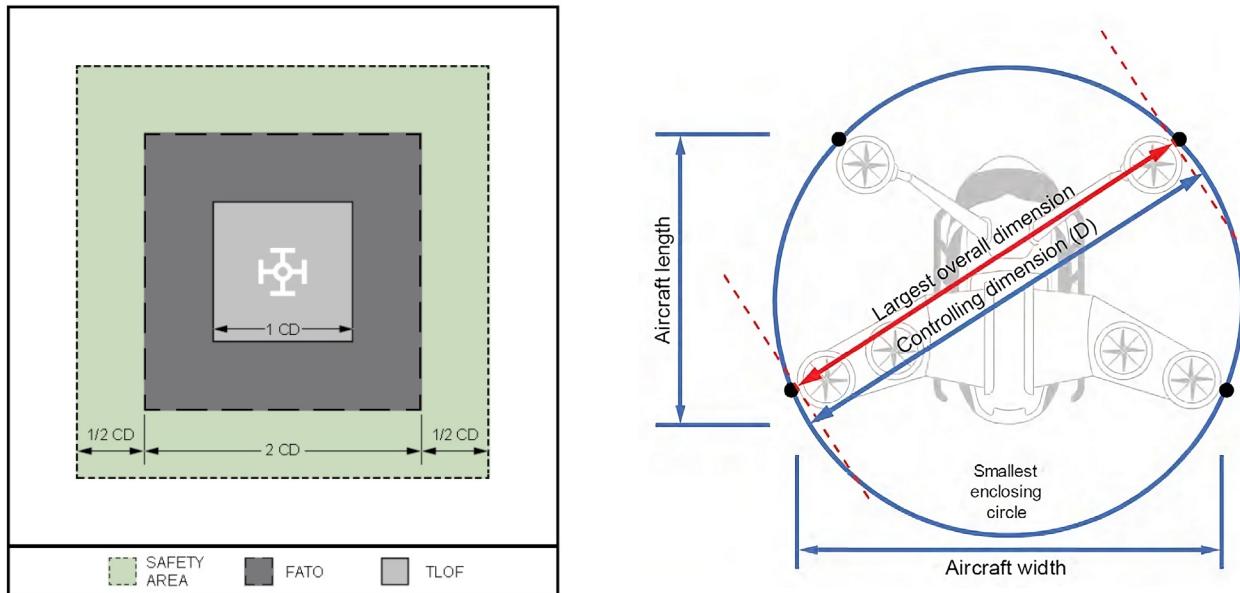
Source: Adapted from Cohen and Shaheen 2016

Key Components

Like airports, vertiport facilities encompass both landside and airside activities. Landside vertiport areas encompass passenger and cargo terminals and ground access, including parking, roadways, public transit access, and loading zones. On the airside, a vertiport consists of the areas where passengers and cargo move to or from an aircraft. The airside also includes the areas where the aircraft park, taxi, take off, and land.

The FAA's engineering brief explains the safety-critical airside design elements of a vertiport (Figure 5.2, p. 52):

- Touchdown and liftoff (TLOF): A load-bearing area on which VTOL aircraft and helicopters may land or lift off.
- Final approach and takeoff (FATO): A defined area over which the pilot completes the final phase of the approach to a hover or a landing, and from which the pilot initiates takeoff.



Figures 5.2 (left) and 5.3 (right). FAA engineering brief illustration of the relationship and dimensions of the touchdown and liftoff (TLOF), final approach and takeoff (FATO), and safety areas; the controlling dimension (CD) equals the largest overall dimension of the aircraft (FAA)

- Safety area: A space intended to reduce the risk of damage to aircraft and helicopters that diverge from the FATO.

The FAA's engineering brief establishes a series of controlling dimensions (CD) for these areas (Figure 5.3). The CD is determined by the longest distance between the two outermost opposite points of the aircraft (e.g., wingtip to wingtip, rotor tip to rotor tip, rotor tip to wingtip, or fuselage to rotor tip).

The CD of a vertiport will ultimately determine what size aircraft can use the facility. Understanding these dimensions can help planners integrate AAM into zoning and land use regulations, including establishing minimum parcel sizes and potential setback requirements for planned vertiports.

Another key component is the approach/departure path, or the flight track that VTOL aircraft follow when landing at or departing from a vertiport. From a planning perspective, the heights of nearby buildings, floor area ratios, land use, and zoning can all influence and be influenced by approach and departure paths.

Additional Design Considerations

Vertiports also can have a variety of amenities specific to their design, placement, and built environment. Key considerations should include any regulatory takings concerns

regarding adjacent property development rights; airspace access; aircraft parking, charging, and battery swapping; facility security; and open access to accommodate a variety of aircraft types, operators, and users. In addition, the design of vertiports can include multimodal services for parking, charging, and last-mile goods delivery, such as drones, lockers, and small robots.

Furthermore, energy infrastructure must be considered as part of vertiport design. Charging and refueling could occur at vertiports or as part of separate stand-alone facilities. Ensuring a charging infrastructure that may include battery swapping and a network of refueling facilities (e.g., aviation fuel, hydrogen, and other alternative or biofuels) could create a variety of logistical, operational, and technical challenges. For electric VTOL aircraft, new charging infrastructure and power grid improvements will be necessary. Enabling infrastructure, such as ground battery storage, may be needed to manage aircraft charging demands and modulate demand on the power grid. The sidebar on [p. 53](#) delves into the importance of providing adequate electrical infrastructure to power AAM facilities and aircraft.

Multimodal Integration

For use cases involving passenger transport, planners will need to consider the “complete AAM trip” that accounts

ENERGY INFRASTRUCTURE FOR ADVANCED AIR MOBILITY

Paul Stith, Associate Vice President, Global Transportation Initiatives, Black & Veatch

Advanced air mobility (AAM) will open the skies to a new era of mobility and logistics. Success in the air will be defined by the convergence of technologies, business models, and the requisite infrastructure to power these machines. Planners will benefit from ground transportation electrification and early aviation programs, such as the first national aviation charging network being deployed by [BETA Technologies](#) with the support of engineering, procurement, and construction firm [Black & Veatch](#) (Figure 5.4).

As deployment of both electric conventional and vertical takeoff and landing (eCTOL and eVTOL) technology begins to ramp up, more electricity will be needed to power these aircraft. Often talked about but too frequently underestimated are the challenges and opportunities associated with deploying high-power charging infrastructure.

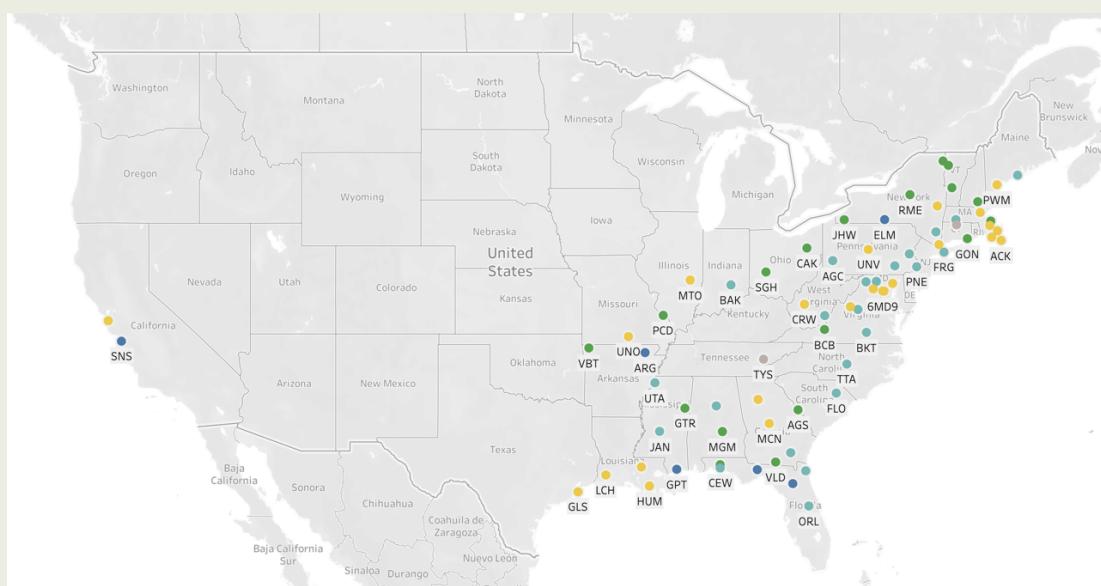
Energy supply and electrical distribution upgrades will be a significant component of any new AAM facility development. The further away the power comes from, the more it will cost and the longer it will take to supply. Deploying infrastructure in the built environment requires assessing each site's unique existing conditions, developing plans, engaging with stakeholders, designing and engineering systems, and obtaining approvals. In addition to building permits, some locations could require land use and zoning updates

with processes measured in months, if not years. When utility equipment is placed on public property, specific right-of-way filings and agreements must be processed before construction can begin. Not allocating enough budget and time to build adequate infrastructure will limit the market's success.

Whether for AAM operations at airports or for vertiport sites supporting takeoffs and landings, it is challenging enough to find existing electric capacity for one charger, let alone the multiple high-power units needed to support daily aircraft operations. Moderately busy sites will need at least four chargers with a total capacity easily surpassing three megawatts (MW). For scale and comparison, a typical supermarket uses less than half a MW, while a large warehouse store with freezers and air conditioning may draw up to one MW.

For most sites, charging facilities sufficient to power aircraft will require an application for new or upgraded electric service from the host utility to power these industrial loads. This kicks off the utility's process of reviewing capacity to host more load, assess the timing of grid upgrades, and address other customers' applications already in the queue. As applications get into the megawatts, complexity and costs go up accordingly (Figure 5.5, p. 54). Deploying smart charging, onsite energy generation and storage, and microgrids—so-called "non-wires" solutions—can augment, optimize, or

Figure 5.4. National aviation charging network being developed by [BETA Technologies](#) ([BETA Technologies](#))



Grid Connection Lead Times are Complex

Every location and its relationship to the grid is unique, requires due diligence and completed application for service process to inform schedule and capital budgets.

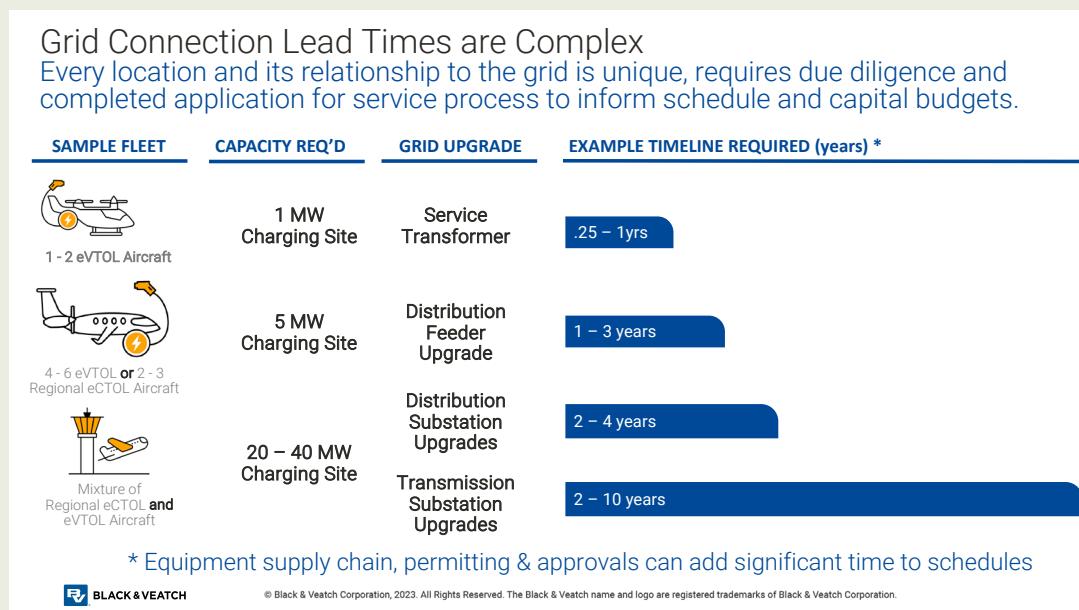


Figure 5.5. New aviation charging facilities will require significant lead times that increase with capacity (Black and Veatch)

eliminate the need for grid interconnection upgrades. In addition to reducing delays, these investments can provide cost savings over time and enhance resilience.

There are over 3,000 utilities across the United States. Hundreds offer transportation electrification programs to support infrastructure development, ranging from rebates and electric vehicle rates to utility-owned charging facilities. These funds are already being used for electric aviation projects, and more than 100 airports are in various stages of planning and deploying aircraft chargers. The emerging aviation charging infrastructure sector can benefit from lessons learned from the thousands of charging sites already deployed for cars, trucks, and buses across the country, as the power and operational needs of fleet depots have many similarities. These lessons include the following:

- Vehicle production and delivery can quickly outrun infrastructure availability.
- Funding and incentives for infrastructure does not equal energized infrastructure.
- Supply chain constraints are real and require creative strategies.
- Workforce development is required across all trades and disciplines to handle today's growth and the coming tsunami of infrastructure buildout.
- If the grid doesn't reach your facility, you may need to build your own (micro)grid.

- Construction is the "easy" part. There is no substitute for solid feasibility, planning, and engineering, and locking in an energy supply.
- Be prepared for expansion and scale following the initial success of a project.

Planners will also benefit from information shared in three foundational documents: NASA's *Urban Air Mobility Infrastructure* report (Black & Veatch 2018), written to educate industry stakeholders regarding charging infrastructure costs, electrical grid upgrades, and the different utility operator business models across the United States; *Powered for Take Off* (Stith and Khangura 2020), highlighting the synergies and need to think holistically across eCTOL, eVTOL, and regional airports; and *NASA Regional Air Mobility* (Antcliff et al. 2021), a collaboration among over two dozen industry experts sharing perspectives on how new technologies will drive opportunities.

The best intentions, policy, and funding do not automatically translate into infrastructure. Too often the success of small pilots, demonstrations, and press releases leave an impression that infrastructure is easy. It is not. As we decarbonize energy-intensive transportation and begin to ramp up AAM, the success of this sector will require planning for scaling infrastructure from the outset.

for every step in a traveler's journey: ticketing and check-in, first-and last-mile connections to and from a network of vertiports, and arrival at a traveler's destination (Shaheen et al. 2020). This will require the physical and digital integration of AAM with other travel modes.

Integrating AAM with surface transportation modes will be key. Planners can play an important role in preventing and mitigating surface congestion to and from vertiports and encouraging intermodal connectivity. Locating vertiports in mixed-use walkable locations with access to shared mobility, micromobility, and high-frequency public transportation can help reduce vehicular trips to and from these facilities, though such siting decisions must also consider the potential airspace access and community impacts, as discussed in Chapters 3 and 4. Connecting vertiports with public transportation could provide transportation alternatives in the event of inclement weather, maintenance, or other operational delays impacting AAM. This could also increase access to AAM in areas that have existing transit service but where siting a vertiport might not be feasible due to airspace limitations and concerns about environmental impacts.

Adapting and reusing existing parking structures as vertiports could be another option for AAM facility development. Given that many vertiports will require substantial electric infrastructure for charging, some experts envision vertiports as multimodal facilities that could integrate electric vehicle charging and serve as a depot for shared automated vehicles. The U.S. Department of Transportation has developed a mobility on demand (MOD) [planning and implementation guide](#) to aid local, regional, and state governments in preparing for mobility innovations, such as AAM and automated vehicles (Shaheen et al. 2020).

Additionally, fare payment and digital integration with other transportation modes through MOD and mobility as a service (MaaS) will be key. MOD and MaaS can enable multimodal travel by allowing travelers to access multiple transportation modes over a single digital interface. Digital and fare payment integration not only allows travelers to have seamless modal connections, but also could allow the public and private sectors to price trips in a way that discourages AAM for shorter trips that would be better accomplished by existing surface transportation modes.

One potential model for the integration of AAM into existing transportation systems comes from California's Bay Area Rapid Transit District (BART), which has developed a [station access typology](#) to help guide modal connections at an array of station types (Figure 5.6, p. 56). Broadly, BART's station access typology classifies stations from least

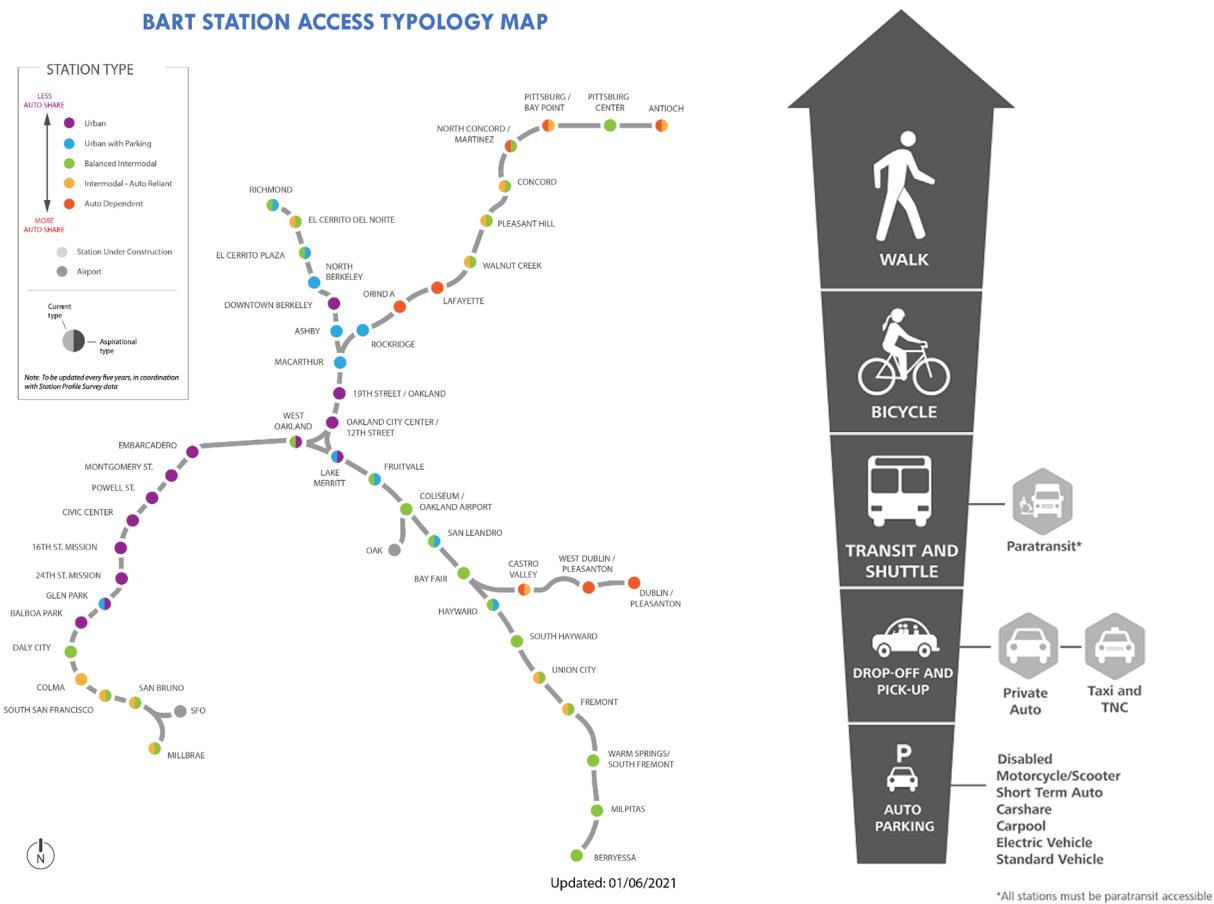
automobile-oriented to most automobile-oriented (e.g., urban, urban with parking, balanced intermodal, intermodal auto reliant, and auto dependent). The typology is designed to help guide BART's multimodal investment priorities based on each station type. BART also has developed a [station access hierarchy](#) intended to guide design decisions at a station level (Figure 5.7, p. 56). The hierarchy prioritizes walking, cycling, and public transportation while deprioritizing passenger pick-up and drop-offs and vehicle parking (BART n.d.). Although originally designed for public transportation, many of these concepts could be applied to vertiport design and access.

One potential approach to multimodal integration is vertiport-oriented development (VOD). Building on the model of transit-oriented development (TOD), the concept of VOD maximizes residential, office, retail, and other synergistic land uses, along with connections to public transportation (e.g., bus or rail), within walking distance of a vertiport. Depending on the planned volume and time of flight operations, however, public agencies may want to limit density to some degree and encourage nonresidential land uses, particularly in the vicinity of planned approach and departure paths, as a preemptive measure to preserve airspace access and mitigate potential noise concerns.

Like TOD, the densest areas of VOD would generally be located within a core of approximately one-quarter to one-half mile (400 to 800m) around the vertiport, with smaller block sizes to encourage walkability. Integrating vertiports with public transit and other transportation options can provide mobility alternatives in the event of inclement weather or other AAM operational delays. VOD could minimize auto-oriented land uses, decrease demand for station parking, and promote bidirectional AAM use. In doing so, VOD could reduce single-occupancy vehicle travel, reduce motorized first- and last-mile connections to vertiports, and minimize "deadheading" (an AAM trip without paying passengers or cargo) by encouraging more balanced AAM travel patterns.

Closely related to VOD is a concept known as joint development (Raine et al. 2021). This is real estate development that occurs on a public agency-owned facility or through some other type of real estate transaction in which the public agency is a party. The public sector can participate in joint development by contributing funding or real property.

There are several reasons why public agencies may want to engage in AAM joint development. It presents an opportunity to raise revenue by monetizing publicly owned real property to help fund capital improvements and ongoing operations, increase passenger volumes and farebox revenue



Figures 5.6 and 5.7. BART station access typology (left) and station access design hierarchy (right) (Bay Area Rapid Transit District)

in the case of first- and last-mile connections to intermodal passenger facilities, and support broad planning goals such as placemaking and sustainability.

A few types of AAM joint development scenarios that a public agency may engage in include the following:

- Development of a privately owned or operated vertiport on publicly owned property, such as at or near an intermodal passenger facility (e.g., sale of a parcel, long-term lease of a parcel, or lease or sale of air rights).
- Development of a publicly owned vertiport on privately owned land.
- Development of publicly owned land off-site away from a vertiport for AAM use (e.g., the construction of a joint charging or refueling facility for AAM and public transportation).

The public and private sectors can work together on VOD and joint development through the following actions:

- Implementing a transfer of development rights and/or aviation easement program that protects property rights and potential takeoff and landing approaches to and from existing, planned, and potential vertiports.
- Considering local, regional, or state financing to assemble parcels, remediate brownfields, and connect with surface transportation modes. This could also include financing through economic development programs for vertiports that can demonstrate urban or neighborhood revitalization.
- Reducing parking requirements for residential, commercial, and mixed land uses at vertiports that are integrated with public transportation, and allowing shared parking among uses.

- Minimizing the spatial and visual impacts of vertiport operations on surrounding land uses.
- Providing zoning density bonuses for increased development intensity around vertiports that consider airspace needs, such as height limits, and the potential impacts of development on aircraft operations, such as the “canyoning effect” when wind is channeled between buildings in urban areas.
- Reducing transportation impact fees for the inclusion of public transportation and shared mobility services (e.g., carsharing, bikesharing) at a vertiport.

The sidebar on [pp. 58–59](#) explores the integration of vertiports within the existing urban fabric and transportation systems, in addition to other design and locational considerations, in envisioning a vertiport master plan for London. Careful modeling, analysis, and visualization will be key in designing vertiport facilities that will integrate with transportation systems and the built environment to minimize disruptive impacts on nearby residents. The sidebars on [p. 60](#) and [pp. 61–62](#) delve deeper into the emergence of such tools.

CONCLUSION

AAM will require an extensive network of takeoff and landing facilities, as well as charging and fueling infrastructure. Communities will need to carefully consider how to integrate vertiports and other AAM-related infrastructure into the existing built environment in ways that connect with existing transportation networks.

The business models that emerge in the AAM industry will likely impact the development of this sector, and planners should be aware of the implications of—and tradeoffs between—public versus private funding, ownership, and operation of vertiports. Privately funded and constructed vertiports may not be subject to the public-sector restrictions and obligations commonly associated with state and federal funding or grant assurances. Widespread construction of vertiports by the private sector, however, could lead to more AAM infrastructure than is needed in a community. In contrast, public funding, ownership, and operation of vertiports could give local governments greater influence in ensuring that development of a vertiport network aligns with community goals and is integrated with surface modes of transportation.

In all cases, planners will likely play an important role in encouraging intermodal connectivity through the

planning, design, and approval of vertiports in mixed-use, walkable locations with access to public transit and shared and active transportation. The next chapter explores how planners can use local plans, regulations, and investments to help shape the development of AAM in their communities.

A LONDON VERTIPORT MASTER PLAN

Darrell Swanson, Co-Founder, EA Maven

What would an advanced air mobility (AAM) facility integrated with existing transportation systems in a dense urban setting look like? To explore this scenario, AAM consultants Darrell Swanson and Jarek Zych at EA Maven and Julian Carlson of architects Pascall+Watson developed a concept master plan for a vertiport atop a redeveloped building near Waterloo Station in the heart of London.

A key question for any new transport infrastructure is whether it will increase the use of single-occupancy car trips on the local road network or encourage the use of public transportation. London, with its extensive underground and bus network, already employs a congestion zone charging system to limit the number of vehicles in the city center. Despite this, significant congestion persists. Therefore, a fundamental principle in the planning of vertiports is their need to complement, and not compete with, existing public transport systems. This can be achieved through a holistic transportation strategy that includes both the local public transport and road network and the wider transportation system in general. Planning for a large vertiport needs to consider the impact not just on local roads and public transport nodes, but also on how people will change their behavior in using these transport systems with the vertiport in operation at capacity.

The EA Maven and Pascall+Watson team began with the London Underground map to develop a vertiport that would leverage the existing public transport network. Certain underground stations, offering extensive connection opportunities, were identified as potential sites. Similar to the site selection process for airports, the team looked for sites that addressed the following issues:

- **Noise.** Ideal sites have sufficient distance from schools, places of worship, hospitals, or similar public amenity spaces to achieve a 50db or less noise contour of a landing electric vertical takeoff and landing (eVTOL) aircraft, and/or high levels of background noise that would suppress the noise from eVTOL operations.
- **Public transportation access.** Ideal locations include subway or underground stations that have multiple lines intersecting with good bus transport, or terminus rail stations with underground or subway services.
- **Location.** Ideal sites have high actual interest for the users of eVTOL services— i.e., business destinations in the first years, then major tourist attractions as the system increases

in density. Waterside sites offer opportunities for vertiports in that the approach and departure routes can be over the water, thus avoiding flying over other built-up areas.

- **Airspace considerations.** This includes understanding the makeup of the local airspace and how new routes into and out of cities may affect existing air traffic. In most countries there is a defined set of rules and practices that apply to making changes to the airspace system or adding new approach and departure routes to new airports or vertiports.

Based on these considerations, the team eventually settled on a site near Waterloo Station along the River Thames, leveraging the existing helicopter route through London and ensuring easy connectivity to the underground station, local bus routes, and water taxi services on the river.

The team developed a travel time analysis illustrating the areas accessible within 20 minutes from the station and two stops on the underground services (Figure 5.8), demonstrating the significant impact of vertiport location on its apparent catchment area. The right location can encourage the use of public transport for passengers to complete their journeys, mitigating any additional road congestion.

The proposed rooftop vertiport features twin takeoff/landing areas, 10 aircraft parking stands with automated shuttles to move passengers to and from aircraft, and passenger facilities located beneath the “airfield” (Figure 5.9). Inclined elevator systems ensure accessibility of the facility. The design anticipates that vertiports will prioritize time-based services



Figure 5.8. Map showing the catchment area of the proposed Waterloo vertiport station based on a 10-minute walk, a 10-minute micromobility trip, and access to two tube stations (image Google Earth; analysis EA Maven)

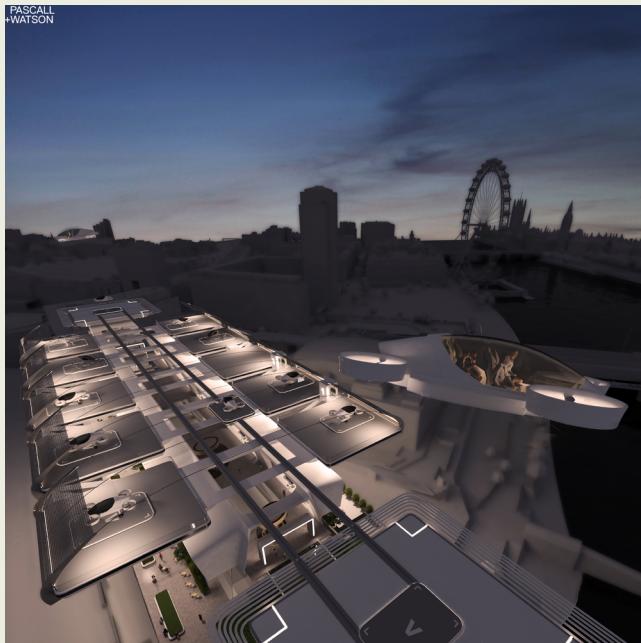


Figure 5.9. The proposed rooftop vertiport concept (Pascall+Watson)

that cater to passengers' brief stays, rather than traditional food, beverage, and retail offerings.

The team developed a dedicated transport interchange concept (Figure 5.10) that provides access to the Transport for London Underground station at Waterloo via a dedicated tunnel, active travel options, and access to river taxi, bus stops, and green shared taxi services. This integration is crucial for the seamless movement of passengers, ensuring the vertiport enhances rather than hinders the existing transport infrastructure.

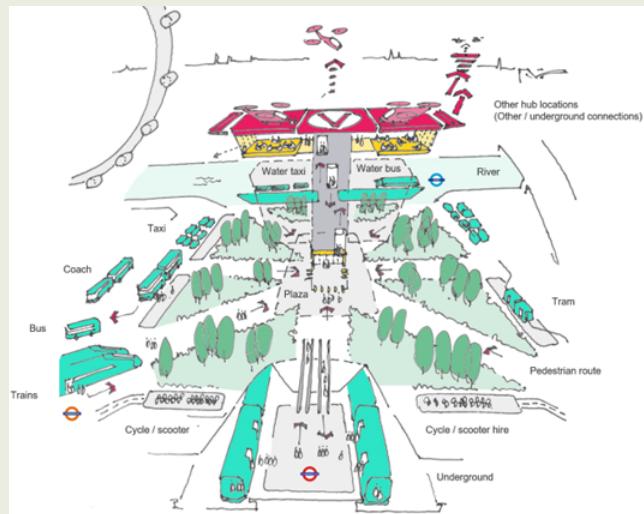


Figure 5.10. The envisioned Interchange Plaza connects the vertiport station with the London Underground and various transportation connection options (Pascall+Watson)

The planning and development of vertiports will require meticulous consideration to ensure this emerging mobility sector complements existing transportation systems. In addition, it will be critical for planners to consider more broadly the potential impacts of vertiports on the local economy and social makeup to ensure that vertiport development will positively impact the local community. This concept master plan for a vertiport near Waterloo Station in London shows how planners can begin to understand and address these considerations, paving the way for the successful integration of vertiports into urban landscapes.

AAM VISUALIZATION AND ANALYSIS TOOLS

Shahab Hasan, Vice President, Aeronautics Strategy and Analysis, Crown Consulting, Inc.

Advanced air mobility (AAM) is still in its nascent phase. There are many aircraft designs undergoing development and new infrastructure for AAM is largely in the planning stage, with most initial operations planned for existing facilities, such as airports. This relative lack of maturity poses a challenge for urban design and transportation planning because operations are mostly theoretical, not actual. It would be imprudent, however, to wait until actual operations commence to address AAM community integration.

Visualization and design tools can help address this challenge by enabling planners to scenario plan using an array of existing data (e.g., location of existing physical infrastructure, population and travel demand, commercial air traffic patterns) and simulated data (e.g., AAM traffic forecasts, potential vertiport locations, hypothetical flight paths). As planners are already adept at using tools such as geographic information systems (GIS), AAM tools that build off these kinds of existing visualization and analysis platforms will be more amenable to adoption.

Identifying the optimum site for vertiports presents notable challenges because of the wide array of multidisciplinary considerations required, such as safety, airspace management, surface transportation access, land use compatibility, equity, social acceptance, and environmental impacts (Mendonca et al. 2022). To address this challenge, NASA has supported the development of visualization and analysis tools through its [Small Business Innovative Research](#) (SBIR) program, a general-purpose initiative to support small businesses in conducting technology research and development.

As part of the SBIR, NASA contracted with [Crown Consulting, Inc.](#) to develop an AAM Community Integration Platform (AAM-CIP) capable of (1) data fusion, (2) airspace adaptation data creation, (3) scenario generation, (4) AAM traffic simulation, (5) metric computation, and (6) data visualization. The AAM-CIP enables a user to develop recommendations for vertiport locations and airspace routes considering travel demand, safety, and noise. The top-level system architecture establishes a data flow from user objectives and requirements to a graphical user interface (GUI), including a graphical layer for editing vertiport placement, generating routes, and defining AAM airspace (Figure 5.11) that will enable the user to assess the impacts of relevant issues and rapidly explore the trade space of alternatives.

Additional features planned for the AAM-CIP include the integration of analytics software; addressing additional community issues such as infrastructure, equity of benefits, and connectivity with other transportation modes; software automation to automatically generate and analyze ranges of inputs and alternatives to map the AAM system trade space or rank alternatives with respect to specified optimization criteria and constraints; and simulations and displays to present a dynamic real-time or fast-time picture of AAM operations and their impacts on the population being overflowed. While this platform will be proprietary to Crown Consulting, similar tools intended for more general usage are currently under development by several entities, including NASA.

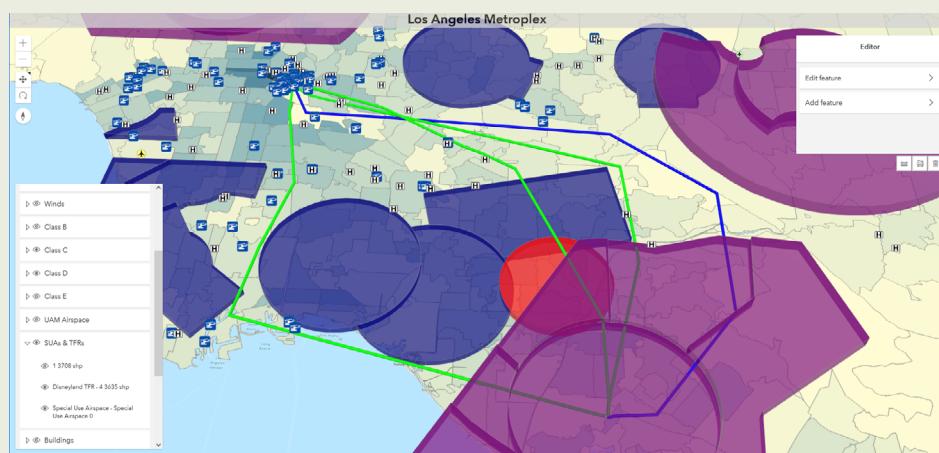


Figure 5.11. The AAM Community Integration Platform will allow users to edit vertiport placement, generate routes, and define AAM airspace (Crown Consulting, Inc.)

THE IMPORTANCE OF AAM MODELING AND SIMULATION

Pavan Yedavalli, PhD, Head of Data Science and Systems Simulation, Wisk Aero

Advanced air mobility (AAM) is at the forefront of innovative technologies in the transportation sector, with a broader goal to decarbonize aviation and enhance the multimodal transportation network in cities across the world. However, the introduction of transportation technologies such as AAM must come with extreme caution, and more importantly, responsible deployment to maximize beneficial outcomes for broad swaths of society.

Given significant computing advances and data collection capabilities over the past several decades, we are now developing sophisticated simulation software and comprehensive decision-support systems to model urban air mobility (UAM)'s short- and long-term effects on cities. Public agencies such as local governments and metropolitan planning organizations (MPOs) have historically used travel demand models and aggregated data for economic impact assessments, transportation infrastructure provision, and policy making. To simulate AAM holistically, and specifically UAM, an integrated land use, travel demand, and transportation model would be a gold standard for city and regional planners (Yedavalli 2021; Waddell 2011).

A multimodal UAM trip involves an access leg from a traveler's origin to their origin vertiport, groundside and air-side wait times at the origin vertiport, flight times, groundside and airside wait times at the destination vertiport, and finally an egress leg from the destination vertiport to the traveler's destination. As a result, these simulations must be both granular and accurate on both the ground and in the air.

Once a methodology is developed to model ground-based traffic and air-based traffic, a traveler's total multimodal UAM travel time can be determined. These models must then have the capability to do sensitivity analyses based on UAM adoption rates, vertiport network designs, and different variants of urban air transit and air taxi paradigms to find optimal deployments based on a set of constraints that are critical for public agencies, such as minimizing total vehicle miles traveled (VMT) or emissions, or maximizing equity outcomes or economic impact (Balac, Vetrella, and Axhausen 2018; Yedavalli 2021).

There has been a variety of AAM simulation and modeling research conducted in the past several years. In industry, Uber developed an aggregate model based on ride-hailing trips in the greater Los Angeles and London areas, applying a k-means clustering methodology to the set of trip origin and destination points to reduce the number of candidate locations for consideration (Holden and Goel 2016). How-

ever, this analysis did not take the further step to understand what impacts this service could have on the existing transportation network or the cities themselves; as it stands, Uber does not have that holistic capability. A³ by Airbus developed unmanned traffic management blueprints for when drones and aerial taxis are in the sky, but these did not extend to the effects such vehicles will have on the ground (Yedavalli and Mooberry 2019).

In the realm of aviation research, Bongiorno et al. (2015) developed an agent-based model for air traffic simulation, called ELSA, which tests high-level performance changes at airports and for commercial airlines, but they have neither extended it to emergent UAM nor found impacts to urban environments. Grether and Nagel (2019) developed an agent-based model of air transport demand in Europe, determining the types of travelers who take specific commercial flights; while this is a step to understand those who fly, it has not extended past commercial airport operations, similar to the ELSA project. Several other air traffic simulators, such as SIMMOD and RAMSrams, are also widely used today, but none of these tools moves past aviation operations or is able to represent people on an individual agent-based level for long time periods (Kokkinogenis et al. 2011). Balac, Vetrella, and Axhausen (2018) and Rothfeld et al. (2018) are currently using MATSim for UAM simulation, but such mesoscopic approaches are also not granular enough to understand daily activity patterns.

In addition to the aforementioned gaps in research, many analyses have assumed static parameters in either ground traffic, vertiport transfer times, aerial flight, or a combination of the three. However, for UAM, since its purported value is in travel time savings, simulating the margins at a granular level and incorporating dynamics and scheduling in each leg of the trip is of utmost importance (Rothfeld et al. 2020; Bulusu et al. 2020; Yedavalli 2021; Lim and Hwang 2019). In addition, because UAM will be particularly valuable across larger markets that suffer from congestion and sprawl, metropolitan-scale simulation is paramount to understand downstream spatiotemporal effects.

Recent work from the University of California, Berkeley's Urban Analytics Lab and Cal Unmanned Lab, in collaboration with NASA Ames, has shown the capabilities of developing a holistic simulator, with fast, metropolitan-scale GPU-based microsimulation, parallelized vertiport simulation and scheduling, and advanced machine learning techniques for vertiport

location optimization (Yedavalli, Kumar, and Waddell 2020; Yedavalli et al. 2021; Yedavalli et al. 2022).

Integrating AAM into the planning process is critical not only for understanding downstream effects, but also in shaping regulatory policy prior to scaled deployments. It can allow public agencies to study the impacts of UAM airspace corridors and vertiport placement on noise, safety, land use, and other aspects of comprehensive plans. Modeling and simulation of AAM fits within this broader integration and can inform those recommendations. Without understanding quantitatively how a specific UAM use case will be deployed, it will be challenging to understand how people will change their travel behavior, and ultimately what effects these new mobility patterns will have on sustainability, equity, land use, and economic development.

Major aircraft manufacturers and service providers, such as Joby Aviation, Archer Aviation, and Wisk Aero, are currently developing their own simulation models to understand not only which global markets to enter, but also the operations, ridership, and throughputs that will help close their business cases. To prepare them to engage with aircraft original equipment manufacturers (OEMs), operators, and vertiport developers, cities and MPOs should leverage these sophisticated models to help them understand how to align policy and incentives while preserving the key tenets of aviation: safety and efficiency. Partnering with federal or state agencies that have developed these modeling tools can be an efficient and effective way to support decision-making at these levels.

CHAPTER 6

**INTEGRATING
ADVANCED
AIR MOBILITY
INTO PLANNING
PRACTICE**

Local policies such as zoning, other regulatory codes, and approval processes can have a notable influence on how advanced air mobility (AAM) is integrated into a community. Communities have the potential to guide planning outcomes by addressing key local policy and regulatory issues affecting AAM.

This chapter underscores the need for communities to consider incorporating AAM into long-range planning efforts. It discusses potential opportunities for integrating AAM into local and regional planning processes, such as comprehensive plans. It then examines how AAM intersects with other strategic points of planning intervention, such as land use compatibility, regulations, public investments, and partnerships.

AAM IN THE COMPREHENSIVE PLAN

Comprehensive plans—known as general plans in several states—set long-term visions, goals, and policies that communities use to guide development decisions. Common plan elements include transportation, land use, housing, natural resources, and open space; in California, general plans must address noise and public safety.

These plans offer planners and policymakers an opportunity to initiate community discussions around AAM, document the state of local transportation networks (including access and mobility), and establish a vision, goals, and policies to help guide future AAM decision-making. The comprehensive planning process also enables a community to catalog mobility strategies beyond major roads and public transportation, such as AAM and other transportation services.

As an example, California law requires that each county and city in the state develop and adopt a general plan, which must address airports and other aviation facilities within the circulation element of those plans (Governor's Office of Planning and Research 2020). California's guidance encourages municipalities and counties to include the following considerations, many of which would be applicable to AAM:

- An assessment of port (e.g., airport and seaport) facilities, including the need for expansion and improvements
- A projection of future demand based on new or expanded economic activities and recreational trends
- An assessment of the safety hazards associated with existing aviation facilities and the need for expansion and improvements
- Limitations on potential noise and safety hazards posed by port activities to surrounding land uses (e.g., creating land use and zoning buffers between noise-sensitive land uses and noise-generating transportation facilities)
- Mitigation of aviation-related hazards posed to and by aircraft
- Accessibility of aviation facilities by all transportation modes

Other examples of the way AAM could be incorporated into comprehensive planning include goals and policies that address safety considerations, land use in the vicinity around vertiports, and existing and forecasted noise contours around existing and planned vertiports.

The general plan of the City of Tracy, California, includes key goals, objectives, policies, and actions pertaining to its municipal airport (Tracy 2011), which also could be applicable to vertiports and AAM operations. The following is an aviation-related goal, objective, policy, and action from Tracy's plan:

Goal SA-5: Protect from the risks associated with aircraft operations at the Tracy Municipal Airport.

Objective SA-5.1: Ensure that land uses within the vicinity of the Tracy Municipal Airport are compatible with airport restrictions and operations.

PLANNING FOR THE FUTURE TO PRESERVE OUR PRESENT

Jacques Coulon, AICP, Mobility Innovation Manager, City of Orlando

The arrival of new transportation technologies and approaches can have a very disruptive impact if not done in a coordinated effort with the communities they are introduced into, as seen with the emergence of transportation network companies (TNCs) and shared micromobility. Acknowledging the need to proactively identify and plan for these and other potentially disruptive innovations, the City of Orlando, Florida, embarked on an effort to identify those “future is today” items for advanced air mobility (AAM) across the breadth of city services with an eye on strategies to address those opportunities.

Future-Ready City Master Plan. The [Orlando Future-Ready City Master Plan](#) was adopted by the Orlando City Council in 2021 following years of internal and external outreach and collaboration with municipal departments and the public. Divided into seven focus areas, the document is a strategic plan that seeks not only to continue the city’s path of innovation, but to continue a tradition of learning, listening, and co-creating a beautiful community that meets the diverse needs of its residents. The need to plan for AAM was initially recognized as a priority during the formulation of Orlando’s Future-Ready Master Plan, and a specific strategy under the mobility focus area was created to encourage the city to create a regional AAM mobility plan.

Mobility/AAM in the Growth Management Plan. Orlando’s comprehensive plan, known as the [Growth Management Plan](#) (GMP), sets the overarching vision, policy, and direction for growth of the city and includes specific goals, objectives, and policies setting the framework for the implementation of the plan. This includes Objective 1.22, which states that the City “shall continue to review individual requests for the construction of vertiports as a conditional use consistent with the procedures in the Orlando Code of Ordinances.”

While there is a framework within both the GMP and the municipal code relating to the review and approval process for vertiports, this framework was put into place with traditional helicopters referencing the Federal Aviation Administration’s Heliport Design Guide, AC 150/53901A, dated November 5, 1969. As noted in the vision statement of the GMP, “The transportation system should not dictate the land use pattern, it should further the desired land use objectives.” Implementing AAM as currently envisioned may place vertiports throughout our region and introduce aviation within neighborhoods that have not previously experienced the direct impacts that come with it.

Engagement with aviation stakeholders. There is a seeming contradiction between the city’s goal that transportation systems should not dictate the development of an area and the transformative nature of vertiports on the communities that they are built within. While this tension between transportation and land use is not new, the Central Florida region has seen this through the continued expansions of our expressways as well as the introduction of Sunrail, the regional commuter rail system. The unique nature of aviation further cemented the need for Orlando to develop a plan for AAM.

In the summer of 2021, Orlando city staff held a series of meetings and workshops to bring together stakeholders from the Greater Orlando Aviation Authority (GOAA) area city and county governments, regulators, and private industry. The purpose of these meetings was twofold: the first was to provide some education about AAM to our local partners so that as discussions occurred we were all coming from a place of understanding the possibilities and challenges that must be considered as we plan, and the second was to bring together local land use and transportation planners with those in the aviation sector—two groups that do not have a history of working together.

As is the case in many cities, Orlando staff typically have limited interaction with our local aviation authority outside the boundaries of the airport and a few off-airport tall structures cases; staff have even less interaction with our local Federal Aviation Administration (FAA) representatives. The broad-based stakeholder meetings provided an opportunity for city staff to begin a working relationship with and have a direct line of communication to the regulatory subject matter experts within the regional FAA and state Department of Transportation (DOT) aviation offices, as well as GOAA. These relationships and open communication channels have allowed the city to provide direct feedback to federal and state policymakers to help ensure that local land use control of vertiport siting and associated impacts are considered in any new regulations or policies. While there remains uncertainty around the control of airspace immediately around vertiports, local land use control must remain at the core for the city with respect to vertiports.

GMP and code updates. The discussions with our partners made it clear that current city code related to the review and approval of vertiports does not adequately address the local impacts and increased operations associated with

AAM. At the core of our updates is the desire to accommodate the introduction of this emerging mobility option while ensuring that both the positive aspects (additional mobility options, jobs, economic growth, and stronger connections to regional hubs) and negative impacts (the possibility for additional ground traffic around vertiports, environmental issues such as noise and visual pollution, and the need for increased electrification) are fully considered and integrated into our code updates. While it is not an exhaustive list, Orlando has identified a number of key questions as the city proceeds with code updates:

- Where should vertiports be located?
- How can the city update regulations in a way that allows for the introduction of AAM into our community while not allowing unfettered development and unintended consequences?
- Will vertiports be owned and operated by a public entity or private firm and how will this affect the operations at the vertiport?
- How do we ensure safe operations and integration into existing airspace and ground transportation networks?
- How should the city regulate, measure, and enforce external AAM impacts (noise, visual pollution, etc.)?
- How will approval of a vertiport affect property rights for surrounding parcels?

Aviation has not been a part of the everyday considerations of the city's land use and transportation planners, but the introduction of AAM throughout our communities provides the very real possibility that this will change. While it is too soon to dedicate staff solely to aviation planning, it is imperative for Orlando's planners to have a basic understanding of aviation rules and policies, such as airspace and vertiport design regulations. Of even more importance are the relationships with the state DOT aviation divisions and local FAA regulators. These subject matter experts have provided Orlando with a deeper understanding of the constraints that need to be considered as code updates to address AAM are completed.

Policy P1: Ensure that new development is consistent with setbacks and height and land use restrictions as determined by the Federal Aviation Administration and the San Joaquin County Airport Land Use Commission, as well as the policies of the City's Airport Master Plan.

Action A1: Develop an emergency plan to respond to aviation incidents in the City.

Each of these items could easily be adapted to address AAM and vertiports. This serves as an example of the type of language that other communities could incorporate into their comprehensive plans to create a policy basis to inform further decision-making around AAM.

One city that has recognized the need to plan for the potential disruptive effects of AAM deployment on existing transportation systems is Orlando, Florida. The sidebar on [pp. 65–66](#) describes how the city is working to integrate AAM considerations in planning documents and code updates. And as with other mobility systems, AAM must also be integrated into transportation plans and planning processes that occur at the regional level. The sidebar on [pp. 67–69](#) discusses why metropolitan planning organizations (MPOs) are well positioned to play an important role in AAM planning and implementation across local jurisdictional boundaries for a coordinated regional approach.

Local Vertiport Land Use Compatibility Planning

In the past, comprehensive plans have often only minimally recognized the implications of planning for aviation facilities. As such, many practitioners and policymakers have developed other planning processes for determining appropriate (and inappropriate) use of properties around takeoff and landing facilities.

Although AAM aircraft may be considerably quieter than current-generation helicopters and commercial aircraft, the compatibility of aviation with existing land uses is important to both local governments and airports, and the same will be true of vertiports. AAM may bring additional aviation facilities and uses into nontraditional districts, such as downtowns and neighborhoods, that have not had to address many of these impacts. Ensuring compatibility will require understanding how AAM facilities will function and how they will impact or might be impacted by the communities that surround them—for example, in terms of noise or traffic to and from the facility (FAA 2022a).

For AAM, land use compatibility planning should encourage land uses that are more compatible with aviation

METROPOLITAN PLANNING ORGANIZATIONS AND REGIONAL AAM INTEGRATION

Ernest Huffman, Program Manager, Aviation Planning and Education, North Central Texas Council of Governments

Advanced air mobility (AAM) will likely get its start in one of America's largest metropolitan areas. The most populous metropolitan statistical areas (MSAs) are New York–Newark–Jersey City, Los Angeles–Long Beach–Anaheim, Chicago–Naperville–Elgin, Dallas–Fort Worth–Arlington, and Houston–Pasadena–The Woodlands. Each of these regions has anywhere from six to 14 counties, with an even greater number of municipalities.

In the Dallas–Fort Worth region there are 45 cities with populations greater than 50,000. Each municipality has its own transportation issues, processes, and politics, and all are very competitive with each other for economic and workforce development. The advent of AAM has raised a number of regional planning questions:

- With the integration of AAM being touted as a viable option for local and regional aviation, who in these regions should be responsible for ensuring that the technology is implemented equitably across the region and not just the larger cities?
- Why would two neighboring municipalities coordinate with one another when integrating the technology?
- Will a region's [FAA Regional Airports Division and District Offices](#) (ADOs) have the bandwidth or funding to plan AAM integration alongside all other modes of transportation?
- Can the staff responsible for deployment at the largest commercial airports be expected to plan and fund deployment at nearby reliever airports (smaller airports designated by the FAA to relieve congestion at larger commercial airports)?

The answer to all of these questions is probably no. For this reason, metropolitan planning organizations (MPOs) are likely in the best position to integrate and coordinate AAM planning and implementation across all of these local governments. MPOs are federally mandated and funded transportation policy-making organizations made up of representatives from local governments and governmental transportation authorities. They were created to ensure regional cooperation in transportation planning. MPOs also apply and compete for most federal and state transportation funding sources.

MPOs have existing planning processes that can easily accommodate planning for AAM. For example, the Dallas–Fort Worth region's MPO, the [North Central Texas Council of](#)

[Governments](#) (NCTCOG), prepares the following planning documents in accordance with federal law:

- Metropolitan Transportation Plan
- Transportation Improvement Program
- Congestion Management Process
- Regional Aviation System Plan

Each document is designed to ensure that MPOs conduct public outreach, solicit feedback, and identify funding while simultaneously collaborating with all stakeholders, including industry, local, state, and federal representatives. MPOs can use these existing plans and processes to integrate AAM.

Metropolitan Transportation Plans (MTPs) are comprehensive blueprints for multimodal transportation systems and services intended to meet the needs of a metropolitan area over 20–25 years. Projects, programs, and policies are proposed as recommendations to improve mobility, air quality and quality of life. The MTP traditionally focuses on multiple strategies involving roads, passenger rail, and enhancements such as bicycle-pedestrian lanes and off-street paths. The MTP is limited to reasonably available financial resources, meaning it may only include projects that can be afforded.

MTPs can be adapted to include AAM in the following ways:

- Multimodal integration: Integrate AAM as an additional mode, connecting urban and remote areas seamlessly.
- Infrastructure: Identify suitable locations for AAM facilities, enhancing transportation hubs.
- Intermodal connectivity: Design connections between AAM and existing modes for easy transfers.
- Technology embrace: Recognize AAM's potential and encourage innovation in the field.
- Safety and regulations: Establish safety guidelines and collaborate with aviation authorities.
- Emergency response: Integrate AAM into disaster relief strategies for swift transportation.

Transportation Improvement Programs (TIPs) are federally and state-mandated lists of funded projects with committed funding for construction or implementation within a four-year period. The TIP includes project information and details about funds allocated from federal, state, and

local sources. Every two to three years, NCTCOG develops a new TIP document with the help of the Texas Department of Transportation, local governments, and transportation agencies. Projects listed in the TIP represent the region's commitment to mobility and air quality.

TIPs can be leveraged to integrate AAM in these ways:

- Project inclusion: Adding AAM projects with secured funding for implementation within four years.
- Regular updates: Incorporating AAM-related updates in the TIP every two to three years to reflect industry advancements.

Congestion Management Processes (CMPs) outline effective management of transportation facilities and systems to maximize the benefit of available resources. A transportation system as large as Dallas–Fort Worth's needs more than just capital improvements to run smoothly. The CMP develops lower-cost operational management and travel demand reduction strategies that complement costly infrastructure improvements. It is required for metropolitan areas with populations exceeding 200,000 people.

Integrating AAM into the CMP involves these steps:

- Recognition of AAM potential: Acknowledge AAM's role as a regional congestion alleviation tool in the CMP.
- Strategic expansion: Extend CMP strategies to incorporate AAM as an innovative means of optimizing transportation resources.
- Synergy with infrastructure: Align AAM with traditional capital improvements, leveraging it as a complementary solution to enhance transportation efficiency.
- Operational AAM strategies: Develop AAM-specific strategies within the CMP framework, focusing on operational management and demand reduction.
- Corridor-specific approaches: Identify congested corridors where AAM could be particularly effective in reducing traffic.
- Intermodal connectivity: Integrate AAM services into existing transportation networks to facilitate seamless transfers.
- Peak time relief: Plan for deployment of AAM during peak congestion hours to alleviate strain on transportation facilities.
- Regulatory alignment: Ensure AAM operations comply with aviation and transportation regulations within the CMP framework.
- Scalable approaches: Develop adaptable AAM strategies that can evolve based on congestion patterns.

Regional Aviation System Plans (RASPs) are airport system planning documents for public-use airports (including heliports, vertiports, seaplane bases, and spaceports) and related facilities that are necessary to meet the current and future air transportation needs of a metropolitan, state, or multistate area. They provide guidance on how to maximize the system benefits of airport investments and how to align federal priorities with state and local objectives.

The RASP process can be instrumental in integrating AAM by incorporating the following steps:

- AAM infrastructure integration: Expand the RASP scope to include vertiports, heliports, and relevant facilities necessary for AAM operations within the public-use airport system.
- Future air transportation needs: Analyze AAM's role in meeting current and future transportation needs, aligning it with traditional aviation services.
- Spatial planning: Identify suitable locations within the regional airport system for AAM facilities, considering factors like airspace management, noise levels, and land use.
- Intermodal connectivity: Integrate AAM infrastructure into existing airports to enable seamless transfers between traditional aviation and AAM services.
- Safety and regulation: Address safety considerations and regulatory requirements specific to AAM operations in coordination with aviation authorities.
- Airspace management: Develop procedures to accommodate AAM aircraft in the National Airspace System, ensuring safe integration with existing airspace users.
- Facility design: Plan and design AAM-specific infrastructure such as vertiports, considering factors such as aircraft size, charging infrastructure, and passenger amenities.
- Investment optimization: Provide guidance on maximizing the benefits of AAM infrastructure investments and aligning them with broader airport system objectives.
- System-wide benefits: Identify how AAM can enhance the overall airport system's efficiency, connectivity, and accessibility.
- Federal-state alignment: Ensure that AAM planning aligns with federal priorities and funding mechanisms while meeting state and local transportation objectives.
- Long-term vision: Include AAM as part of the future vision of the regional aviation system, considering how it fits into transportation goals over time.

Integrating AAM into transportation planning within our largest MSAs is a daunting mission. The largest MSAs possess

intricate transportation networks and, as AAM emerges, offer strategic pathways for integrating AAM into planning and policy, and with other modes of transportation. In summary, the MTP can include AAM as a forward-looking mode; the TIP provides a funding platform for AAM initiatives, ensuring adaptability; incorporating AAM into the CMP offers cost-effic-

tive strategies for managing resources and improving mobility; and the RASP can encompass AAM infrastructure, expanding its scope to create a comprehensive aviation ecosystem. By leveraging MPOs and aligning AAM with existing planning processes, the largest MSAs can pave the way for a more connected, efficient, and accessible future across all cities.

to locate closer to vertiports and those less compatible with aviation, such as schools and places of worship, to locate further away from these facilities (FAA n.d.). This can include a variety of techniques and approaches, such as requiring noise mitigation measures for land uses near a vertiport, placing commercial and mixed uses near vertiports, and limiting residential land uses or positioning residential land uses away from approach paths and touchdown and liftoff areas (TLOFs).

The primary responsibility for integrating vertiport considerations into the local land use planning process rests with local governments. Although the federal and many state governments cannot dictate local land use policies, both can play a role in facilitating the coordination between AAM facilities and local, county, and regional planning agencies to ensure that compatibility in land use planning occurs around vertiports (FAA n.d.).

One approach to addressing land use compatibility planning for vertiports might be to borrow from airport master planning. This process projects future aviation activity and designs the airport layout (FAA 2015). A similar type of master planning process could theoretically be applied to the development of a vertiport master plan, which would be a process to plan for the short-term, intermediate, and long-term development goals of a vertiport or network of vertiports.

Airport master planning typically includes eight key elements (FAA 2015): (1) a public involvement program, (2) consideration of environmental issues, (3) existing conditions evaluation, (4) aviation activity forecasting, (5) facility requirements analysis, (6) alternatives development and evaluation, (7) an airport layout plan, (8) a facilities implementation plan, and (9) a financial feasibility analysis. All of these elements could be addressed in a vertiport master planning process.

When planning for AAM, it is important to remember that the FAA has already established interim design guidance for vertiports, including dimensional requirements for

eVTOL landing areas and approach/departure paths, as discussed in Chapter 5. The FAA regulates ground clearance for takeoff and landing safety, including land uses and dimensional standards for buildings within the takeoff and landing approaches. Vertiports will also be subject to FAA and sometimes additional state-level guidance, which all must be considered in the planning process (FAA 2022b). Additionally, state DOTs may have airport land use compatibility planning processes that could be applicable to vertiports. For example, California requires comprehensive airport land use planning through Airport Land Use Commissions (ALUCs) to promote compatibility between airports and surrounding land uses. However, ALUCs make advisory recommendations that are not binding on local land use decisions.

LOCAL POLICY AND REGULATORY CONSIDERATIONS FOR AAM

Local policy and regulatory considerations for AAM predominantly relate to vertiport land use compatibility issues, as addressed through zoning, local vertiport approvals and permitting, local funding for AAM infrastructure, and local public-private partnerships. As with comprehensive planning, ensuring that land uses adjacent to vertiports are compatible with this aviation use is important for a community's quality of life and the safe operations of a vertiport and its users.

Several states have developed processes to help facilitate appropriate land use compatibility with aviation facilities. As noted above, in California, ALUCs have been established for all counties with public-use airports within the state. ALUCs coordinate airport land use compatibility planning efforts at the state, regional, and local levels; prepare and adopt an airport land use compatibility plan for each public-use airport in their jurisdictions; and review plans, regulations, and other actions of local agencies and

airport operators. In the future, the authority of these commissions could be expanded to include vertiports, or similar commissions could be established for AAM to assist local officials with vertiport land use compatibility.

Legal definitions of AAM services and infrastructure will be essential for incorporating such services into planning practice. Clear terms and definitions for AAM will be required for addressing this use in plans, zoning, and community engagement processes. The FAA [Vertiport Engineering Brief](#) defines a vertiport as “an area of land, or a structure, used or intended to be used, for electric, hydrogen, and hybrid VTOL aircraft landings and takeoffs and includes associated buildings and facilities” (FAA 2022b). One local example of a definition comes from the City of Orlando, Florida’s Land Development Code, which defines a vertiport as “an identifiable ground or elevated area, including any buildings or facilities thereon, that has been designated to be used for the takeoff and landing of tiltrotor aircraft and rotorcraft” ([§66.200](#)). Additional definitions at the local, regional, and state levels of government will likely be developed as the issue of vertiport land use compatibility comes to the forefront.

Zoning for AAM

The zoning ordinance divides a jurisdiction’s land into different districts and specifies the permitted uses and standards required within each zoning district. Zoning can be used as a tool to guide the location of proposed vertiports and to control development around vertiports, such as limiting land uses that may be less compatible with vertiports.

Local governments have wide discretion in how they regulate land uses, which influences the ease of approval (or lack thereof) for different uses. The zoning ordinance could define “vertiport” as a distinct use, or it could include vertiports within a broader land use category, such as “urban aviation,” to differentiate these facilities from more traditional aviation-related uses, such as airports, airstrips, and hangars. The local government could designate vertiports or urban aviation as a by-right use in certain zoning districts, and as a conditional or special use in others. In the former case, a vertiport proposal would automatically be approved if it conforms with all relevant standards, while the latter case would require compliance with specified conditions, a discretionary review process by planning staff, and approval by the planning commission, zoning board, or city council. This latter approach provides flexibility while still ensuring that the use is and will remain in harmony with the purposes and intent of the zoning ordinance (Porter 2012). For example, es-

tablishing vertiports as a conditional use in a residential zone could allow a private facility to move forward if a vertiport owner/operator agreed to restrict flights to between 10 p.m. and 6 a.m. (when noise is of the greatest concern), in addition to meeting additional criteria or standards to minimize negative impacts on residents. Such local development review processes would be in addition to any review and permitting required by state departments and the FAA.

Communities may also consider overlay zoning as a tool to regulate the built environment in ways that influence vertiport placement and operation. The overlay zone could be a special zoning district for AAM placed over existing, or base, zones. It could share common boundaries with the base zone or fall across several base zone boundaries. Development standards for the overlay zone could limit building heights and preserve approach paths for either planned or potential vertiports under consideration. Additional tools, such as the transfer of development rights and aviation easements that can be used to limit building heights and address airspace access, are discussed below.

Overlay zones could also incorporate regulations or incentives to encourage particular types of vertiports within certain areas, such as within a radius of an existing or planned public transit station or along a transit corridor. Similarly, overlay zones could be used to encourage AAM mobility hubs by reducing development requirements, such as parking standards or setbacks, to support new construction near multimodal facilities.

Form-Based Codes for AAM

Form-based codes are land development regulations that support predictable building outcomes by using physical form (rather than separation of uses) as the organizing principle for the code (FBCI n.d.). The purpose of form-based codes is to guide the relationships between building facade and building mass in relation to the scale and types of streets and blocks.

Communities could develop form-based codes for vertiports that include the following elements:

- Designate the locations in the community where AAM form-based code applies. For example, a community might adopt different form-based codes for vertiports in urban, suburban, edge city, exurban, and rural built environments. This could allow vertiports to be better integrated physically into the neighborhoods where they are placed.
- Specify building standards, design elements, and the interaction between the vertiport and public spaces,

such as curb and street access. When developing form-based codes for vertiports, communities could integrate required elements from the [FAA's Vertiport Engineering Brief](#) that might influence vertiport shape, configuration, and possible placement or orientation on a parcel. A community could also add architectural, landscaping, signage, and other standards. For example, a community might require a vertiport to have ground-level retail or mixed use and a building facade consistent with the architectural standards of a particular neighborhood. The form-based code could also provide guidelines on the placement of parking, loading zones, active transportation, and other facility characteristics and enabling infrastructure.

- Provide a detailed glossary for vertiports with visuals and key terms.
- Explain a standardized application, review, and approval process for vertiports.

Developing form-based codes for vertiports could be an effective tool to ensure that vertiports are well integrated into neighborhoods and conform to local design aesthetics.

Other Codes, Regulations, and Permitting Requirements

In addition to local zoning ordinances, building and fire codes could affect the establishment and operation of vertiports (FAA 2022b). Building and fire codes will likely need to be updated to include standards for vertiports. Entities seeking to establish a vertiport should coordinate closely with local planners, nearby airports and aviation stakeholders, emergency response departments, and other stakeholders where a proposed vertiport will be located (FAA 2022b).

The transfer of development rights is another tool that property owners can use to preserve airspace in areas that have by-right zoning approval for building heights that might impact AAM operations and safety. Public and private entities can also acquire aviation easements, or rights for the use of airspace above a specified height, from property owners. The transfer of development rights and aviation easements are tools that can convey various rights relating to the free and unobstructed passage of aircraft, such as the right to fly over a property at or above a specified altitude; the right to cause environmental impact, such as noise, vibration, fumes, dust, or fuel particles; the right to prevent a property owner from constructing obstacles in the airspace; and the right to limit glare, lighting, or electrical interference emitted from a property. The public and private

sectors can use these tools to restrict property owners from building over a specific height. Aviation easements can also be used to limit tort claims against pilots, aircraft owners, and air carriers.

In addition to FAA requirements, many state DOTs, aeronautics commissions, or similar authorities require entities to obtain approval and, in some instances, a license or permit to establish and operate takeoff and landing facilities (FAA 2022b). These state offices may review and assess vertiport permit applications; assist current and prospective vertiport owners, managers, and consultants with permitting, regulatory, and other aviation issues; and facilitate coordination between local governments, state agencies, and the FAA.

Local planners who receive requests to establish a vertiport should ensure that the requestor has contacted the relevant state or local transportation or aeronautics departments or commissions for specifics on applicable licensing or permitting (FAA 2022b). It is recommended practice that local governments codify the requirement that proposers of vertiports receive relevant state and federal approvals, though planners should be aware that such approvals may have long lead times and may need to manage local timelines accordingly. Some state and local agencies also may offer financial assistance programs and have staff who can provide technical advice. As noted throughout this report, federal regulations ultimately govern aviation safety, and the FAA will review all new vertiport proposals for the safe and efficient use of navigable airspace by aircraft and the safety of persons and property on the ground (FAA 2022b).

Finally, new and emerging mobility options bring with them the potential for disruption of established transportation systems, as experienced by many cities with the rollout of scooters. To that end, local governments may need to review their policy and regulatory options for managing AAM operations, as discussed in the sidebar on [p. 73](#). The sidebar on [pp. 74–76](#) sums up many of the planning, design, and regulatory issues that will need to be considered in vertiport development.

PUBLIC INVESTMENT CONSIDERATIONS FOR AAM

Both public and private planning and funding often play a notable role in large development projects. Public investments in infrastructure can influence the location, type, and scale of development in cities and regions. Likewise, public investments in AAM, whether at local, state, or federal levels

of government, could influence the design and characteristics of vertiports. The use of grant assurances and other requirements as a condition of accepting public funds could be a tool to encourage specific planning outcomes. For example, a local or state government could, as a precondition to providing public funds for a vertiport, require that the facility be co-located with public and active transportation.

Some policymakers have raised concerns that funding for AAM may come at the cost of funding other infrastructure with broad social benefit. Although a fair critique, public-sector investment may not require a choice between funding a vertiport or funding public transportation or affordable housing.

The most likely potential sources of federal funding for AAM could come from sources already dedicated to airport and other aviation improvements. For example, the FAA has an Airport Improvement Program (AIP) that provides grants to public agencies and, in some cases, to private owners and entities for planning and development of public-use airports, heliports, and seaplane bases that are included in the National Plan of Integrated Airport Systems (NPIAS) (FAA 2022d). A public-use airport is an airport open to the public that is either publicly owned or privately owned but designated by FAA as a reliever, or privately owned but having scheduled service and at least 2,500 annual enplanements. In some cases, these grants can provide 75 to 95 percent of eligible costs, depending on the facility and projects (FAA 2022d).

State, regional, and local governments could consider similar funding programs for AAM projects and add requirements that help guide planning goals, such as offering grants for vertiports that are co-located and integrated with public transportation. At the local and regional levels of government, community engagement on potential investments and funding for AAM will be key to ensure that publicly supported projects have broad societal benefit.

PARTNERSHIPS AND COLLABORATION FOR AAM PLANNING

Public-private partnerships (P3s) have the potential to play a key role in addressing planning and policy challenges and could help guide AAM outcomes. For example, P3s that focus on developing AAM infrastructure could result in faster project completion and leverage additional public- and private-sector investments, which might otherwise not be available if a project was wholly public or private.

P3s also could reduce risk among additional partners and allow the public sector to guide outcomes by adding requirements as a condition for partnering with the private sector. For example, a public agency might provide funding or other institutional support for AAM infrastructure if such infrastructure is integrated with public transportation or includes another type of broad social benefit.

In addition, P3s could create additional opportunities to engage stakeholders, community partners, and the public in the planning and implementation of AAM. However, P3s could present some risks for both the public and private sectors, such as fraud, waste, abuse, contractual compliance, financing, and other challenges (Swan 2021). In addition to P3s, the public and private sectors can collaborate in other ways, such as participating together in working groups and community engagement activities.

CONCLUSION

The planning process enables planners and policymakers to assess the state of the transportation network and establish goals and policies to guide future evolution and infrastructure development. As AAM presents unique opportunities and challenges, incorporating AAM into the planning process allows local municipalities, regional governments, and other public agencies to understand modal and intermodal complexities, provides an opportunity for practitioners to address potential impacts, and ensures that AAM has broad societal benefits.

Addressing AAM in comprehensive plans, incorporating AAM terms and definitions into local ordinances, and integrating AAM into land use and zoning regulations can help planners manage the future evolution of AAM in their communities. Public-private partnerships and public investments will offer additional opportunities for the public sector to guide the development of AAM and its outcomes. The final chapter of this report will conclude with a discussion of what is known and unknown about AAM, and discusses key areas for research, engagement, and policy to help communities prepare for AAM in the future.

DIGITAL POLICY FOR AAM

By Todd Petersen, Aviator and Technology Consultant

Advanced air mobility (AAM) will likely act as a significant disruptor to the transportation sector. Long established aviation plans and procedures may not be sufficient to address all of the complexities that vertiports may bring to communities, in particular the ability of local agencies to track vertiport activity and ensure compliance with regulatory and operational requirements. One potential strategy to address this challenge may come from the experience of local governments with micromobility, another disruptive transportation sector.

In 2018, the Los Angeles Department of Transportation (LADOT) introduced a groundbreaking city-wide open-source digital infrastructure standard known as [mobility data specification](#) (MDS) to manage its fleet of 50,000 privately operated shared electric scooters. MDS is a single, open-source application programming interface (API) that local governments can use to both collect data from mobility providers and also communicate directly with those providers and their customers to actively manage operation of shared vehicles (LA DOT 2018). In doing so, MDS provides cities with a [digital tool](#) for managing the public right-of-way and allows local governments to implement rules for how mobility service providers operate in the city (Open Mobility Foundation 2023a). Cities can also use MDS to assess the effectiveness of their policies with respect to municipal equity, environmental, and economic objectives.

The outcome was a system that could be managed by municipal departments, thus empowering city staff to respond proactively to curbside planning, micromobility parking, and other issues. By using near real-time data, the city gained the ability to dynamically manage scooter operations and enforce compliance with rules and regulations, as well as measure key outcomes and identify needs for regulatory and policy adjustments. For operators, the system provides a standardized approach for implementing their technology and business models across different cities, effectively reducing implementation and operational costs.

As of November 2023, the MDS standard is being used by more than 130 cities and public agencies around the world (Open Mobility Foundation 2023b). Los Angeles now has more than 100 scooter-related policies, which are implemented and monitored through the use of MDS. This includes regulations such as geographic prohibitions on scooter parking and per-ride monetary incentives that operators can use to subsidize rides in underserved communities.

A similar system of digital policy could be used by local governments to track and monitor private-use vertiport operations. For example, if takeoffs and landings at a vertiport located in a dense urban area are only allowed between 6 a.m. and 10 p.m., staff could use MDS to monitor and enforce compliance with these operational restrictions. MDS could also be used to communicate about and enforce temporary operational restrictions, such as limiting takeoffs and landings during special events like holiday parades. This gives authorities the ability to fine-tune the management of vertiport operations on a real-time, dynamic basis. Municipal governments could also leverage MDS to limit the access of louder legacy aircraft, such as helicopters, to vertiports. As such, MDS could offer planners a tool to mitigate nuisances and address the concerns of neighborhoods adjacent to private-use vertiports, which could increase community acceptance of these facilities.

The system encourages a standardized approach for service providers, simplifying compliance and implementation across various regions. It also gives the public agency a built-in dataset for informing future infrastructure needs and ensuring that vertiport siting aligns with broader policy goals. The success of such a system hinges on collaboration and co-operation. Service providers must grasp the mutual benefits of a system that addresses public acceptance, which is the linchpin for the expansion of aerial mobility across regions and, in turn, fosters business growth. Public agencies must recognize that AAM is an emerging market and operators can only fully realize public goals, such as equity, when there is a sufficient scale to drive down operational costs.

While technology can play an important role in efficiently achieving collective goals, its use is not without controversy. Uber fought the rollout of MDS in Los Angeles by suing the city and forming a coalition protesting the use of MDS by local governments, calling it "a dangerous technology" and citing privacy concerns (Plautz 2020). The ACLU also filed suit on behalf of two scooter users, but the case was dismissed by a federal judge, as was the Uber lawsuit (Descant 2021). It will be crucial for policymakers to address how the use of digital policy for vertiport operations management and compliance could impact privacy and security of operators and users, and to work with federal and state agencies as well as aviation experts to determine how to best apply these concepts to AAM.

CONSIDERATIONS FOR VERTIPORT DESIGN AND DEVELOPMENT

Darrell Swanson, Co-Founder, EA Maven, and Clint Harper, Advanced Air Mobility Infrastructure and Community Integration Advocate

Proposals for any major transportation facility must be carefully evaluated against a wide range of factors to ensure its safe and effective integration into the urban landscapes. Considering the emerging nature of vertiport development, the following factors represent a potential list of key issues to consider in the design and development of vertiports.

- 1. Operational Considerations.** Clarifying specific use cases for the facility helps in understanding its role in the community, its contribution to local transportation needs, and its potential economic and social impacts.

- **The types of aircraft intended to use the facility.** This will help tailor the facility's infrastructure, noise mitigation strategies, and operational procedures to the specific needs and impacts of these aircraft.
- **Operating hours and the anticipated aircraft types, number, and frequency of operations.** This will help in maintaining harmonious relations with the local community, aligning operations with local lifestyles and regulations, right-sizing the facility, and evaluating and managing the facility's impact on local air traffic, noise levels, and potential disruption to the community.
Whether the facility will be open to public use or restricted to authorized individuals. This will be important for infrastructure planning, security measures, and ensuring the facility's integration and acceptance within the community.

- 2. Integration with local transportation systems, including public transit.** The goal is to ensure that the vertiport aligns with and supports broader planning objectives, contributing positively to the existing transportation ecosystem and promoting an integrated multimodal network that enhances connectivity, accessibility, and mobility for all.

- **Integration with the local transportation network.** This includes dedicated tunnels, active travel options, and other surface transport services. Accessibility to a diverse range of destinations through active transportation, microtransit, or public transit, could enhance the vertiport's potential to mitigate surface traffic, particularly single-occupancy vehicles.

- **Integration with existing public transport systems.**

Strategic locations relative to transit nodes and high-density employment centers can help vertiports complement and integrate seamlessly with existing public transport systems and contribute to the creation of mobility hubs where AAM, active transportation, and transit networks converge.

- **Alignment with local and regional transportation plans.** Vertiport development may help meet stated goals or objectives within local or regional transportation plans, such as mode shift, transition to electric/emission-free modes, and enhancing equitable mobility for all.

- 3. Vertiport design.** The design and planning of vertiports should account for a consistent, reliable, and safe experience for all users of all abilities. The goal is to ensure that facilities are not only comfortable and accessible for users but also account for local environmental factors, particularly the influence of wind and microweather conditions, to assure that facilities are also resilient to varying weather challenges.

- **Inclusivity and accessibility to all passengers.** This includes access for passengers with reduced mobility or hidden disabilities, to both facilities and aircraft.

- **Adequate passenger facilities and services.** Vertiport design should meet passengers' needs, focusing on time efficiency and convenience. Landside facilities accessible to the general public could present opportunities to benefit the wider community, including non-users.

- **Mitigation of site-specific environmental factors.** Vertiport site selection and design could mitigate impacts from wind and microweather anomalies through incorporating specific architectural features or choosing strategic locations that are less prone to adverse weather conditions.

- 4. Energy master plan.** Energy requirements for electric aircraft operations include both current needs and anticipated future demands. Additionally, vertiports have the potential to serve as resiliency hubs in emergency situations.

- **Energy requirements for electric aircraft operations.** Understanding both current needs and anticipated

future demands involves considering the growth in eVTOL use, potential increases in flight frequency, and advancements in aircraft technology that may impact energy consumption.

- **Potential resiliency hub functions.** The vertiport may offer capacity to provide critical energy resources during power outages or natural disasters, thereby contributing to community resilience and emergency response efforts.
- 5. Environmental impact.** In assessing the environmental impact of vertiports, a critical aspect to consider is the effect on local wildlife. Identifying and implementing measures that mitigate these impacts will help ensure that the development and operation of vertiports do not compromise the ecological balance and biodiversity of their surrounding environments.
- **Environmental footprint of the vertiport and associated air traffic.** Understanding the vertiport's environmental footprint, which includes noise, lighting, and air quality impacts, will help identify potential impacts on the surrounding community and corresponding mitigation strategies.
 - **The effects of vertiport operations on wildlife.** Vertiport noise, light pollution, and the presence of physical infrastructure might disrupt the natural behaviors and habitats of wildlife in the area, including bird migration patterns, local fauna habitats, and the overall biodiversity in the vicinity of the vertiport.
 - **The effects of wildlife on vertiport operations:** The wildlife and natural environment around potential vertiport locations, including the location of nesting grounds, migratory routes, and other specific habitats, will affect the likelihood of wildlife hazards, such as bird strikes, to air travel.
- 6. Safety.** The maintenance of clear and safe air routes during both standard operations and emergency scenarios, emergency access to and from the vertiport, and the ability for local emergency personnel to respond effectively to vertiport incidents are key safety elements. The FAA is responsible for regulating aviation safety, but at the local level, vertiport operators, city authorities, and emergency response teams should coordinate the sharing of information for integrated safety and emergency preparedness within the urban air mobility ecosystem.
- **Emergency access.** Emergency access routes to and from the vertiport and emergency landing sites should enable effective emergency response and evacuation capabilities.
 - **Emergency response capacity.** The local fire department should be prepared to respond to incidents at the vertiport and at potential emergency landing locations, including those specific to vertiport operations and eVTOL aircraft, such as battery fires.
 - **Communication measures for safe operation of aircraft and passenger movement.** Vertiport operators require methods to communicate risk information to pilots, air operators, and city authorities and emergency response teams, ensuring safety and preparedness.
- 7. Regulatory compliance.** It is imperative that vertiports adhere to established airspace regulations, standards, and design guidelines set by authoritative bodies such as the FAA and relevant state and local authorities. Regulatory compliance is critical for safe integration into the national airspace system and essential for ensuring that the vertiport meets the highest standards of safety, operational efficiency, and accessibility.
- **Compliance with all local, state, and national regulations and standards related to aviation and urban development.** This includes coordination of the proposed activities at the facility with the FAA; airspace regulations, including the securing of necessary approach and departure paths; state licensing requirements, if applicable; local and national environmental standards and regulations; and established design guidelines as set forth by the FAA or relevant state or local authorities.
 - **Consideration of FAA guidance on airspace for proposed vertiports.** FAA aeronautical studies and determinations regarding proposed aviation facilities evaluate how those facilities and their approach and departure routes might affect air navigation and aviation safety. Understanding these findings for a proposed vertiport could help inform local decision-making that prioritizes community safety and compatibility with existing aviation infrastructure.
- 8. Social impact.** A thorough assessment of the vertiport's social impacts is essential to ensure it aligns with the local community's social fabric. The aim is to harmonize the vertiport with the community's social development goals.

- **Potential displacement of communities.** The potential for displacement will require strategies to mitigate such impacts and support affected residents.
 - **Alignment with social and cultural goals and strategies.** Such alignment will help vertiport development contribute positively to the long-term objectives and vision of the community.
- 9. Community engagement.** A robust community engagement strategy on the part of both developers and city officials is vital to ensure the vertiport development is in line with the community's needs, expectations, and well-being.
- **Developer engagement of the local community.** This involves organizing open forums, surveys, and public meetings where community members can express their views, ask questions, and provide input, ensuring their voices are heard and considered in the development process.
 - **Developer response to community feedback.** The developer should transparently show how the community's input is influencing the vertiport's design and operation. This includes regularly updating the community on how their feedback is being integrated and maintaining an ongoing dialogue to adapt to evolving needs and concerns.
 - **Transparency and clear communication by city staff.** City staff should be able to provide clear information about a vertiport project, including transparent details about potential impacts, integration with existing transportation systems, and alignment with community goals.
- 10. Long-term sustainability.** Major new infrastructure investments such as vertiports should be designed and planned to maximize effective and sustainable operations over the long term. This can help align the vertiport with broader urban development goals, emphasizing its role in sustainable, resilient community growth.
- **Long-term sustainability.** Considering future urban development, transport trends, and environmental considerations can inform the adaptability of vertiports to future advancements in air mobility and urban transportation.
 - **Adaptation to change.** The construction of new buildings, growth of trees, and changes in traffic patterns can introduce new challenges to vertiport operations. Mechanisms should be in place for ongoing evaluation and adaptation to these changes.
 - **Potential for resiliency hub functions.** This could include serving as a multimodal transportation center, generating renewable energy, enhancing digital connectivity, and providing critical support during emergencies.
- 11. Facility oversight.** The establishment of a robust oversight framework for vertiports is essential to ensuring their long-term compliance and safety. This ensures that vertiports not only meet current standards but are also prepared to adapt and evolve in response to future challenges.
- **Recurring compliance audits.** Regular checks are vital to ensure that the facility remains in compliance with established regulations and standards. These include compliance with design standards and airspace compatibility requirements; emergency preparedness and fire codes, particularly concerning the unique challenges posed by eVTOL aircraft, such as battery fires; and local building codes, with a focus on passenger safety and accessibility.
 - **Coordination and information sharing between local and state oversight bodies.** In regions where state-level oversight exists, this ensures a comprehensive approach to vertiport safety and compliance.

CHAPTER 7

LOOKING AHEAD

Advanced air mobility (AAM) is a broad concept focusing on emerging aviation markets and use cases for urban, suburban, and rural operations. Converging innovations of advancements in aircraft technologies and capabilities, including vertical lift, electrification, and automation, and the growth of app-based on-demand mobility are contributing to the growing policy focus on AAM. However, concerns about safety and the regulatory environment; air traffic management; security; infrastructure, multimodal integration, and land use compatibility; emission impacts; noise; and community acceptance present notable challenges to the growth, adoption, and mainstreaming of AAM.

This PAS Report highlights the need for greater awareness about AAM and its potential impacts for local and regional governments. Many municipalities and metropolitan planning organizations (MPOs) have limited or no experience in aviation planning issues. While the impacts of AAM are uncertain at present, AAM could have disruptive effects on planning practice, built environment, and mobility behavior. As AAM is expected to evolve over the coming decades, planners can help to prepare communities for potential opportunities and challenges.

WHAT WE KNOW

A key challenge for many urban planners is the general lack of familiarity and expertise with aviation-related planning issues. While AAM may still be an unfamiliar concept to many local and regional stakeholders, planners should bear in mind the following points:

- **AAM is not a new concept.** For many decades, inventors and entrepreneurs have envisioned a variety of urban air mobility concepts. Although limited in scale, between the 1950s and 1980s, air carriers began providing passenger services using helicopters in metropolitan regions such as Los Angeles, New York City, and San Francisco. Many of these services received financial support, however, such as airmail revenue and federal helicopter subsidies.
- **Consumer interest in on-demand mobility is increasing.** The growth of smartphone apps and on-demand

access to goods and mobility has begun to change how consumers access both ground transportation and aviation services. Shared mobility, such as transportation network companies, bikesharing, and scooter sharing, have mainstreamed in many U.S. cities. More recently, on-demand, app-based aviation services also have begun entering the marketplace.

- **Private-sector interest in innovative aviation technologies is increasing.** At present, there are several hundred electric and hydrogen-powered vertical takeoff and landing aircraft under development. A number of pre-pandemic market studies suggest the potential for scaled operations and profitable services by the late 2020s and early 2030s; however, market forecasts vary considerably due to differences in assumptions, methodologies, and the use cases examined. Considerable emphasis has been placed by the private sector on passenger use cases serving a premium market segment. While many of these studies tend to emphasize the growth of premium air taxi and airport shuttle markets, there are several examples in rural and developing countries of drones already serving as an integral part of health care delivery.
- **AAM has the potential to both enhance and harm social equity.** Social equity concerns associated with AAM include affordability and accessibility, gentrification and displacement around vertiports, and the impacts of flight operations and vertiports on neighborhoods and underserved populations. However, AAM has the potential to support social equity goals by creating new job opportunities. AAM can also facilitate aeromedical, emergency

response, and other humanitarian use cases, which could provide broad benefits to communities.

- **Stakeholder and community engagement is critical.** Ensuring full and fair participation in AAM planning and decision-making processes, engaging stakeholders and empowering the public through education and community engagement, and understanding the degree and distribution of AAM impacts, coupled with appropriate mitigation measures, will be key to ensuring AAM has broad public benefits and equitably serves the public.

Several resources relating to AAM are available to planners and policymakers. Appendix C ([p. 85](#)) includes additional resources for planners on AAM.

AREAS OF UNCERTAINTY

Though many signals point to the continuing development and deployment of the AAM sector, many areas of uncertainty about AAM, which could impact planning and policymaking at the local and regional levels of government, remain. These include the following:

- **Use case mainstreaming and market affordability.** There is uncertainty about which use cases, such as air taxis, logistics, or aeromedical, could scale; how much AAM services will ultimately cost; and how long it will take for AAM services to become affordable—if ever.
- **The role of local and regional governments.** While the Federal Aviation Administration (FAA) is responsible for the certification, safety, and regulation of aircrew, air carriers, and aircraft operating with the National Airspace System, AAM will likely require local and regional coordination, particularly in the context of zoning, land use compatibility, and infrastructure siting. Future legislation or FAA regulation could further define the role of local and regional governments on AAM-related issues and apply guardrails to ensure safety and standardization of approaches across jurisdictions.
- **Public investment for AAM.** There is uncertainty about what types of public investments—if any—should support AAM, such as the role of local and regional governments in supporting planning studies and infrastructure funding. There is also uncertainty about who should pay for the infrastructure required for AAM and the potential impacts of this infrastructure if exclusively used by one provider versus shared among multiple services.

- **Social and environmental impacts of AAM deployments.** The impacts of AAM deployments, such as noise, aesthetics, equity, and emissions, are unknown, and they will likely vary based on an array of contextual variables such as infrastructure location and flight paths, built environment, use cases, aircraft type, and the scale and frequency of AAM operations.
- **Social adoption and public acceptance.** Negative community perceptions of safety, noise, or accessibility could present challenges to adoption, mainstreaming, and public acceptance of AAM. Additionally, perceptions that AAM does not provide broad social benefit could present public acceptance challenges.

These uncertainties present ongoing challenges for planners and policymakers trying to understand and prepare for the potential impacts of AAM. However, these uncertainties should not prevent meaningful action to plan and prepare for AAM. Planning in advance can help communities leverage the potential opportunities and mitigate the potential adverse impacts.

PRIORITY AREAS FOR RESEARCH, ENGAGEMENT, AND POLICY

As AAM becomes a transportation strategy that more communities may need to plan for, the public sector will likely need to prioritize the following key areas for research, engagement, and policy, particularly at the local and regional levels of government:

- Building institutional capacity for AAM research, planning, and implementation from the municipal and MPO perspectives.
- Researching the potential impacts of vertiport locations and AAM routing, ideally in partnership with state departments of transportation and the FAA, to develop policies that protect vulnerable communities from potential impacts.
- Evaluating demonstrations to (1) enhance public-sector preparedness for AAM, (2) validate the technical and institutional feasibility of early deployments to identify physical, digital, and energy infrastructure needs and support public-good use cases, (3) measure the impacts of early deployments, and (4) examine regulations and policies that could influence AAM operational concepts and use case adoption.

- Understanding public perceptions of potential AAM deployments and potential concerns from both user and nonuser perspectives.
- Prioritizing stakeholder and community engagement to advance understanding of potential stakeholder and public concerns, societal barriers, and policies that serve the public good.
- Developing zoning provisions and design guidance to ensure land use compatibility in the vicinity of vertiports.

Research, stakeholder and community engagement, and policy can help planners navigate through uncertainty and guide socially optimal outcomes.

PREPARING FOR THE FUTURE

AAM is a transportation strategy that has the potential to serve a variety of mobility, logistics, emergency response, and other use cases. Numerous studies have documented the industry's forecasted growth, and emerging research is beginning to examine its potential environmental, social, and transportation-related impacts.

How planners plan and manage the physical, energy, and digital infrastructure needed for AAM deployment will likely be a key topic of conversation in the coming years.

Planners and policymakers will need to decide what level of commitment to and influence over AAM-related issues is desired by—and appropriate for—the public sector. Greater public-sector influence will likely require greater commitment in terms of institutional readiness, funding, and coordination with other public agencies. However, greater government commitment also could allow for greater public-sector influence over AAM planning and operational outcomes. Although there are many unknowns, planning and policy are needed to support use cases that provide broad societal benefit.

In the future, the introduction of electrification, sustainable fuels, and automation could continue to transform AAM and potentially disrupt communities. While the impacts of these technologies remain to be seen, institutional capacity building, thoughtful planning, and ongoing research will be needed to guide sustainable and equitable outcomes. Planners and policymakers must be prepared to balance public goals for AAM with commercial interests. Only then will our communities be able to harness the potential social and environmental benefits of these transportation innovations.

APPENDIX A: GLOSSARY

Advanced air mobility (AAM): A broad concept focusing on emerging aviation markets and use cases for on-demand aviation in urban, suburban, and rural communities. AAM includes local use cases of about a 50-mile radius in rural or urban areas and intraregional use cases of up to a few hundred miles that occur within or between urban and rural areas.

Air traffic control (ATC): The ground-based personnel and equipment concerned with monitoring and controlling air traffic within a particular area.

Air traffic management (ATM): The management of air traffic services (ATS), airspace management (ASM), and air traffic flow and capacity management (ATFCM).

Avigation easement: A legal property right that grants an easement or right of overflight in the airspace above or in the vicinity of a particular property. It may also be referred to as an aviation easement.

Class A airspace: The airspace from 18,000 feet mean sea level up to and including flight level (FL) 600.

Class B airspace: The airspace from the surface to 10,000 feet mean sea level surrounding the nation's busiest airports in terms of airport operations or passenger enplanements.

Class C airspace: The airspace from the surface to 4,000 feet above the airport elevation (charted in mean sea level) surrounding those airports that have an operational control tower, are serviced by a radar approach control, and have a certain number of instrument flight rules (IFR) operations or passenger enplanements.

Class D airspace: The airspace from the surface to 2,500 feet above the airport elevation (charted in mean sea level) surrounding those airports that have an operational control tower.

Class E airspace: Controlled airspace that extends upward from either the surface or a designated altitude to the overlying or adjacent controlled airspace.

Class G airspace: Uncontrolled airspace, or the portion of the airspace that has not been designated as Class A, B, C, D, or E.

Controlling dimension (CD): The largest overall dimension of an aircraft. The CD is an important factor in vertiport design and is further defined in the [FAA Vertiport Design Engineering Brief](#).

Conventional takeoff and landing (CTOL): A fixed-wing aircraft with runway requirements for takeoff and landing.

Crowdsourcing: The practice of obtaining information by enlisting the services of a large number of people, either paid or unpaid, typically via the internet.

Digital flight rules: An emerging operating mode in which flight operations are conducted by reference to digital information, with the operator ensuring flight-path safety through cooperative practices and self-separation enabled by connected digital technologies and automated information exchange.

Electric vertical takeoff and landing (eVTOL): An electric aircraft that can take off and land vertically.

Final approach and takeoff (FATO): A defined area over which the pilot completes the final phase of the approach to a hover or a landing, and from which the pilot initiates takeoff.

Floor area ratio (FAR): The measurement of a building's floor area in relation to the size of the lot or parcel that the building is located on. FAR is expressed as a decimal number and is calculated by dividing the total area of the building by the total area of the parcel.

Mobility on demand (MOD): A concept envisioning an interconnected and coordinated mobility ecosystem to meet the needs of all users by providing the safe, reliable, and efficient movement of travelers and goods. MOD offers users personalized mobility and goods delivery options upon request, matched with coordinated network strategies of service providers and operations managers.

Mobility as a service (MaaS): A concept envisioning integrated mobility in which travelers can access multiple transportation modes over a single digital interface. MaaS primarily focuses on passenger mobility allowing travelers to seamlessly plan, book, and pay for travel on a pay-as-you-go or subscription basis.

National Airspace System (NAS): A network of both controlled and uncontrolled airspace, both domestic and oceanic. The NAS includes air navigation facilities, equipment, and services; airports and landing areas; aeronautical charts, information, and services; rules and regulations; procedures and technical information; and personnel.

On-demand air mobility: Enables consumers access to air mobility, goods delivery, and emergency services by dispatching or using advanced air mobility and enabling technologies through an integrated and connected multimodal network.

Pilot in command (PIC): The person aboard the aircraft who is ultimately responsible for its operation and safety during flight.

Regional air mobility (RAM): Envisions a safe, sustainable, affordable, and accessible air transportation system for passenger mobility, goods delivery, and emergency services for intra- and interregional trips of about 50–500 miles (e.g., from one metropolitan region or urban area to another one). RAM includes scheduled and on-demand flights, typically between smaller airports, using small aircraft with less than 20 passengers (or an equivalent weight in cargo).

Rotorcraft: A rotary-wing aircraft, such as a helicopter or gyroplane.

Rural air mobility: Envisions a safe, sustainable, affordable, and accessible air transportation system for passenger mobility, goods delivery, emergency services, and other applications within or traversing rural and exurban areas (i.e., passenger mobility and logistics between rural communities and urban centers, delivery of health care and other critical services in rural communities, agriculture crop dusting using unmanned aircraft, etc.). Rural air mobility may overlap with urban air mobility (UAM) in cases where a flight traverses an urban area and at an altitude low enough to impact communities on the ground.

Shared automated vehicles (SAVs): Automated vehicles that are shared among multiple users and can be summoned on demand or can operate via a fixed-route service similar to public transportation.

Shared mobility: The shared use of a travel mode that provides travelers with access to a transportation mode on an as-needed basis.

Short takeoff and landing (STOL): An aircraft that requires a short runway for takeoff and landing.

Small uncrewed aircraft systems (sUAS): An uncrewed aircraft system (UAS) or drone that weighs less than 55 pounds on takeoff, including everything that is on board or otherwise attached.

Touchdown and liftoff (TLOF): A load-bearing area on which vertical takeoff and landing (VTOL) aircraft and helicopters may touch down or lift off.

Transit-oriented development (TOD): A type of development that maximizes the amount of residential and commercial land uses and public spaces within the immediate vicinity of public transportation.

Transportation network companies (TNCs): A service that provides the traveler with pre-arranged and/or on-demand access to a ride for fee using a digitally enabled application or platform (e.g., smartphone apps) to connect travelers with drivers using their personal, rented, or leased motor vehicles. Digitally enabled applications are typically used for booking, electronic payment, and ratings.

Uncrewed aircraft: An aircraft that operates without the possibility of direct human intervention from within or on the aircraft (i.e., no on-board pilot).

Uncrewed aircraft system (UAS): An uncrewed aircraft and its associated elements (including communication links and control components) that are required for the safe and efficient operation of the uncrewed aircraft in the national airspace. Also called *unmanned aircraft system* or *drone*.

Urban air mobility (UAM): Envisions a safe, sustainable, affordable, and accessible air transportation system for passenger mobility, goods delivery, and emergency services within or traversing metropolitan areas. UAM typically includes services within or between edge cities and urban, suburban, and exurban areas.

Vertical takeoff and landing (VTOL): An aircraft that can take off, hover, and land vertically.

Vertiport: An area of land or a structure used or intended to be used for electric, hydrogen, and hybrid vertical takeoff and landing (VTOL) aircraft landings and takeoffs, including associated buildings and facilities.

Vertiport-oriented development (VOD): A development concept that maximizes residential, office, retail, and other compatible land uses along with first- and last-mile connections within the immediate vicinity of a vertiport.

APPENDIX B: ACRONYMS USED IN THIS REPORT

AAM: Advanced air mobility

ATC: Air traffic control

ATM: Air traffic management

BVLOS: Beyond visual line of sight

ConOps: Concept of operations

CD: Controlling dimension

CTOL: Conventional takeoff and landing

dB: Decibel

DOT: Department of transportation

EAS: U.S. Department of Transportation Essential Air Service program

eVTOL: Electric vertical takeoff and landing

FAA: Federal Aviation Administration

FAR (aviation acronym): Federal Aviation Regulations

FAR (planning acronym): Floor area ratio

FATO: Final approach and takeoff

IPP: Federal Aviation Administration Unmanned Aircraft System Integration Pilot Program

MaaS: Mobility as a service

MOD: Mobility on demand

MPO: Metropolitan planning organization

NASA: National Aeronautics and Space Administration

NAS: National Airspace System

OEM: Original equipment manufacturer

PSU: Provider of service for urban air mobility

RAM: Regional air mobility

SAV: Shared automated vehicle

STOL: Short takeoff and landing

sUAS: Small uncrewed aircraft system

TLOF: Touchdown and liftoff

TOD: Transit-oriented development

TNC: Transportation network company

UAS: Uncrewed aircraft system

UAM: Urban air mobility

USDOT: U.S. Department of Transportation

VTOL: Vertical takeoff and landing

VOD: Vertiport-oriented development

APPENDIX C: AAM RESOURCES FOR PLANNERS

RECOMMENDED READINGS

Foundational Literature

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ONLINE RESOURCES

Federal Agencies

[Federal Aviation Administration \(FAA\) Advanced Air Mobility/Air Taxis Resource Page](#)

This webpage summarizes FAA activities on AAM, including certification of aircraft and operators, implementation plans, infrastructure development, operations, community engagement, and global partners.

[National Aeronautics and Space Administration \(NASA\) Advanced Air Mobility Ecosystem Working Groups](#)

The NASA AAM Ecosystem Working Groups exist to support the development of safe, high-volume flight operations by bringing together the broad stakeholders involved in developing AAM. There are four working groups: Aircraft, Airspace, Community Integration, and Crosscutting.

[U.S. Department of Transportation Advanced Air Mobility Interagency Working Group](#)

The AAM Interagency Working Group was established by Congress to plan and coordinate efforts related to safety, operations, infrastructure, physical security and cybersecurity, and federal investment necessary for maturation of the national AAM ecosystem, particularly passenger-carrying aircraft.

Academic and Nongovernmental Organizations

[Canadian Advanced Air Mobility Consortium](#)

The Canadian Advanced Air Mobility Consortium is a socially responsible, federal not-for-profit consortium that acts as the national catalyst for the advanced air mobility industry in Canada.

[Community Air Mobility Initiative](#)

The Community Air Mobility Initiative (CAMI) is a public educational nonprofit whose mission is to support the sustainable and responsible integration of AAM into transportation systems through education, communication, and collaboration. CAMI provides programming, including the Urban Air Policy Collaborative cohort, and educational, planning, and policy resources for public agencies at all levels of government, decision-makers, planners, and the general public.

[Innovative Mobility Research](#)

Innovative Mobility Research conducts research on technology applications, behavioral response, and public policies that seek to expand and enhance transportation choices, better manage demand for transportation services, and improve the environment.

[Intelligent Transportation Society of America](#)

The Intelligent Transportation Society of America works to advance the research and deployment of intelligent transportation technologies to save lives, improve mobility, promote sustainability, and increase efficiency and productivity through policy, thought leadership, and developing a diverse workforce.

[Mineta Transportation Institute](#)

The Mineta Transportation Institute conducts research, develops education programs, and facilitates information and technology transfer focusing on multimodal transportation policy and management issues.

Open Mobility Foundation

The mission of the Open Mobility Foundation is to support the development of open-source standards and tools that provide scalable mobility solutions for cities. Governed by cities, the Open Mobility Foundation brings together public- and private-sector stakeholders to develop and promote technology used by commercial mobility service providers and governments that manage the public right-of-way.

Transportation Research Board

The Transportation Research Board promotes transportation innovation and progress through research activities involving engineers, scientists, researchers, and practitioners from the public and private sectors and academia. It is one of seven major programs of the National Research Council, which is the principal operating agency of the National Academies and is jointly administered by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

Transportation Sustainability Research Center

The Transportation Sustainability Research Center conducts analyses and evaluation to develop findings and recommendations for key transportation issues of interest to industry leaders and policy-makers to aid in decision making. It is part of the Institute of Transportation Studies at the University of California, Berkeley.

Vertical Flight Society

The Vertical Flight Society is a nonprofit, charitable educational and technical organization for engineers, scientists, and others working to advance vertical flight technology. Its mission is to provide the opportunity for technical data exchange and dissemination; promote awareness of vertical flight capabilities, challenges, and development; engage in community outreach and advocate for public policy consistent with the goals of the Society; leverage the technical base to explore innovation; and foster a diverse and inclusive environment that promotes careers and professional advancement in vertical flight.

Industry Associations

Association for Uncrewed Vehicle Systems International

The Association for Uncrewed Vehicle Systems International is dedicated to the advancement of uncrewed systems and robotics, and represents corporations and professionals from more than 60 countries involved in industry, government, and academia. Its members work in the defense, civil, and commercial markets.

General Aviation Manufacturers Association

The General Aviation Manufacturers Association exists to foster and advance the general welfare, safety, interests, and activities of the global business and general aviation industry. This includes promoting a better understanding of general aviation manufacturing, maintenance, repair, and overhaul and the important role these industry segments play in economic growth and opportunity, and in serving the critical transportation needs of communities, companies, and individuals worldwide.

National Association of State Aviation Officials

The mission of the National Association of State Aviation Officials is to represent the interests of the states and the public before policymakers at the federal level to ensure a safe, secure, efficient, and well-funded aviation system. It represents the public interest in all facets of aviation and airports.

National Business Aviation Association

The mission of the National Business Aviation Association is to foster an environment that allows business aviation to thrive in the United States and around the world. Its members are companies that rely on general aviation aircraft to help make their businesses more efficient, productive, and successful.

National League of Cities

The National League of Cities is an organization comprising city, town, and village leaders whose mission is to advocate for, and protect the interests of, cities, towns, and villages by influencing federal policy, strengthening local leadership, and driving innovative solutions.

APPENDIX D: METHODOLOGY

For this PAS Report, the authors built upon a multimethod approach to researching advanced air mobility (AAM) policy and planning spanning approximately five years, four academic studies, and other supporting activities. Methods included literature review, expert interviews, engagement with advisory groups, online survey, and stakeholder engagements. This multimethod approach provided a rich understanding of the state of the industry as well as the opportunities and challenges for planners and policymakers. Table 1 (p. 90) presents a summary of the studies and methods used to develop the content of this report.

LITERATURE REVIEW

To begin, the authors conducted a comprehensive review of more than 150 pieces of literature, including 12 market studies, 30 governmental reports, 60 journal articles, numerous conference proceedings, and other materials. This review was supplemented with an internet search documenting recent and planned developments. Given the vast number of planned deployments and industry developments, it is possible that some examples may have been inadvertently omitted.

EXPERT INTERVIEWS

In addition to the literature review, the authors developed an interview protocol and conducted more than 50 expert interviews with members of a National Aeronautics and Space Administration (NASA) market study advisory group and other thought leaders representing a variety of academic, public-sector, and private-sector perspectives between summer 2017 and summer 2023.

ADVISORY GROUPS AND INDUSTRY ENGAGEMENTS

Study advisory group members represented senior leaders and subject matter experts from the Federal Aviation Administration (FAA), NASA, National Transportation Safety Board (NTSB), North Carolina Department of Transportation, New York City, the City of Los Angeles, Los Angeles World Airports, International Civil Aviation Organization (ICAO), and numerous startups, manufacturers, and academics. Some of the participating public-sector thought leaders included directors for the FAA's Aviation Plans and Policy Office, Office of International Affairs, and Unmanned Aircraft Systems (UAS) Integration Office, as well as a former NTSB chairman. There was notable representation from manufacturers and startups, reflecting the diverse range of planned airframes with different operational requirements, such as fixed-wing, rotorcraft, short takeoff designs, vertical takeoff designs, piloted, and autonomous aircraft.

Further, the authors sponsored the SAE International standards JA3163 and J3163, between November 2017 and February 2020, to develop definitions for terms related to AAM, shared mobility, and enabling technologies. As part of this process, the authors engaged 20 experts representing NASA, the General Aviation Manufacturers Association, the FAA, and private-sector original equipment manufacturers and air carriers as part of three expert panel meetings on AAM. Finally, the authors actively participated in a number of committees, working groups, and professional organizations, including NASA's Transformative Vertical Flight Roadmap, AAM, and Community Integration working groups, as well as the Vertical Flight Society.

ONLINE SURVEY

The authors also conducted an AAM practitioner census between February and June 2021 comprising an online sur-

TABLE 1. SUMMARY OF STUDY METHODS EMPLOYED

Study / Other Supporting Activities	Methods				
	Literature Review	Expert Interviews	Advisory Groups and Industry Engagements	Online Survey	Workshops and Peer Exchanges
NASA Urban Air Mobility Market Study	X	X	X		X
NASA Emerging Practices Playbook	X				X
AAM Practitioner Census				X	
Transportation Research Board Annual Meeting					X
Future of Aviation Conference			X		X
Airport Cooperative Research Program Insight Event			X		X
National Cooperative Highway Research Program Study 23-15	X				X
CAMI Urban Air Policy Collaborative					X
SAE International			X		

vey (n=105) of U.S. public agencies on AAM opportunities, challenges, and institutional readiness. Using publicly available databases, the authors assembled contact information for key personnel at cities, metropolitan planning organizations (MPOs), local emergency management agencies, state departments of transportation (DOTs), and public transit agencies from the 100 most populous metropolitan statistical areas (MSAs) in the United States and the three largest MSAs in each state. C-level (chief-level) officials, division or department heads, practitioners and planners, and elected officials responded to the survey. Approximately 500 people were contacted, yielding 105 responses, or a 21 percent response rate. The survey received responses from 49 MPOs (47 percent), 25 cities (24 percent), and 17 state DOTs (16 percent). Other respondents (13 percent) included representatives from other public entities, such as public transit agencies, port authorities, and emergency management agencies.

WORKSHOPS AND PEER EXCHANGES

The authors also facilitated two AAM workshops in April 2018 and January 2020 in Washington, D.C. The first workshop was held as part of a NASA market study. This workshop included over 50 thought leaders representing the

public and private sectors. This format included semistructured discussions around key challenges, such as market feasibility, legal and regulatory barriers, and issues related to societal acceptance from the user and nonuser perspectives. The second workshop was held at the 2020 Transportation Research Board Annual Meeting, which included a facilitated dialogue among over 130 participants from public-sector organizations, private companies, nongovernmental organizations, and educational institutions. More than two dozen government, industry, and academic experts also presented and participated in panel discussions. Participants discussed opportunities and challenges, planning issues, community acceptance, research, and next steps needed for implementation, emphasizing the future of multimodal AAM.

The authors also facilitated 13 virtual workshops as part of the development of an AAM Emerging Practices Playbook for NASA between summer 2021 and spring 2022. The workshops included representation from the City of Orlando, North Texas Council of Governments, and the Massachusetts, Minnesota, and Ohio Departments of Transportation. The authors also co-authored the National Cooperative Highway Research Program study 23-15, Guidance on Risks Related to Emerging and Disruptive Transportation Technologies, in 2023. As part of this study, the authors engaged 60 AAM stakeholders as part of three

peer exchanges in the spring of 2022 on AAM and cross-cutting issues related to emerging transportation technologies. Additionally, the authors facilitate the Community Air Mobility Initiative's Urban Air Policy Collaborative (UAPC), an ongoing program that provides a structured forum for airports, state, regional, and local jurisdictions to discuss AAM issues, questions, and strategies, and develop policies and best practices. As of summer 2022, 60 staff from 24 public agencies have participated in the UAPC.

Additionally, the authors organized the Future of Aviation Conference at San Francisco International Airport in August 2022. This event included interactive discussions among more than 200 public- and private-sector participants and advanced key research and policy discussions around environmental impacts, safety, security, equity, multimodal integration, and the role of government. Finally, the authors organized the Airport Cooperative Research Program Insight Event On-Demand Aviation Services for Mobility, Logistics, Emergency Response, and Humanitarian Use Cases in July 2023. This symposium facilitated a dialogue among over 90 participants from diverse professional perspectives about AAM opportunities and challenges, planning issues, community acceptance, research, and next steps needed to support aeromedical, emergency response, humanitarian, and other on-demand aviation use cases.

LIMITATIONS

As with any qualitative research, the insights from published literature and experts are not entirely unbiased. In an attempt to mitigate potential bias, an effort was made to engage as many published sources and experts as possible. When engaging experts, the researchers used standardized questions whenever possible. Additionally, all qualitative responses were aggregated to ensure the objectivity of the final results. However, given this emerging topic and the vast number of stakeholder perspectives and industry developments, it is possible that some viewpoints were inadvertently omitted.

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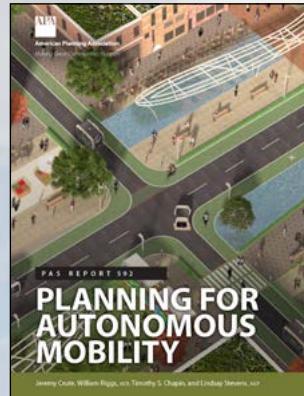
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