Miami-Dade Transportation Planning Organization

URBAN AIR MOBILITY

Policy Framework and Strategic Roadmap

November 2023

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1.1. Purpose and Need

Urban Air Mobility (UAM), and the broader concept of Advanced Air Mobility (AAM), is a rapidly evolving industry that will revolutionize the transportation of people and goods within urban and suburban environments. To stay ahead of the ever-changing air transportation landscape, the Miami-Dade Transportation Planning Organization (TPO) is conducting an evaluation of existing and emerging UAM technology and an assessment of policy framework requirements for the integration of this technology into the County's existing transportation network. This study will support the ongoing efforts of the Miami-Dade County UAM Working Group, a collaborative effort involving state, county, and local officials as well as representatives from various private industry and infrastructure firms.

Through this study, the Miami-Dade TPO aims to:

1. Evaluate existing and emerging UAM technology to understand potential markets for this technology and how UAM will affect air transportation, environmental sustainability, and economic vitality.
2. Identify infrastructure needs to accommodate an UAM ecosystem in Miami-Dade County.
3. Assess policies needed to prepare and integrate UAM into Miami-Dade County's existing transportation network.

The UAM system evaluation for this study will focus on intra-county travel within Miami-Dade County. However, this research may be used as a foundation from which future inter-county, or even inter-state, AAM uses cases may be based. Ultimately, this study and its recommendations emphasize an UAM framework for Miami-Dade County that is rooted in safety, efficiency, connectivity, sustainability, and community engagement.

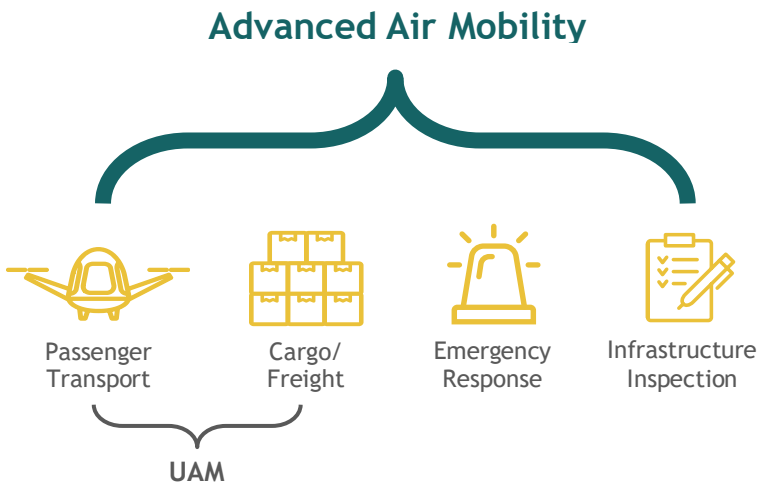
This section introduces the fundamentals of an evolving UAM industry along with existing literature, research, and data. Policy frameworks, concepts of operations (ConOps), federal regulations, and various case studies from around the world are reviewed to explore the existing state of UAM and to develop an understanding of future applications.

Additionally, Miami-Dade County's transportation network and future infrastructure projects are analyzed to identify UAM integration opportunities within the County's existing system.

1.2. UAM Ecosystem

UAM is on a course to disrupt urban transportation. This fast-emerging system will use highly automated aircraft to transport passengers and cargo at lower altitudes within urban and suburban areas. Emerging technologies in electrification, automation, and big data have provided new opportunities for the development of aircraft, airspace management systems, and associated infrastructure. Although UAM has existed for many years with the use of traditional helicopters, new electric vertical takeoff and landing (eVTOL) aircraft will facilitate on-demand urban air transportation that is more frequent and efficient than ever before. As of this writing, there are more than 100 UAM vehicles in various stages of development across the globe being produced by over two hundred companies, also known as original equipment manufacturers (OEMs). Additionally, local governments, airport sponsors, and private developers are working to incorporate vertiports, charging stations, and other UAM-related infrastructure into existing projects and long-term planning efforts. The Miami-Dade TPO recognizes the disruptive potential of UAM and is proactively planning for full integration into the County's existing transportation system.

As previously noted, UAM is a subset of AAM, which describes low-altitude aircraft operations for passengers and cargo within urban and suburban areas. More broadly, AAM incorporates use cases not specific to operations in urban environments such as regional air mobility (RAM) between cities and regions and public services such as emergency response and drone operations.



While some AAM use cases may be further developed than others, such as the use of unmanned aerial systems (UAS) to carry medical equipment to communities in need, studies project two primary UAM applications based on technological and consumer trends: package delivery and on-demand urban transportation service.[1] Successful deployment of an integrated UAM system requires further exploration of aircraft technology, infrastructure needs, airspace management, and industry stakeholders. These components are discussed in the following sections.

[1] Goyal, R. et. al (2021). Advanced Air Mobility: Demand Analysis and Market Potential of the Airport Shuttle and Air Taxi Markets. *Sustainability*, 13, 7421.

Aircraft

Over 100 VTOL aircraft are currently in development around the world. Unlike helicopters, which rely on internal combustion engines and mechanical transmissions to power rotors, VTOL aircraft are typically powered by smaller propulsion units. These aircraft utilize electricity, hydrogen fuel, or a hybrid of both, and are being designed in numerous shapes, sizes, and configurations. In the context of UAM, most VTOL aircraft are designed for the primary purpose of transporting passengers and/or cargo. While these aircraft may be intended to operate autonomously in the future, most will initially operate with a pilot on board.

A critical distinction must be made between "VTOL" and "eVTOL." Although both acronyms represent aircraft with vertical takeoff and landing capabilities, "eVTOL" specifically denotes fully electric and hybrid-electrical VTOL. For purposes of this report, "VTOL" is used as a comprehensive term to represent all UAM aircraft, which include hydrogen-powered vehicles. Alternatively, "eVTOL" is used in specific contexts related to fully electric and hybrid-electric UAM aircraft and the associated infrastructure required to support these systems.

Ground Infrastructure

Identification of required infrastructure is paramount to the successful integration of UAM into Miami-Dade County's transportation network. Ground infrastructure associated with UAM includes vertiports, electric charging stations, emergency response capabilities (i.e., fire suppression), and other mobility support facilities.

Vertiports

Vertiports are dedicated areas for the landing and takeoff of VTOL aircraft. Unlike helipads and heliports that accommodate traditional helicopter operations, vertiports are designed more broadly to account for the wide variations of VTOL aircraft characteristics and dynamic performance capabilities. Vertiports are expected to be constructed in a number of locations, including at existing airports, on the rooftops of buildings and parking garages, on elevated platforms, and at ground level in both urban and suburban areas. Additionally, multiple vertiport variations and configurations have emerged based on location, intended use, and anticipated capacity. These facilities range from single-stand vertiports that accommodate individual operations to a central site for vertiports and associated infrastructure. Similar to traditional airports and other mobility hubs, these central sites—or vertihubs—are envisioned to accommodate both passenger and cargo UAM operations and include vehicle parking facilities; security checkpoints; connectivity to other transportation modes; and maintenance, repair, and overhaul (MRO) services.

Although largely conceptual, the Federal Aviation Administration (FAA) has released federal guidance for the siting and design of vertiport structures and associated facilities due to the increased speed with which the AAM/UAM industry is emerging. This guidance is outlined in **Section 1.3** of this Technical Memorandum #1.

Energy Infrastructure

OEMs have converged on three primary approaches to VTOL aircraft energy sources: lithium-ion batteries, hydrogen fuel cells, and hybrid-electric. Considering that most VTOL aircraft are anticipated to be all-electric or hybrid-electric in the near-term, adequate aircraft charging stations, electrical grid capacity, and refueling infrastructure are vital components of a comprehensive UAM ecosystem. Unlike modern electric vehicles (EVs), eVTOL aircraft are being developed with various charging capabilities and equipped with different charging hardware. While cases are being made to promote charging connector standardization, it is likely that several variations of eVTOL electric charging stations will be required to service different vehicles. In the absence of industry-wide cooperation and consensus-driven standards, local governments, airport sponsors, and private developers will be faced with the decision of what eVTOL charging infrastructure, and by association, what eVTOL aircraft are right for operations within their respective communities.

Some OEMs are developing hydrogen-powered VTOL aircraft. These aircraft use hydrogen fuel cells to increase operational range and reduce vehicle refueling time. However, constraints with the fuel source—including availability, safety, and storage and transportation considerations—present significant planning challenges for OEMs and government agencies. Since the majority of urban operations are anticipated to be served by eVTOL aircraft, the ability for UAM to reach its full potential depends on the availability of electricity, especially as energy grid demand increases with the rise of EVs.[2] In the near term, charging stations may be installed at locations where initial piloted eVTOL aircraft are likely to operate, such as existing airports and heliports. However, when operations are scaled up to include standalone vertiports located throughout urbanized areas, many charging stations may be required to meet the demand for UAM services.[3] Especially as battery technology continues to evolve, vertihubs designed to accommodate the simultaneous charging of dozens of eVTOL aircraft may place new strains on the energy grid.

Safety and Security

Safety and security are major factors in the certification and widespread adoption of UAM. However, with new technologies, increasing automation, and low-altitude urban air operations (i.e., ground level to 400 feet for drone operations; 1,500 feet to 4,000 feet for UAM operations), industry safety standards are largely undefined and have been unable to keep pace with the rapidly developing industry. In the interim, stakeholders are attempting to innovate and move the industry forward within the current safety framework of the aviation industry. Recent federal guidance provides some direction on safety and security related to UAM ground infrastructure, which generally encompasses site safety elements of vertiports, associated

[2] NASA (2022). Analysis Of Electrical Grid Capacity By Interconnection For Urban Air Mobility.
[3] Kohlman, L., Patterson, M. (2018). System-Level Urban Air Mobility Transportation Modeling and Determination of Energy-Related Constraints.

facilities, and the safety of the public on the ground. Included in this guidance are firefighting considerations for electrical fires, UAM passenger screening, security at and around vertiports, and protection from vehicle downwash/outwash and turbulence.[4] Other considerations include cybersecurity to protect the highly automated and interconnected network of VTOL aircraft as well as effective land planning efforts to ensure compatible land use in the vicinity of vertiports and high-traffic VTOL airspace routes.

Airspace

Existing airspace infrastructure—the rules and regulations, structure, procedures, and policies—will not accommodate UAM as it is envisioned. While current airspace may support a limited number of piloted VTOL aircraft, as early systems will likely operate at existing airports and heliports, the airspace and existing regulatory framework is not equipped to support large numbers of autonomous vehicles operating at low altitudes within urban environments. Therefore, the scalability of the National Airspace System (NAS) and existing air traffic control (ATC) procedures is expected to be one of the most significant challenges for the adoption and expansion of UAM networks.[5]

As the primary manager and regulator of the NAS, the FAA partnered with the National Aeronautics and Space Administration (NASA) and other industry stakeholders to identify opportunities to prepare the NAS for large-scale AAM operations. The result of this effort was a task force whose mission is to develop innovative technology solutions to promote increased mobility and safely accommodate the growing demand of new air vehicles. Air Traffic Management eXploration (ATM-X) utilizes technological advances to incorporate faster computing speeds, communication systems capable of handling more data, the cloud, and autonomous technologies to transform the national airspace for the next generation of operations.[6] As part of ATM-X, NASA and the FAA are developing airspace management technologies to provide routine airspace access to low-altitude UAM operations within urban areas (less than 5,000 feet above ground level) and for autonomous vehicles.[7]

Currently, the NAS consists of various classifications of airspace based on level of service and operating rules. These classifications impose requirements on the operation of aircraft including visibility minimums, cloud clearance, communication with the ATC, and specific aircraft equipment. These classifications, along with challenges associated with UAM operations, are summarized below and illustrated in **Figure 1.1**.

[4] FAA (2022). Engineering Brief 105, Vertiport Design.
[5] Vascik, P., Balakrishnan, R., Hansman, J. (2018). Assessment of Air Traffic Control for Urban Air Mobility and Unmanned Systems. Massachusetts Institute of Technology, Department of Aeronautics and Astronautics.
[6] NASA (2021). What is Air Traffic Management eXploration? Retrieved from: www.nasa.gov/ames/atmx.
[7] NASA (2021). NASA Sets Stage for Future Flights, Auditions Advanced Air Mobility Technologies. Retrieved from: https://www.nasa.gov/feature/nasa-sets-stage-for-future-flights-auditions-advanced-air-mobility-tech.

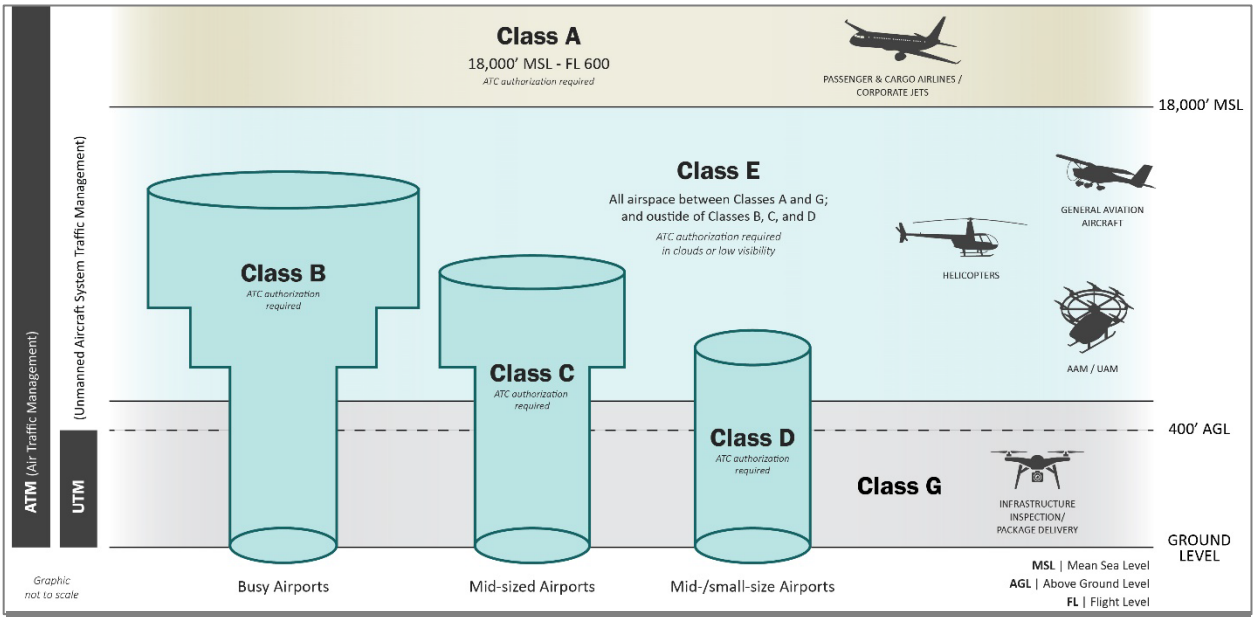
Controlled Airspace: Controlled airspace (Classes A, B, C, D, and E) refers to airspace in which ATC services are provided. Aircraft need to establish two-way communication and comply with ATC instructions when operating within Classes A, B, C, and D. With current procedures, proposed UAM networks will increase ATC workload while autonomous vehicles will not be able to establish two-way communication with ATC via traditional radio.

Uncontrolled Airspace: Uncontrolled airspace (Class G) is airspace in which ATC has no authority or responsibility to control. VTOL aircraft may operate within Class G airspace without authorization or guidance from ATC. However, pilots operating in uncontrolled airspace often communicate on shared radio frequencies to ensure safe operating distances between aircraft. Similar to VTOL aircraft operating in controlled airspace, autonomous aircraft in uncontrolled airspace will be unable to communicate with nearby pilots.

Airspace for UAS Traffic Management: NASA and the FAA are working to develop airspace to enable Beyond Visual Line of Sight (BVLOS) drone operations at low altitudes (ground to 400 feet above ground level). BVLOS refers to operations performed by UAS at distances outside the normal visible range of a pilot. UAS Traffic Management (UTM) airspace is not intended for passenger transport use cases.

Airspace for UAM Operations: Initial UAM operations are likely to utilize existing helicopter routes and adhere to traditional air traffic regulations. As the industry matures, it is anticipated that UAM corridors will be established between 1,500 feet to 4,000 feet above ground level (AGL). Although it is expected that UAM corridors will be located within controlled airspace, autonomous UAM operations will not need to establish two-way communication with ATC.

Figure 1.1 - Airspace Classifications



Source: Kimley-Horn (2022).

Stakeholders

Successful implementation of an integrated UAM ecosystem in Miami-Dade County requires planned coordination and continuous engagement between several key stakeholder groups from both the public and private sectors. Although legacy aviation issues such as the regulations of operations and airspace have traditionally been the responsibility of the FAA; state, regional, and local stakeholders must take active roles in shaping policy and engaging the community to support the integration of UAM into Miami-Dade County's existing transportation network. **Table 1.1** highlights the stakeholders responsible for bringing a safe and efficient UAM system to market.

Table 1.1 - Stakeholder Roles and Responsibilities

Stakeholder Group	Roles and Responsibilities
Federal Agency - NASA	Supports public-private engagement while conducting research to foster the growth of AAM and UAM.
Federal Agency - FAA	Governs aircraft certification, NAS, and infrastructure requirements.
Federal and State Legislators	Promote policy development to enable and regulate the UAM industry such as those related to the infrastructure, safety, and investment needed to bolster an UAM ecosystem.
Local Governments	Promote local policy and planning decisions—especially zoning, land use, and transportation planning efforts—to foster an efficient, sustainable, and equitable UAM ecosystem. Develop proactive community engagement strategies to promote public perception of UAM.
OEMs and Private Industry	Drive VTOL aircraft and market development while ensuring the safety of UAM users and the public.

Source: Kimley-Horn (2022).

1.3. Literature Review

A thorough review of existing literature was conducted to lay the foundation for an UAM policy framework for Miami-Dade County. Information reviewed included research, legislation, policies, and case studies from public agencies, private entities, and research organizations within the U.S. and abroad. To align with study objectives, the review focused on literature related to the current state of UAM technology, existing UAM policies, and the promotion of integrated UAM systems. Findings from this review are highlighted within this section and will provide a baseline of understanding upon which a policy framework for Miami-Dade County will build.

Regulatory Guidance

Defining the regulatory context for UAM development is key to understanding how the technology can be effectively integrated into Miami-Dade County's existing transportation network. The innovative technologies associated with AAM/UAM—including automation, VTOL aircraft, and BVLOS operations—do not fit within the existing rules and regulations of traditional aviation design, aircraft development, and operations within the NAS. Therefore, stakeholders are faced with the challenge of developing technologies and creating markets within the context of existing regulatory frameworks. With this challenge and the rapidly emerging technologies and interest in mind, various agencies around the world are working to develop regulations that pertain specifically to components of AAM/UAM including aircraft, airspace, operations, and associated infrastructure. As previously discussed, the FAA and NASA are leading efforts in the U.S. for the development of technical guidance and regulations to govern aircraft design, airspace management, and overall safety. Equally as critical state, regional, and local government agencies such as the Miami-Dade TPO are actively developing policy frameworks to create regulatory guidelines for their respective communities within which the AAM/UAM industry must operate.

FAA Engineering Brief 105, Vertiport Design

In September 2022, the FAA released Engineering Brief (EB) 105 to provide guidance for the design of vertiports. EB 105 includes design elements for VTOL use, standards for electric and charging infrastructure, and safety considerations for vertiport siting. This EB is specific to VTOL aircraft with maximum takeoff weights (MTOW) of 12,500 pounds or less and is intended to support the growing interest for initial infrastructure development for VTOL operations. It is important to recognize that the FAA considers EB 105 to be interim guidance due to a lack of demonstrated VTOL aircraft performance data. The guidance will be periodically updated as new data becomes available. As research and technology progress, the FAA expects to develop a comprehensive performance-based advisory circular (AC) that will feature vertiport considerations for different design criteria and aircraft characteristics as well as frequent

operations and autonomous operations.[8] In the meantime, EB 105 establishes acceptable levels of safety and performance upon which vertiport development in the U.S. should be based.

FAA Advisory Circular 150/5190-4B, Airport Land Use Compatibility Planning

FAA AC 150/5190-4B provides comprehensive guidance on land use as it relates to airport safety and operations. Recently published in September 2022, the AC identifies compatible land uses for airport operations and shares resources and tools to help protect airport-adjacent land and surrounding communities from adverse impacts associated with airport operations. Incompatible land uses are those that pose potential hazards to aircraft operations or may compromise the safety of people on the ground. Tall buildings, antennas, and wildlife attractants such as waste landfills may adversely impact aircraft operations, specifically as it relates to takeoffs and landings. Similarly, residential and noise-sensitive land uses such as schools, churches, and hospitals located near an airport may adversely affect the well-being and safety of those residents.

Although AC 150/5190-4B is specific to airport-adjacent land uses, the underlying principles of the AC can be applied to VTOL operations and vertiport siting. While VTOL aircraft will be significantly quieter than propeller, jet, or rotary-wing aircraft, it is anticipated that VTOL aircraft will perform frequent operations within dense urban areas. As such, land use compatibility is a critical consideration in the planning and development of an interconnected UAM network. In the absence of AAM/UAM-specific land use guidance, industry stakeholders should consult existing guidance on land use compatibility and VTOL aircraft operations.

Airworthiness and Operation Certifications

To provide commercial services to the public, VTOL aircraft must receive an airworthiness certification and operators must receive certification to carry people or goods from the FAA. An airworthiness certification addresses safety risks by setting requirements for aircraft design, manufacturing, performance, failure response, and maintenance. However, existing airworthiness regulations were designed for traditional aircraft. Like most elements of AAM/UAM, VTOL aircraft challenge the existing certification processes due to new technology, operating features, and aircraft applications such as advanced flight controls, electric propulsion, number of passengers, autonomy, and low-altitude operations within an urban environment.[9] To continue moving the development of VTOL aircraft forward, OEMs are seeking airworthiness certification under existing rules and regulations; but this will not suffice for mass production of aircraft. The FAA has recognized the challenges associated with this approach and has recently announced that it will update its regulatory process for the certification of VTOL aircraft. In the interim, VTOL aircraft will seek certification under the “special class”

[8] FAA (2022). Engineering Brief 105, Vertiport Design.

[9] Coudert, A., et al. (2019). A Roadmap to Certify Flying Cars. Air Traffic Control Association.

process as identified in Part 21, Section 17(b) of Title 14 of the Code of Federal Regulations (CFR) to account for the unique features of these emerging aircraft.[10]

Since most VTOL are being designed to carry no more than ten passengers, UAM operators that wish to perform non-scheduled operations for compensation within the U.S. must obtain an FAA Air Carrier and Operator Certificate under 14 CFR Part 135. This certificate is required for both passenger and cargo operations. Part 135 certification represents another instance where UAM operators will need to operate within the existing regulations of the aviation industry. While certification processes may complicate and delay the availability and adoption of UAM technologies, the high safety standards may also provide a level of comfort to local governments and the public.

Legislation

As with many new technologies and innovations, legislation has not been able to keep pace with advancements in VTOL and the AAM/UAM industry. While some legislation has been established for UAS, most is not relevant to passenger transport and, therefore, UAM. **Table 1.2** presents an overview of active and pending federal and state legislation related to AAM and UAM.

[10] Reed, J. (2022). The FAA Confirms Changes to Regulatory Approach for Powered-Lift Certification. *Aviation Today*.

Table 1.2 - Active and Pending AAM/UAM Legislation (U.S. and Florida)

Legislation	Status	Summary
United States Legislation		
Advanced Air Mobility Coordination and Leadership Act (S.516)	Awaiting President's signature	Directs the USDOT to establish an AAM interagency working group to plan and coordinate efforts related to the safety, infrastructure, physical security, cybersecurity, and federal investment necessary to bolster the AAM ecosystem in the U.S.
Drone Infrastructure Inspection Grant Act (H.R. 5315)	Passed in House on 9/13/2022; Awaiting Senate vote	Authorizes a grant program to state, local, and tribal governments to purchase drones for infrastructure inspection and to community colleges/universities to support drone education and workforce training programs.
Advanced Aviation Infrastructure Modernization Act (H.R. 6270)	Passed in House on 6/13/2022; Awaiting Senate vote	Authorizes a grant program to state, local, and tribal governments; transit agencies; port authorities; and MPOs to plan the infrastructure needed to facilitate AAM operations and construction for public use vertiports.
State of Florida Legislation		
Use of Drones by Government Agencies Bill (CS/SB 44)	Approved by Florida Governor on 6/29/2021	Expands the authorized use of drones by law enforcement agencies and other entities for specified purposes. Requires the Department of Management Services to publish a list of approved drone manufacturers meeting specified security standards and to establish minimum security standards for governmental agency drone use.
Drones Bill (CS/HB 659)	Approved by Florida Governor on 6/29/2020	Adds exception to prohibited uses of drone for managing and eradicating invasive exotic plants or animals on public lands and suppressing and mitigating wildfire threats.
Unmanned Devices Bill (CS/HB 1027)	Approved by Florida Governor on 6/26/2017	Authorizes operation of personal delivery devices within a county or municipality under certain circumstances, exempting personal delivery devices from certain registration and insurance requirements and creating the "Unmanned Aircraft Systems Act."

Sources:
www.congress.gov (accessed September 2022).
www.flsenate.gov (accessed September 2022).

UAM Working Group

On November 2, 2021, a resolution was passed by the Miami-Dade County Board of County Commissioners to create an UAM Working Group with the objectives of exploring the industry and helping prepare the County for UAM operations. The working group is comprised of representatives from public agencies and private industry, including the Miami-Dade TPO, the Miami-Dade Aviation Department (MDAD), PortMiami, the Florida Department of Transportation (FDOT), the University of Miami, consulting firms, and VTOL manufacturers. Diverse representation on the working group provides a cross-section of backgrounds, perspectives, and industry knowledge to aid in the development of a policy framework that promotes a connective, safe, and sustainable UAM ecosystem in Miami-Dade County.

The UAM Working Group has conducted extensive research on various policy frameworks, ConOps, and other industry publications. The information gathered was critical in understanding the current state of the market as well as emerging policies and best practices that are aiding other regions in preparing for UAM integration. Additionally, to facilitate a robust understanding of the UAM industry, both nationally and internationally, the UAM Working Group participated in a peer exchange program that enabled group members to learn from UAM policy frameworks and studies from around the world. Reviewed publications include a ConOps for UAM operations across the European Union, a mobility plan in France, and an UTM system in France. An overview of the UAM Working Group's research is presented in the following section.

Case Studies and ConOps

There are a vast number of UAM-related studies that have been published in recent years, by public and private entities, that are intended to support the integration of this technology into existing transportation networks. In general, these studies have two main objectives:

1. Establish the fundamental components of UAM.
2. Identify considerations for developing policy and procedural frameworks to regulate UAM operations in anticipation of greater adoption.

To develop a foundation of knowledge for UAM concepts and policy frameworks, the following sections provide an overview of various UAM-related publications. This review of literature included a close evaluation of recommendations from other governmental agencies on UAM implementation including considerations of noise and privacy concerns, multi-modal integration, and preservation of regional transportation assets. **Table 1.3** provides a broad overview of findings including lessons learned and proposed action items from the respective publications. Additionally, common themes and their relevance to Miami-Dade County are analyzed in the following sections. This literature review and its findings are intended to inform the foundation of Miami-Dade County's policy framework.

Table 1.3 - Summary of Literature Review

Agency	Publication Date	Literature	Goals and Objectives	Key Takeaways and Proposed Actions
FAA	Jun 2022	UAM: ConOps V1.0	Describe the envisioned operational environment that supports the expected growth of UAM flight operations in and around urban areas.	• FAA NAS data sources are available to UAM operations via FAA industry exchange protocols. This allows for authorized data flow between the UAM community and FAA operational systems. • UAM implementation is an evolutionary development approach starting with low-complexity, low-operational tempo operations and building toward an environment of high-operational tempo operations and the introduction of UAM airspace structure to mitigate an otherwise high level of complexity. The concept will evolve through the results of analysis, simulation, demonstration, and community engagement.
EURO-CONTROL	Oct 2019	U-Space ConOps	Describe the ATM environment in which manned and unmanned aircraft must co-exist safely.	• Reduce the presence of uninvolved people by, for example, flying at non-busy hours. • Phased approach to UTM integration; Services will be introduced in four phases as technology and operational readiness allow. • Key guiding principles of U-space include ensuring the safety of all airspace users and people on the ground and providing a scalable, flexible, and adaptable system that can respond to changes in demand, volume, technology, business models, and applications while managing interface with manned aviation.
NASA	Jun 2022	NASA Near-Term Use Cases in the Dallas-Fort Worth (DFW) Area	Evaluate the extent to which UAM flights are possible in the current NAS and identify whether existing approaches to expand operations will work for UAM.	• Near-term UAM operations are possible without any changes to airspace regulations, policies, or helicopter routes (where available). However, the placement of vertiports near active runways will pose challenges in near-term implementation. • Flights to and from uncontrolled airspace will be possible for UAM flights without a need for an ATC communication. • There may be limitations on airspace usage under specific airport configurations and certain arrival and departure procedures. • Further research should focus on early operations with simple use cases and progress to more complex evaluations.
City of Orlando	Aug 2020	UAM Overview	Provide an overview of UAM and identify initial business case by analyzing potential origins and destinations in the City of Orlando.	• Vertiport siting regulation will be determined by community acceptance. The City of Orlando plans to utilize existing community outreach processes in addition to partnering with UAM providers to ensure that the community is aware of projects. • The City has experience issuing permits for vertiports and can utilize those existing regulations for initial facilities. FDOT also has a permitting process for new vertiport siting in the state. • Implement UAM pilot program with simplified initial framework to test community acceptance, infrastructure, and fixed-base operator (FBO) sharing, flight paths, and automated ATC technology with full data sharing between all partners.
Los Angeles DOT (LADOT)	Sep 2021	UAM: Policy Framework Considerations	Identify land use and permitting policy considerations for UAM implementation to preserve equity, safety, and sustainability.	• Establish data gathering process to influence modifications to vertiport design and community planning standards. • Conduct interagency coordination between regulators and agencies at all levels to define and resolve any conflicts that may arise. • Develop community engagement/education strategy.
Ohio DOT (ODOT)	Aug 2022	AAM Framework Study	Identify key considerations, constraints, and recommended policy framework to inform the planning process for the state, its partners, and stakeholders in preparing for AAM integration.	• Integrate AAM into statewide transportation plans and airport master plans. • Airports and other locations that are suited for AAM operations should consider adopting zoning to protect the airspace that will be needed for AAM operations. • Work with local communities to define the most impactful AAM use cases and missions for their respective areas. • Develop educational materials that can be used by the state, regional, and local agencies to educate their partners, members, and the public.
Texas DOT (TxDOT)	Sep 2022	Report and Recommendations of the UAM Advisory Committee	Develop new regulations that can facilitate the development of Texas' UAM deployment and adaptation capabilities.	• Create consistency across Texas law by developing statutory uniformity and standard definitions pertaining to unmanned aircraft operations and AAM/UAM. • Develop a statewide plan or integrate within the Texas Airport System Plan. • Direct the state to work with municipalities to provide technical assistance to local governments in adapting and integrating AAM/UAM in their communities. • Ensure Texas law does not conflict with federal law.

Opportunities and Challenges

Opportunities and challenges associated with UAM will vary by location due to geography, political environment, and the needs of specific populations. However, certain considerations were consistent themes throughout the literature review. These opportunities and challenges are identified and summarized below.

Opportunities

- **Increase mobility:** UAM can provide additional opportunities for mobility while increasing the capacity and efficiency of an urban transportation system.
- **Reduce congestion and strengthen connectivity:** UAM can help reduce the need for vehicle traffic within an urban core while increasing connectivity between urban and rural areas.
- **Bolster emergency response:** Dedicated UAM routes can improve the delivery of emergency services such as fire and medical.
- **Environmentally sustainable:** UAM and eVTOLs can help reduce carbon emissions and noise pollution associated with automobiles.
- **Economic opportunity:** UAM and associated infrastructure can provide opportunities for economic growth through transit-oriented development, workforce development, and improved access to population and employment centers.

Challenges

- **Regulatory environment:** Technology and investment have drastically outpaced rules and regulations for VTOL development and UAM operations, forcing industry stakeholders to innovate and plan within the existing regulatory framework.
- **Lack of data:** There is inadequate data and guidance to support comprehensive planning efforts for UAM infrastructure and technologies, such as vertiports and autonomous operations.
- **Technology:** Existing battery storage and charging technologies, paired with energy grid capacity concerns, do not support a dense UAM system where many VTOLs can spend most of the time airborne.
- **Airspace traffic management:** With increased low-altitude operations in an urban environment, an automated traffic management system is required to enable scaled UAM operations and ensure the safety and efficiency of all VTOL aircraft.
- **Public acceptance:** As an innovative technology that can fundamentally alter the urban landscape, the public may express concerns over UAM, particularly as it relates to safety, noise, security, privacy, social equity, and environmental impacts.

- **Affordability and social equity:** Without promoting an integrated UAM system as an affordable transportation option for all, including for those with disabilities and special needs, UAM has the potential to become an exclusive method of transportation for the wealthy. Based on current technologies and the emerging nature of the industry; however, uncertainty exists around the timeline for UAM to obtain mass-market affordability.[11]

Proposed Actions

To capitalize on opportunities and mitigate potential challenges, industry stakeholders have identified proactive solutions to help integrate UAM into existing transportation networks. The following sections highlight key takeaways from the literature review of proposed actions that Miami-Dade County may consider employing in local planning efforts.

Establish Working Groups

The importance of establishing a working group is consistently emphasized across all reviewed case studies and research. Like the Miami-Dade UAM Working Group, a successful working group includes participants with various technical knowledge and diverse perspectives and should include representatives from government agencies at all levels, private industry, and the public. Working groups should emphasize an UAM framework that can be integrated into a broader transportation network while considering the needs of local communities.

Develop Community Engagement Strategies

According to existing research and various case studies, public acceptance is one of the most important elements and greatest challenges of UAM integration. Although improving public perception of UAM is a shared responsibility among all industry stakeholders, local governments possess intimate knowledge of their communities' wants and needs and are best positioned to develop tailored community engagement strategies. Community program recommendations within the reviewed publications include public focus groups, educational seminars, open house meetings, and job training programs targeted at marginalized communities to improve access into the aviation and aeronautical industries. Proactive and thoughtful community engagement throughout the planning and development process can support the implementation of an UAM system that becomes a sustainable asset within the community for all populations.

The Miami-Dade TPO is well-versed in executing successful community engagement practices to facilitate equitable transportation networks. For example, in 2016 the Miami-Dade TPO conducted extensive community outreach as a part of the Beach and Northeast Corridor Land Use Scenario and Vision Planning project. This project facilitated public involvement through a series of charettes to obtain valuable public input for various land use scenarios. Similar community engagement practices would be beneficial during the planning process for UAM.

[11] Cohen, A., Shaheen, S. (2021). Urban Air Mobility: Opportunities and Obstacles. *Transport Modes.*

Incorporate UAM into Existing Operations and Planning Efforts

To lay the groundwork for integrated UAM systems, research suggests that local governments should begin incorporating UAM considerations into existing operations and future planning efforts. Initiating preparations for UAM integration, both in policy and procedures, can help facilitate a smooth market entry for the new transportation system. Alternatively, lack of preparedness by local agencies may cause additional challenges and/or delays. **Table 1.4** provides examples of how government agencies can begin preparing for UAM in their communities.

Table 1.4 - UAM Considerations for Public Agencies

Local Agency / Department	Opportunities for Incorporating UAM Considerations
Planning and Zoning	• Land use planning • Zoning codes • Code enforcement
Fire and Rescue	• Fire codes • Incident management • Emergency response • Input on location of UAM infrastructure
Police	• Enforcement • Public relations (incident management) • Security
Economic Development	• Marketing and economic incentives • Maximizing opportunities for vacant land • Redevelopment/re-use of existing assets (heliports, airports)
Legal	• Liability • Privacy and property rights • Noise ordinances
Transportation and Public Works	• Multimodal planning • Future parking facilities • Overall system integration

Source: Kimley-Horn (2022).

Integrate UAM into Transportation Planning

Long-term transportation planning plays a critical role in identifying mobility needs and opportunities for the future of transportation networks. Incorporating UAM into long-range planning efforts can help develop multimodal improvement opportunities, steer funding priorities, and drive overall system integration. As such, through proactive planning efforts, Miami-Dade TPO has a unique opportunity to further define the long-term visioning process of UAM; raise awareness of UAM benefits at the local, regional, and state levels; and help develop consistent policies and procedures across Miami-Dade County and beyond. An exploration of UAM benefits and challenges in the context of the County's long-range planning efforts is provided in **Section 1.4**.

Promote Interagency Public Data Sharing

As previously noted, one of the challenges associated with UAM integration is the current lack of real data related to UAM operations that could be used to guide policy and development decisions. To leverage as much data as possible, interagency sharing of available data can help broaden existing knowledge and help inform the decisions of local planners and policymakers. While data can be supplemented through various research and ConOps such as the NASA-led AAM National Campaign, complete operational data and public perception to UAM operations will not be available until commercialization and full integration. As a solution, LADOT, ODOT, and the City of Orlando are applying similar approaches to UAM adoption: a phased rollout of UAM into their transportation networks where a limited number of VTOL operate in a loose framework environment in ways that each agency can collect necessary data, observe changing trends in the industry, and inform the decisions of responsible government agencies on various topics such as land use, zoning, and the permitting of operators and vehicles. Miami-Dade County can benefit from a similar phased approach to UAM technology while leveraging existing data collection tools such as Mobility Data Specification (MDS), which is currently being utilized for the Miami Scooter Pilot Program. Data collected, best practices, and lessons learned should be shared among other agencies to promote and advance UAM as an integrated mode of transportation.

1.4. UAM and Miami-Dade County

Miami-Dade County is home to more than 2.7 million residents, the most populated county in Florida and the seventh-most populated county in the U.S. The County maintains the largest public transit system in the state, Miami-Dade Transit (MDC), which serves millions of users each year. However, in 2021, the Miami Urbanized Area was ranked the fifth-most congested urban area in the U.S. in terms of automobile traffic according to transportation data and analytics firm INRIX. Contributing to this statistic: 75 percent of Miami-Dade County residents reported driving personal vehicles to work each day, according to the U.S. Census Bureau, with more than 30 percent of residents reporting one-way commute times of over 40 minutes. Moreover, the County is anticipating significant growth over the next 20 years with an expected population increase of 26 percent to 3.4 million by 2045.[12]

While tourism, hospitality, real estate, and professional services are traditional economic drivers of the region, much of this growth is attributed to Miami positioning itself as an international hub for technology and innovation. Tech startups based in Miami-Dade County raised more than $2.6 billion in venture capital in 2021, and Miami is leading the U.S. in both tech job migration and growth.[13] By 2045, total employment within the County is expected to increase by 34 percent.[14]

Especially during periods of rapid growth, effective and efficient transportation systems are vital to the long-term prosperity of regions. UAM is proposed to offer additional mobility options with increased frequency and efficiency. However, as sustainable UAM ecosystems require dedicated infrastructure and carefully managed airspace, existing modes of public transportation will remain essential to the urban fabric of a growing region. UAM's full potential is dependent upon integration into existing and planned infrastructure. Simply put, the proposed benefits of an UAM ecosystem within Miami-Dade County can only be maximized when complementing, not replacing, existing transportation systems.

This section explores the potential relationship between UAM and the transportation network of Miami-Dade County. Also highlighted are the County's long-range transportation planning efforts and the associated benefits and challenges of an integrated UAM ecosystem within the context of planning.

[12] University of Florida Bureau of Economic and Business Research (2021). Florida Population Studies, Volume 54, Bulletin 189.
[13] Loyola, M. (2022). *How Miami 'Caught a Wave' and Became the Hot New Tech Hub*. Wall Street Journal.
[14] Miami-Dade TPO (2019). 2045 LRTP.

Transportation Planning

Since UAM will introduce additional infrastructure considerations such as vertiports, electrical charging stations, autonomation, and the frequent use of urban airspace, local governments must prioritize the evaluation of UAM impacts on local communities, future transportation projects, and long-range planning efforts. Led by the Miami-Dade TPO in conjunction with local, regional, and state organizations, Miami-Dade County has robust transportation planning programs to serve the needs of its growing communities. To identify the potential benefits and challenges of a future UAM system in Miami-Dade County, an understanding of the County's major transportation planning efforts is imperative. As highlighted below, several planning documents and transportation initiatives identify future mobility needs and prioritize infrastructure projects within the County. Together, these planning efforts formulate a framework for transportation project priorities, foster collaborative multi-modal planning, identify project funding sources, and develop implementation strategies.

2045 Long Range Transportation Plan

The Miami-Dade TPO published the current Long Range Transportation Plan (LRTP), entitled *2045 LRTP*, in September 2019. With an emphasis on significant growth in population, employment, development, and tourism, the LRTP's overall purpose is to prepare Miami-Dade County's transportation network for future demand and capacity through increased mobility options and reliable modes of transportation. The LRTP outlines improvement projects over a twenty-five-year period, 2020 through 2045, and represents a long-term blueprint for the region's transportation system.

Transportation Improvement Program, 2023-2027

Under federal law, each Metropolitan Planning Origination (MPO) is required to develop a Transportation Improvement Program (TIP) that prioritizes upcoming transportation improvement projects for federal, state, and local funding. Serving as the MPO for the Miami-Dade County, the Miami-Dade TPO adopted the current TIP in June 2022, for fiscal years 2023 through 2027. The TIP represents the capital improvements element of the LRTP and plays a major role in the realization of projects identified in the LRTP.[15] The 2023 TIP lists over 1,700 projects of various sizes, locations, and impacts led by eight public agencies including Miami-Dade County, Miami-Dade Expressway Authority (MDX), MDAD, South Florida Regional Transportation Authority (RTA), and FDOT.[16] Transportation improvements address projects planned for the next five years related to highway, transit, aviation, seaport, and non-motorized infrastructure. All projects and priorities listed in the TIP are consistent with those in the 2045 LRTP.

[15] Miami-Dade TPO (2022). Transportation Improvement Program, 2023-2027 – Citizen's Edition.
[16] Miami-Dade TPO (2022). Transportation Improvement Program, 2023-2027

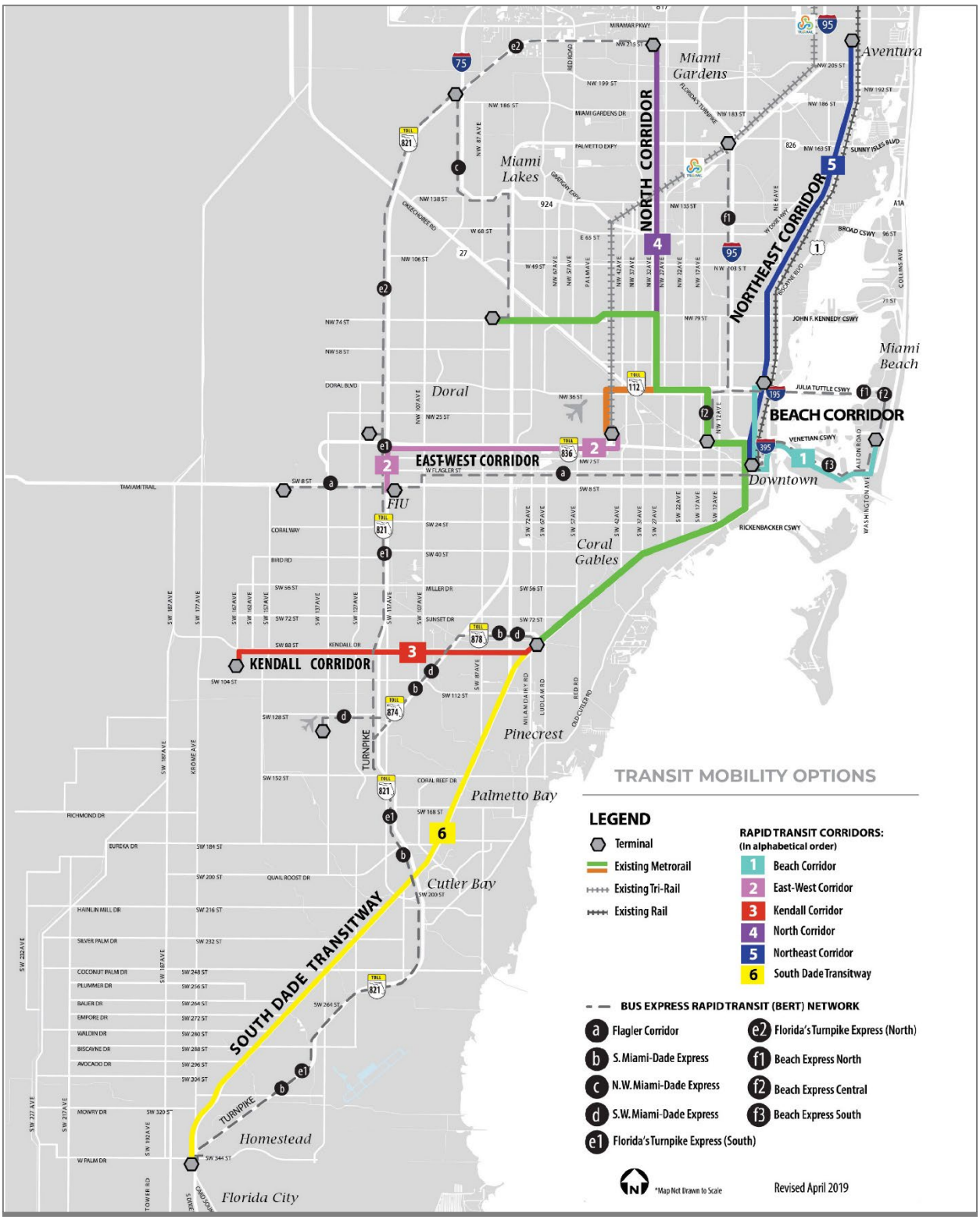
Transit Development Plan

The Miami-Dade County Department of Transportation and Public Works (DTPW) recently published an annual update to the County's Transit Development Plan (TDP), entitled *MDTMovingFwd 2022*, for fiscal years 2023 through 2032. The report evaluates DPTW's existing transit system—including Metrobus, Metrorail, and Metromover—and presents transit needs to create a framework that can be implemented over a ten-year planning horizon. The infrastructure needs identified in the TDP are used to inform project priorities in the LRTP and TIP.

The SMART Program

The Strategic Miami Area Rapid Transit (SMART) Program is a County-wide infrastructure program to encourage the advancement of rapid transit corridor projects. Adopted in 2016, the Program consists of six rapid transit corridors and a Bus Express Rapid Transit (BERT) network system to implement mass transit projects in Miami-Dade County. The SMART Program is a collaborative effort between local, state, and federal agencies with the goal of expanding transit options, enhancing overall mobility, reducing congestion, and promoting economic growth in the County. As illustrated in **Figure 1.2**, the rapid transit corridors and BERT network provide increased connectivity between Miami-Dade County's population and employment centers. These transportation improvements represent the highest priority for the County and are heavily emphasized within many Miami-Dade County transportation planning efforts including the LRTP, TIP, and TDP.

Figure 1.2 - The SMART Program Rapid Transit Corridors and BERT Network



Source: Miami-Dade TPO (2019). 2045 LRTP.

UAM and Existing Planning Efforts

Although Miami-Dade County's existing long-range planning efforts do not explicitly include UAM-related policies or projects, emerging technologies such as UAM, EVs, and automation are increasingly represented as underlying themes as County planning agencies recognize the disruptive nature of these innovations. In the 2045 LRTP, the Miami-Dade TPO listed specific goals to help address the County's growth in employment, development, and tourism and prepare for future transportation demand and capacity. Though broad, these goals align with the proposed benefits of an integrated, sustainable, and equitable UAM system.

Figure 1.3 - Goals of 2045 LRTP and Proposed UAM Benefits

2045 LRTP Goals	Proposed Benefits of UAM
Maximize mobility choices	Increases mobility options
Increase safety and security for all users	Reduces traffic congestion and emergency response times
Support economic vitality	Improves transportation efficiency of people and goods; Attracts private investment; Provides workforce development opportunities
Protect and preserve the environment and quality of life; Promote energy conservation	Reduces noise, carbon emissions, and fuel consumption
Enhance integration and connectivity	Enhances connectivity between urban centers and surrounding communities
Improve and preserve the existing system	Enhances existing transportation system and multimodal connectivity while integrating UAM services

Due to billions of dollars of investment and growing public interest, UAM technologies are rapidly advancing and will soon evolve into realistic mobility opportunities for local governments to explore. As noted several times throughout this document, initial piloted UAM operations may be able to utilize existing aviation infrastructure such as airports, heliports, and ATC. However, additional infrastructure will be required to sustain a high-frequency and fully integrated UAM system. Examples of UAM-related development that already exist in Miami include several private developments, such as the Paramount Miami World Center in Downtown Miami, that have included vertiports in their structure design. Although these developments may foster private air transport for a few, without proactive planning UAM will not be able to reach its full potential as an integrated and sustainable mobility opportunity that benefits all network users.

The technologies, legislation, and guidance described within this document will have direct impacts on the County, its transportation network, and its constituents. While emphasizing growth and development, Miami-Dade County's transportation system must adapt for the future by keeping increased automation, technology, and connectivity at the forefront of planning considerations. Just as the SMART Program intends to integrate rapid transit into existing roadway, public transportation, and bicycle and pedestrian infrastructure, long-range planning efforts should include UAM principles and considerations to promote an integrated multimodal transportation system that addresses future travel demand for all populations. This effort is the Miami-Dade TPO's first step in initiating proactive planning and public outreach strategies to ensure the proposed benefits of UAM align with the stated goals of the LRTP and the goals of the overall transportation network. Infrastructure needs, public engagement strategies, and an overall UAM policy framework for Miami-Dade County are explored further in subsequent phases of this study.

[Chapter 2 Cover Placeholder]

2.1. Policy Framework Overview

UAM is proposed to increase mobility options, reduce congestion, decrease carbon emissions, enhance connectivity, and improve overall transportation network efficiency, among a host of other benefits. However, in order to leverage these proposed benefits and help prepare Miami-Dade County for future transportation demand and capacity, the groundwork must be laid for UAM policy and procedure development.

Recently seen with the advent of micromobility and UAS, the disruptive nature of new technologies can be amplified in the absence of proactive planning and a foundational framework. In many cases, airports, cities, and the NAS were generally underprepared to address the impacts from recreational drones; and most cities did not have the infrastructure or procedures in place to accommodate floods of e-scooters and bikes. Therefore, in advanced preparation for the potential impacts and proposed benefits of UAM, this Policy Framework and its recommendations are proactive in nature and represent a foundation from which future UAM policy and procedures should be developed.

As noted in Technical Memorandum #1, new technologies are quickly emerging while safety standards and best practices are continuously finetuned. In this period of technological disruptions and unprecedented innovation, this Policy Framework must be flexible to adapt to the rapidly evolving industry.

2.2. Key Considerations

It is critical that this UAM Policy Framework is consistent with the goals and objectives of the Miami-Dade TPO and its partner agencies as the region continues to accommodate extraordinary growth in population, employment, development, and tourism. In line with the LRTP 2045 and The SMART Program, this Policy Framework strives to promote an UAM network that complements existing transportation systems while increasing mobility choices and supporting sustainable, equitable, and livable communities.

Table 2.1 represents key considerations related to the opportunities and projected impacts of UAM in Miami-Dade County. From a review of existing literature, federal and state planning obligations, and discussions with various stakeholders, these considerations have been identified as the highest priorities in the planning of an integrated UAM network in Miami-Dade County. The key considerations serve as the underlying principles of this Policy Framework and its recommendations.

Table 2.1 - Key Considerations

Key Consideration	The Policy Framework Should Consider:
Airspace	• Protection of airspace over sensitive areas • Coordination with the FAA and existing airports
Charging / Fueling Infrastructure	• Electrical grid capacity and any required enhancements • Fueling safety and logistics for hybrid-electric and hydrogen-powered aircraft
Data and Network	• Connectivity, coverage, and capacity of communications networks • Data collection and public privacy
Economy / Funding	• Funding sources for UAM infrastructure • Economic vitality • Fostering an environment that attracts private investment
Land Use and Zoning	• Protection of noise-sensitive land uses • Increased connectivity
Noise and Visual Pollution	• Impacts associated with noise and volume of operations • Public engagement
Safety and Security	• Operational and safety requirements of aircraft and vertiports • Overall safety and security of UAM ecosystem
Social Equity	• Equal access to UAM and equity in vertiport siting decisions • Prevention of disproportionate impacts to historically marginalized communities
Sustainability	• Integration of UAM in multimodal transportation network, including first- and last-mile transportation • Promotion of clean energy and environmental sustainability
OEMs and Operators	• Collaboration with the private sector • Local proofs of concept
Vertiport Infrastructure	• Vertiport siting requirements, including surrounding land uses and airspace for the safe takeoff and landing of aircraft • Physical characteristics, safety areas, and support facilities

Source: Kimley-Horn (2022).

2.3. Policy Framework Recommendations

The recommendations within this section represent proposed actions to help evaluate, promote, and plan for an integrated, sustainable, and equitable UAM ecosystem in Miami-Dade County. These recommendations are grouped into three categories based on responsible organization and required coordination: Government, Private Sector, and Public/Private Collaboration. Subsequent phases of this study will utilize these recommendations in the development of an actionable timeline and an overarching UAM Policy Framework.

Government

Historically, state, regional, and local government agencies have generally relied on the federal government (i.e., the FAA) to regulate and monitor aviation activity around the country. However, an integrated UAM network will bring a high volume of low-altitude aircraft operations to Miami-Dade County's congested urban centers and surrounding areas. Therefore, stakeholders at all levels of government must take active roles in shaping policy, collaborating with other agencies, and engaging their respective communities to promote a sustainable UAM network within the County.

This group of recommendations presents opportunities for interagency collaboration between the Miami-Dade TPO and government agencies at the local, regional, state, and federal levels. As the primary regulatory agency for the manufacturing, operation, and maintenance of aircraft in the U.S., the FAA represents the lead agency with which the Miami-Dade TPO will consult and coordinate. The TPO's policy recommendations will ultimately follow or compliment FAA guidance to ensure consistency with existing and future regulations.

The Miami-Dade TPO's policy recommendations will ultimately **follow or compliment FAA guidance** to ensure consistency with existing and future regulations.

State, Regional, and Local Planning

As noted in Technical Memorandum #1, UAM will bring unprecedented change to urban and rural environments. While aviation rules and regulations have traditionally been left to the FAA, government agencies at the state, regional, and local levels must take proactive approaches to understanding the disruptive nature of UAM and leveraging potential benefits to address mobility and logistics needs within the communities they serve. Therefore, considerations for UAM should be incorporated into the TPO's advanced planning efforts, including the LRTP and TIP. The TPO should also encourage partner agencies at all government levels to incorporate consistent UAM principles into their respective planning efforts.

Government planning for UAM should include considerations for numerous factors, including airspace and operations, land use and zoning, utility and support infrastructure, project funding, social equity, and overall system connectivity. As vertiport locations will differ within each community due to varying needs and conditions, local zoning and land development codes will need to be updated to address UAM. Factors to account for include approach and departure airspace, heights of vertiport-adjacent structures, noise-sensitive land uses (e.g., residential, institutional), and potential negative impacts to historically marginalized communities. To aid in future land use and zoning planning, government agencies may consult EB 105, *Vertiport Design* for high-level, interim guidance on vertiport siting. Although no UAM-specific land use guidance from the FAA is presently available, agencies may also consult FAA AC 150/5190-4B, *Airport Land Use Compatibility Planning*, FDOT's 2020 Airport Airspace and Land Use Guidebook, and Chapter 333 – Airport Zoning of the Florida Statutes for aviation-related land use compatibility considerations.

Additional considerations include first- and last-mile transportation, the location of transportation hubs, and the availability of electricity and hydrogen. To integrate into existing transportation networks, vertiports should be co-located with transit hubs and other areas of first- and last- mile transportation. Opportunities for multimodal connections within Miami-Dade County include UAM service to Miami Internal Airport, Metromover and Brightline stations, and park-and-ride locations. With most VTOL aircraft expected to be fully electric, hydrogen-powered, or hybrid-electric, pertinent to an integrated UAM network is an adequate electrical supply and hydrogen fuel availability. Advanced planning should incorporate considerations for energy requirements and the associated utility infrastructure needed to support the specific VTOL anticipated to operate within Miami-Dade County. Planning efforts should also consider local energy capacity and the ability to accommodate UAM along with an increasing number of EVs.

Recommended Action:

Incorporate UAM into Miami-Dade TPO transportation planning efforts and encourage the incorporation of UAM key considerations into state, regional, and local planning.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

Public Engagement

Public acceptance and confidence in technology is crucial to the overall success of UAM and its envisioned benefits. According to a 2021 study by the European Union Aviation Safety Agency (EASA), the general public is open to the proposed benefits and solutions of UAM. However, this acceptance is dependent upon a number of assurances, including strict safety and security standards, environmental protections, the ability to maintain quality of life (i.e., avoid adverse impacts from noise and visual pollution), and the prevention of disproportionate impacts to any community or group of people.[17]

Like the EASA study, the literature review performed as part of Technical Memorandum #1 reveals that the public can greatly benefit from the applications of UAM. It is ultimately the responsibility of the Miami-Dade TPO and other government agencies to engage with, educate, and understand specific needs of local communities to maximize the benefits of an integrated UAM network. A public engagement strategy must be intentional and proactive in nature, and may include open house meetings, educational seminars, and focus groups. Thoughtful public engagement throughout the planning and development process can support the implementation of an UAM system that becomes a sustainable asset within the community.

Recommended Action:

Develop an UAM public engagement strategy in partnership with state, regional, and local government agencies.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

Incentive Program

UAM is a fast-emerging industry. As OEMs, operators, and government agencies work diligently to bring this technology to market, it is critical for local governments to keep public benefit at the forefront of UAM integration. Especially for limited-mobility populations and historically marginalized communities, the Miami-Dade TPO and its partner agencies should maximize public benefit in its planning efforts and subsequent investments.

This recommendation seeks to promote public benefit through the implementation of an incentive program targeted at OEMs and UAM operators. Facilitated by the TPO in partnership

[17] European Union Aviation Safety Agency (EASA) (2021). Study on the societal acceptance of Urban Air Mobility in Europe.

with other government agencies, certain incentives—such as participation in early testing, contributions to vertiport siting decisions, and/or reduced eVTOL charging fees—may be offered to private organizations seeking to bring UAM to Miami-Dade County. In exchange, OEMs and UAM operators may provide local workforce development opportunities (e.g., UAM/aviation training and education programs), a discounted ride program for low-income populations, and help encourage a shared-mobility network in place of an UAM system driven by private ownership and exclusivity.

Recommended Action:

Facilitate an UAM incentive program to encourage an integrated, equitable network.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

Economic Development

Initial UAM operations are likely to utilize existing airports and heliports. However, to scale up operations and realize the technology's full potential, an integrated UAM network requires a significant amount of new ground infrastructure, including vertiports, maintenance and support equipment, charging stations, fueling facilities, and associated utilities. Ground infrastructure and project funding represent some of the greatest challenges to UAM becoming a reality. Recent studies have found that $10 to $30 billion is required to build out UAM infrastructure in the 38 largest American cities.[18]

To promote responsible and sustainable infrastructure development, attract private investment, and maximize public benefits in Miami-Dade County, the TPO will support economic incentives directed toward OEMs and private developers. Program incentives may include expedited permit review or structure height bonuses offered to developers that incorporate public vertiports and/or eVTOL charging infrastructure into planned developments, or tax credits to OEMs that provide service to underserved communities. As part of this program, a comprehensive environmental review process, evaluation of alternatives, and community consultation will be required for each project.

[18] NEXA Capital Partners (2019). Study: Urban Air Mobility—Economics and Global Markets.

Recommended Action:

Promote economic development incentives to help fund the installation of vertiports and charging/refueling infrastructure.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

Proof of Concept - Government Agencies

A proof-of-concept study, also known as a concept of operations (ConOps) in the context of UAM, can be beneficial in the emergence of new technology in order to prove its feasibility. Although a great deal of industry literature is available on UAM and associated innovations, it is necessary to understand implications of the realistic application of UAM within Miami-Dade County to accurately plan for its implementation.

An UAM proof of concept tailored to Miami-Dade County will outline the characteristics, challenges, and potential benefits of the system from the viewpoint of local stakeholders and system users. The study should also outline strategies to maximize system benefits, constraints affecting the system, infrastructure funding requirements, operational and maintenance processes, key participants and stakeholders, and responsible agencies for the implementation and ongoing operation of the system. A local UAM proof of concept should be a collaborative effort between the Miami-Dade TPO, Miami International Airport, federal agencies (i.e., FAA, NASA), local jurisdictions, and community leaders. The study will provide critical information to help refine UAM planning and policy efforts in Miami-Dade County and beyond.

Recommended Action:

Facilitate the development of a local UAM proof of concept in coordination with the FAA, Miami International Airport, and other local government agencies.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

Private Sector

The proposed benefits of UAM present opportunities for both the public and private sectors. As the driving force behind emerging aviation technologies, the private sector is investing in new aircraft development, vertiport infrastructure, and overall market growth. The Miami-Dade TPO will therefore look to the private sector for subject-matter expertise and guidance regarding advanced technologies, regulatory prerequisites, and the support needed to help advance UAM as an innovative solution for both government organizations and business enterprises.

The Miami-Dade TPO will look to the private sector for **subject-matter expertise to help advance UAM as an innovative solution** for both governments and business enterprises.

This group of recommendations promotes direct collaboration between Miami-Dade TPO and private industry, particularly with OEMs and future UAM operators. While much of the technology and operational expertise can be sourced from the private sector, the TPO and partnering agencies will provide local perspective on mobility, infrastructure, and sustainability objectives to accommodate increasing transportation demand within Miami-Dade County.

Technology Development / Infrastructure Gap Analysis

The UAM ecosystem is rapidly evolving. In addition to VTOL aircraft and vertiport infrastructure, there are still many technological hurdles to overcome. An integrated UAM network requires innovations in battery technology, fueling facilities, automation, communication networks, and the airspace environment. As such, a significant amount of new infrastructure and investment are required to support high-volume UAM operations.

The private sector has taken the lead on the development of critical technologies necessary to make UAM a reality. Therefore, in partnership with private industry, the Miami-Dade TPO will monitor emerging technologies and identify opportunities for integration in the County's UAM planning efforts. Additionally, the TPO will assess existing transportation and utility infrastructure within the County to understand further investment and development needs. It is crucial the identified infrastructure improvements associated with this assessment align with County's sustainability goals and are compatible with future development plans.

Recommended Action:

Coordinate with the private sector to monitor emerging technologies and assess infrastructure gaps to understand UAM-related investment and development needs within Miami-Dade County.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

Infrastructure Interoperability

Early on in the growth of the EV market, a critical challenge to mass adaption was a lack of uniformity in vehicle charging stations across geographical locations, EV manufactures, and charging companies. In recent years, automobile manufactures have developed EV charging capabilities to be compliant with current charging infrastructure, either naturally or with an adapter. However, recognizing the need for additional standardization to promote further acceptance and adoption of EVs, the federal government recently enacted the National Electric Vehicle Infrastructure (NEVI) Formula Program, which is meant to accelerate the development of an interconnected network of EV charging stations.[19] A key point of this legislation is to encourage interoperable, or agnostic, EV charging infrastructure that can be utilized by all EVs. Interoperability refers to the ability for all system components, regardless of location or manufacturer, to work together without restriction.

UAM aircraft are currently being developed with various capabilities and needs for charging and/or refueling. Similarly, support infrastructure such as passenger boarding and maintenance equipment may greatly differ with each aircraft. In the absence of industry-wide cooperation and consensus-driven standards, it is possible that specially designed vertiports, charging stations, and other support facilities will be required for each aircraft type. In this case, local governments will be faced with determining what VTOL charging/fueling infrastructure, and by association, what VTOL aircraft are right for operations within their respective communities. This would provide OEMs and UAM operators with exclusive or semi-exclusive access to certain vertiports and charging/fueling stations, decrease competition, and increase the amount of required infrastructure.

To prevent natural monopolies on infrastructure and encourage greater public access to UAM, the Miami-Dade TPO will promote UAM infrastructure interoperability to support various types of vehicles and operations. Design standards for vertiports, charging stations, fueling facilities,

[19] U.S Department of Transportation, Federal Highway Administration (2021). National Electric Vehicle Infrastructure Program.

and passenger boarding equipment will facilitate infrastructure sharing by OEMs and UAM operators, streamline funding and development requirements, and allow all system components to work together seamlessly and effectively. The TPO will follow existing and future FAA guidance on infrastructure design and safety standards and encourage OEMs, operators, and private developers seeking to do UAM-related business in Miami-Dade County to prioritize infrastructure interoperability.

Recommended Action:

Promote UAM infrastructure interoperability to support various types of vehicles and operations and allow all components to work together seamlessly and effectively.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

UAM Testing Areas and Facilities

Early UAM operations can provide critical information and allow the TPO to refine policy and planning efforts in preparation for scaled-up activity. To provide a safe and controlled environment to gather this early data in a local setting, the Miami-Dade TPO will help identify designated areas for on-site UAM testing and early operations. Input from OEMs and UAM operators will be key to this effort, as these stakeholders possess intimate knowledge of operational requirements and the necessary infrastructure and support facilities. Additionally, the TPO should consult local planners on land use, noise, and safety constraints as well as the FAA on airspace and safety considerations.

In many cases, existing airports and/or helipads are top candidates for testing areas, as much of the infrastructure required for UAM operations already exists, including published approach and departure procedures, available airspace, hangar storage facilities, and safety protocols. As previously noted, these locations will also likely serve as the initial sites for commercial UAM operations. In an effort to promote UAM testing operations within Miami-Dade County, the TPO is encouraged to support regulatory approvals for the designated areas.

Notably, the Miami-Dade Board of County Commissioners has already cited the Everglades Jetport, officially the Dade-Collier Training and Transition Airport (TNT), as "available and appropriate for tests."[20] Additionally, parallel UAM planning efforts led by MDAD have identified

[20] Miami Today (2022). Jetport in Everglades could be urban air mobility test site. Retrieved from: https://www.miamitodaynews.com/2022/09/06/jetport-in-everglades-could-be-urban-air-mobility-test-site/

multiple locations at airports within the County which may be conducive for UAM testing operations. It is recommended that all potential UAM sites be thoroughly vetted prior to designation for official testing operations and be consistent of the recommendations of the MDAD AAM Strategic Plan.

Recommended Action:

Partner with OEMs and UAM operators to identify designated areas for on-site testing and early operations in Miami-Dade County.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

Proof of Concept – Private Sector

As previously noted, it is necessary to understand the realistic implications of UAM within Miami-Dade County to accurately plan for its implementation. Unlike the proof of concept recommendation in the previous section—which focuses on potential UAM impacts to local transportation systems, planning efforts, and communities—this recommendation emphasizes the importance of gaining a comprehensive understanding of those specific impacts associated with emerging technologies. As the subject-matter experts on proprietary technology, OEMs are intimately familiar with their aircrafts' respective operational, infrastructure, and safety needs. Similarly, prospective UAM operators can represent their intended operational strategies and preferred vertiport locations. By way of this proof of concept, Miami-Dade County requires proven demonstration projects before government agencies can appropriately identity, plan for, and promote an integrated UAM network.

An UAM proof of concept (or multiple proofs of concept)—led by OEMs and UAM operators in partnership with the Miami-Dade TPO—will outline vehicle types, charging/fueling needs, infrastructure requirements, safety considerations, potential operating areas, and a realistic picture of how UAM will enhance Miami-Dade County's transportation network. A vision for funding sources, sustainability, and equal access should also be highlighted. It is recommended that any OEM, UAM operator, or other private entity seeking to do UAM-related business in Miami-Dade County prepare a proof of concept with these considerations at the forefront of thought. The study, or studies, will provide critical information to help refine UAM planning and policy efforts in Miami-Dade County.

Recommended Action:

Facilitate the development of a local UAM proof of concept in coordination with the private sector.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

Public/Private Collaboration

From aircraft and airspace to vertiports and associated infrastructure, the UAM ecosystem is vast. For UAM to evolve into a sustainably integrated transportation solution in Miami-Dade County, collaboration among all stakeholders is crucial to incorporate considerations for the whole ecosystem. This group of recommendations presents opportunities for multifaceted coordination between the TPO, partner agencies, and private entities. Ultimately, these recommendations encourage intentional collaboration and continuous engagement between public agencies at all government levels and the private sector to bring a safe and efficient UAM system to Miami-Dade County.

For UAM to evolve into an integrated, safe, and equitable transportation solution in Miami-Dade County, **intentional collaboration and continuous engagement** is required between public agencies and the private sector.

Partnership Identification

As evidenced by the large number of key considerations highlighted within this Policy Framework, an integrated UAM ecosystem requires intentional coordination and continuous engagement between several stakeholder groups from both the public and private sectors. As the lead agency responsible for guiding the transportation planning process in Miami-Dade County, the Miami-Dade TPO must be proactive in identifying strategic partnerships to navigate the intricate web of considerations, challenges, and opportunities associated with bringing an integrated, sustainable, and equitable UAM network to market. Examples of critical partnerships include close coordination with: the County's 34 municipalities to help guide consistent vertiport land use compatibility and zoning regulations; local utility providers to identify necessary communication network and electrical grid improvements; FDOT to determine state funding eligibility for UAM infrastructure; the FAA and NASA to understand aircraft, vertiport, and airspace standards; private industry to guide operations and infrastructure development; and the general public to understand local transportation needs

and community concerns. Partnership identification strategies should occur early in the UAM planning process and continuously be refined as transportation goals are updated and the industry matures.

Recommended Action:

Identify strategic partnerships with government agencies and private organizations in the critical path to UAM integration.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

Operational and Regulatory Requirements

New technologies and procedures associated with UAM require new operational and regulatory guidance. While the FAA and NASA are leading overall efforts in the development of technical guidance and regulations to govern aircraft design, airspace management, and safety, government agencies at all levels can benefit from keeping abreast to the evolving regulatory environment and from proactive UAM planning within their respective communities. Particularly, direct coordination with the FAA is advisable on vertiport siting standards and the dedication of airspace for UAM operations.

Vertiport siting standards can have broad impacts on surrounding land uses, traffic patterns, the environment, and the quality of life of nearby residents. Therefore, Miami-Dade County must take a proactive approach to engaging the FAA, the private sector, and other government agencies to understand vertiport siting standards and to assist local jurisdictions establish complementary land use and zoning regulations.

As previously noted, limited vertiport siting guidance is currently available from the FAA. While monitoring the emergence of future guidance, the TPO may consult the FAA's EB No. 105, Vertiport Design; FAA AC 150/5190-4B, *Airport Land Use Compatibility Planning*; the FDOT 2020 Airport Airspace and Land Use Guidebook; and Chapter 333 – Airport Zoning of the Florida Statutes for aviation-related land use compatibility considerations. It should be recognized, however, that existing airport zoning and land use guidance are largely based on noise and emission concerns associated with legacy aircraft operations. VTOL operations, especially eVTOL aircraft, are expected to have significantly different noise, emission, and operational impacts on surrounding land uses. This further emphasizes the need for Miami-Dade County to continue evaluating the state of the industry to inform future UAM-related zoning and land use decision making.

In the absence of comprehensive guidance, an incremental approach to vertiport siting should be taken while the industry continues to emerge. For example, the County should consider conditional use permitting of early vertiports with frequent reassessments of operations and impacts as more data becomes available and as operational frequency increases.

From an airspace perspective, close coordination with the FAA is required to maximize safety and efficiency of an UAM ecosystem while minimizing adverse community and environmental impacts. With consideration for operational frequency, aircraft noise emissions, and varying use cases (e.g., passenger transport, last-mile package delivery, emergency/medical services), the Miami-Dade TPO should coordinate with the FAA to establish safe routes and procedures for efficient point-to-point UAM corridors within the County. As more aircraft and operators enter the market, additional data becomes available, and safety guidance is updated, ongoing coordination with the FAA is necessary to review and/or modify designated UAM corridors.

Key to this recommendation are continuous partnerships with the FAA, government agencies, and the private sector to promote industry-wide, consensus-driven operational and regulatory standards.

Recommended Action:

Under FAA leadership, partner with government agencies and private industry to support the development of UAM operating criteria and regulations.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

Statewide Concept of Operations Framework

AAM and its proposed benefits are not limited to intra-county transportation in urban and suburban environments. Utilizing fully electric, hydrogen-powered, and/or hybrid-electric aircraft, RAM will expand AAM use cases to inter-city passenger transportation, cargo delivery, and other public services, providing increased connectivity between cities that are primarily connected through limited ground transportation.

As the fastest growing state in the U.S., Florida would greatly benefit from additional mobility solutions to help link its 21 metropolitan areas, reduce congestion in high-traffic corridors, support economic development, and accommodate an increasing number of residents and

tourists.[21] An integrated RAM network is proposed to complement existing transportation systems to strengthen statewide connectivity and extend economic activity across the region.

To ensure a consistent and efficient approach to planning, the TPO will promote a multiagency ConOps for RAM in the State of Florida. Like the proofs of concept recommendations for government agencies and the private sector, this ConOps should provide a realistic, tailored picture of RAM in Florida and outline the characteristics, challenges, and potential benefits of the system from the viewpoint of stakeholders and system users. The study should also ensure the consistent application of operational rules and regulations across the state. This statewide ConOps is proposed to be a collaborative effort between local, regional, and state agencies; NASA and the FAA; and private industry. It is recommended that FDOT takes the lead on the development of this study to build upon the department's AAM policy framework, entitled *AAM Roadmap*, and encourage consistency with state transportation goals and objectives.

Ultimately, a statewide ConOps should provide a flexible framework from which future intra- and inter-city AAM mobility solutions should be based. Findings and recommendations from this study should be incorporated into the Miami-Dade TPO's LRTP planning efforts, FDOT's Florida Aviation System Plan (FASP), and other transportation planning initiatives at the local, regional, and state levels.

Recommended Action:

Promote multiagency Concept of Operations to inform regional air mobility (RAM) planning in the State of Florida.

Key Considerations

Airspace • Charging / Fueling Infrastructure • Data and Network • Economy / Funding
Land Use and Zoning • Noise and Visual Pollution • Safety and Security • Social Equity
Sustainability • OEMs and Operators • Vertiport Infrastructure

[21] U.S. Census Bureau (2022). Vintage 2022 National and State Population Estimates.

2.4. Summary of Recommendations

This matrix presents a high-level overview of the policy framework recommendations as they relate to the key considerations. Subsequent phases of this study will utilize these recommendations in the development of an actionable timeline and an overarching Policy Framework for UAM in Miami-Dade County.

Policy Framework Recommendations	Key Considerations										
	Airspace	Charging / Fueling	Data and Network	Economy / Funding	Land Use and Zoning	Noise and Visual Pollution	Safety and Security	Social Equity	Sustainability	OEMs and Operators	Vertiport Infrastructure
Government											
State, Regional, and Local Planning	X	X		X	X	X	X	X	X		X
Public Engagement						X	X	X	X		
Incentive Program								X	X	X	X
Economic Development		X		X					X	X	X
Proof of Concept - Government Agencies	X	X	X	X	X	X	X	X	X	X	X
Private Sector											
Tech. Development / Infrastructure Analysis	X	X	X	X			X			X	X
Infrastructure Interoperability		X						X	X	X	X
UAM Testing Areas and Facilities	X	X			X	X	X			X	X
Proof of Concept - Private Sector	X	X	X	X	X	X	X	X	X	X	X
Public / Private Collaboration											
Partnership Identification	X	X	X	X	X	X	X	X	X	X	X
Operational and Regulatory Requirements	X	X			X	X	X	X	X	X	X
Statewide ConOps Framework	X	X	X	X	X	X	X	X	X	X	X

[Chapter 3 Cover Placeholder]

3.1. Overview of Key Factors

As evidenced by the first two phases of this report, planning for an UAM network requires a comprehensive review of industry stakeholders, new technologies, required infrastructure, cost considerations, and possible constraints. A thorough examination of these elements will help realize a safe, sustainable, and efficient transportation system. Technical Memorandum #3 provides an overview of anticipated UAM-related costs, infrastructure funding, network interrelatedness, systemwide collaboration, and other key considerations associated with the planning and deployment of UAM in Miami-Dade County and beyond. This memorandum lays the foundation for Technical Memorandum #4, which provides a general framework for UAM policy, local and regional planning, stakeholder coordination, and public outreach in Miami-Dade County.

3.2. Infrastructure Costs and Funding

UAM infrastructure to support VTOL operations will become a key prerequisite and enable success of an integrated network. Without critical infrastructure such as vertiports, electricity, navigational aids, and robust air traffic management systems, a viable and profitable market in which UAM aircraft operate may not exist. The following sections build upon Technical Memorandums #1 and #2 through explorations of UAM infrastructure cost considerations and funding opportunities.

Infrastructure Cost Considerations

UAM emerging technologies, regulatory requirements, operational impacts, and industry best practices are not yet fully understood. As such, comprehensive studies to evaluate the costs of UAM infrastructure are extremely limited. McKinsey & Company, an international research firm, released one of the most mature studies of anticipated UAM costs to date. This study examined the likely costs of a single ground-based vertiport and VTOL charging and fueling infrastructure. Based on many high-level assumptions, this study estimated that a single ground-based vertiport, consisting of one takeoff/landing area, aircraft parking facilities, and minimal ground maneuvering areas, would cost between $200,000 and $400,000 to design and construct.[22] Both newly constructed and retrofitted vertiports will also need to support VTOL electric charging and/or refueling needs. This study estimated that VTOL charging and fueling infrastructure may represent between 65 percent and 75 percent of total initial capital expenses. It is important to note that the McKinsey & Company report was published in August 2020, and that the costs of labor, materials, and financing have increased in the time between the report's publishing

[22] Johnston, T., Riedel, R. & Sahdev, S. (2020). To take off, flying vehicles first need places to land. McKinsey & Company. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/to-take-off-flying-vehicles-first-need-places-to-land

and the development of this study. Additionally, the general assumptions used to develop these cost estimates are not specific to anticipated UAM operations in an explicit geographic location, such as Miami-Dade County.

Developing accurate cost estimates is further complicated by the fact that UAM ground infrastructure needs are highly dependent upon on a significant number of factors, including vertiport location, use case, aircraft technology, and overall implementation strategy. For example, a vertihub consisting of multiple takeoff/landing areas, security, passenger amenities, and multimodal connections, among other features, located in an urban center will cost significantly more than a designated VTOL operating area at an existing airport. Vertiports may be designed and constructed to accommodate multi-aircraft operations and elaborate passenger handling areas. However, many others, such as those at existing airports and heliports, are anticipated to include only the basic elements of VTOL operations, such as clear approach and departure paths, areas for aircraft ground maneuvers, recharging/refueling facilities, navigational aids, and safety areas. Therefore, without a strategically defined UAM network that includes specific vertiport locations, use cases, aircraft charging/fueling needs, traffic flow, local electrical capacity, and other critical factors, a list of ground infrastructure needs and associated costs to support UAM implementation can be infinite.

An entire network of vertiports, ground infrastructure, and multimodal facilities will be required for UAM to be truly integrated into existing transportation systems. Early VTOL operations will primarily utilize existing heliports and/or available space at airports. It is expected that on-airport vertiports will require less initial investment than off-airport vertiports since much of the supporting infrastructure already exists. Therefore, expansive new construction for UAM is not expected in the near term.

However, County and partner agencies should understand the general infrastructure requirements anticipated for an integrated UAM network. Due to the number of variables associated with developing rough orders of magnitude costs for UAM, additional research is required to determine ground infrastructure costs and to better understand specific UAM integration needs in Miami-Dade County. Research should include analyses on specific vertiport locations, use cases, types of VTOLs servicing these locations (e.g., charging/fueling needs, vehicle size, noise profile), number of operations, anticipated passenger activity, and the availability of utilities for each location.

In the absence of a defined UAM network, there are several factors Miami-Dade County may want to take into considerations in order to determine general costs associated with future UAM infrastructure. As listed in **Table 3.1**, these high-level factors provide a foundation from which advanced planning efforts and discussions on future funding priorities may be based. Of note, the considerations listed here represent initial capital investment needs for ground and supporting infrastructure and do not include ongoing operating costs. Related costs for consideration include planning and environmental studies, as well as staffing and administrative costs associated with the development, operation, and licensing of these facilities.

Table 3.1 - UAM Infrastructure Considerations

Off-Airport Vertiports	On-Airport Vertiports	Air Traffic Management	Emergency Response

• On-site charging/refueling
• Security
• Passenger access/handling facilities
• Baggage/cargo handling facilities
• Maintenance facilities
• Tug/tow equipment
• On-site weather sensors
• Navigational aids (landing aids, ground-based hazard avoidance)
• Utility, communications, and lighting systems
• VTOL parking, storage, maintenance, and ground maneuvering areas
• Automobile parking
• First-/last-mile transportation
• Obstruction mitigation
• Land costs for vertiport construction
	• On-site charging/refueling
	• Maintenance facilities
	• Location of vertiport (airside or landside)
	• *If separate from existing airport facilities:*
	  ○ Security
	  ○ Passenger handling facilities
	  ○ On-site weather sensors and navigational aids
	  ○ Utility, communication, and lighting systems
	  ○ VTOL parking, storage, and ground maneuvering areas
	  ○ First-/last-mile transportation
		• Communication
		• Navigation
		• Surveillance Facilities (control/remote towers, administrative, etc.)
			• Fire code standards
			• Fire suppression equipment (electrical/hydrogen fires)
			• Response times (Are existing facilities adequate? Can local facilities respond?)
			• First responder training (aircraft firefighting techniques, disaster response)

Source: Kimley-Horn (2022).

Funding Opportunities

With millions of dollars in new infrastructure needed to support an integrated UAM network in Miami-Dade County, it is important to consider who will bear the costs for the planning, design, construction, and operation of these facilities. Cost responsibility for UAM infrastructure will be dependent upon a variety of factors, including the location of facilities (e.g., whether a vertiport is located on- or off-airport), public or exclusive use of the vertiport, vertiport owner/sponsor, the specific OEM and/or UAM operator's business plan, and the availability of public funding and private investment. Ultimately, it is expected that initial investments for

UAM development will be led by the private sector, which parallels the investment patterns that occurred during early emergence of EVs and currently with autonomous vehicles.

Outside of private investment, there may be opportunities within the traditional public funding framework if UAM projects can meet criteria and qualify for "pilot project" and/or "demonstration project" programs. These innovative transportation project funding streams may be available from federal, state, or local funding sources.

Private Funding

Significant private investments in UAM, especially over the past five years, have catapulted the industry forward at a rapid pace, spurring advancements in VTOL aircraft and other mobility-as-a-service (MAAS) technologies.[23] As a result, and in response to the anticipated societal benefits of UAM and AAM, public agencies such as the FAA and Miami-Dade TPO are developing regulatory guidance and incorporating UAM/AAM considerations into advanced planning efforts. The private sector, with support from public agencies, is anticipated to continue spearheading the industry's growth, including leading much of the funding needed for UAM ground infrastructure development.

OEMs, perspective UAM service operators, and investment groups have created various business models and financing plans related to infrastructure funding and cost sharing. Models for UAM infrastructure include the utilization of existing heliports and airports for VTOL operations, providing upfront private capital for infrastructure design and construction in exchange for operational rights at that facility (exclusive or shared use), and a combination of cost-sharing models while partnering with other private organizations and/or public agencies. Public-private partnerships (P3s), or collaborative efforts between government agencies and private enterprises to finance and execute projects, are further explored in a subsequent section.

Public Funding

There are currently two federal funding programs that include funding opportunities for UAM planning, design, and/or construction of UAM infrastructure. These programs, the Strengthening Mobility and Revolutionizing Transportation (SMART) grant and the Advanced Aviation Infrastructure Modernization (AAIM) Act, require an UAM project to meet specific criteria in order to be considered eligible. Leveraging the use of innovative aviation technology is an eligibility requirement for the SMART program. Projects that may fall within that eligibility requirement include the use of unmanned aircraft systems for safe and efficient transportation, as well as the development of air traffic management and infrastructure inspection related to unnamed aircraft operations. The AAIM Act has similar stipulations that a project must meet criteria that make the project qualify for potential funding. The SMART program requires that

[23] Johnston, T., Reuel, F. & Riedel, R. (2021). Future air mobility funding still flows, although down from 2021. McKinsey & Company. https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/future-air-mobility-blog/future-air-mobility-funding-continues-to-flow-after-outlier-year-2021

eligibility criteria for UAM projects would include qualifying as a "Pilot Project" and/or "Demonstration Project". As UAM continues to emerge it can be assumed that public funding opportunities will increase; however, at the early stages of development and implementation, it is likely that private funding sources will bear the majority of the funding responsibilities until UAM reaches a more scalable phase of its implementation.

Similar to federal and state aid for legacy aviation (i.e., existing airports and heliports), public financial assistance for vertiport infrastructure is expected to be accompanied by certain assurances associated with vertiport operations. Assurances requires financial assistance recipients to maintain and operate their facilities in accordance with specified conditions. Assurances may include airspace obstruction removal and mitigation, restrictions on the use of operating revenue, and the provision to be classified as "public-use," an aviation facility that is open for use by the public, not just for specified users. Ultimately, the level of authority for UAM infrastructure development and operations will depend on the funding mechanism or mechanisms used, private or public. As evidenced by the descriptions in **Table 3.2**, future federal and state funding opportunities and associated assurances are not yet fully clear. It will be critical for Miami-Dade County and other industry stakeholders to follow funding legislation related to UAM infrastructure at all levels of government.

Public-Private Partnerships (P3s)

The private and public sectors may also form strategic partnerships through P3s to facilitate funding opportunities for UAM infrastructure. P3s have been gaining in popularity as alternative project financing, delivery, and operating mechanisms for airport improvement projects in the U.S. As part of these long-term agreements, government infrastructure projects are typically completed with private capital financing. This arrangement generally requires lower upfront public capital, reduces government and taxpayer risk, and allows the public agency to benefit from the operational efficiencies and innovation of the private sector. In turn, public agencies offer incentives to private partners such as tax concessions, protection from liability, operating revenue associated with the facility, and/or partial ownership rights.

Miami-Dade County has created a comprehensive P3 process to help streamline this alternative delivery method for public infrastructure. Notably, the County's P3 process was used to design, build, finance, operate, and maintain the PortMiami Tunnel—a $668 million project, completed in 2014, that provides direct connection between PortMiami and nearby highways.[24]

Given the significant infrastructure needs, complexity, and innovative nature of the UAM ecosystem, P3 opportunities may be advantageous funding mechanisms for the development of UAM infrastructure. When considering the provisions of a P3, however, it is important that the agreement maximizes future public benefit to the extent practical.

[24] Florida Department of Transportation (2014). PortMiami Tunnel – Projects Overview. http://www.portofmiamitunnel.com/organization/public-private-partnership/project-overview

3.3. Systemwide Approach to UAM

UAM does not exist within a silo, which is evidenced by the number of interrelated considerations related to land use, air traffic management, accessibility, and more, that factor into a functioning UAM ecosystem. Moreover, UAM operations will not be confined to the boundaries of Miami-Dade County. While operations may start or end in the County, they may also start and end in a neighboring county or region. Due to the interrelated factors of UAM operations occurring across jurisdictional boundaries, there must be a systemwide approach to UAM planning and development. A systemwide approach allows for a broader understanding of how the UAM ecosystem interacts with other transportation modes and land use policies, helping to better identify needs and create an informed decision-making environment.

To support this systemwide approach to UAM development, some OEMs are focusing on the concept of RAM, which includes plans for VTOL operations in a regional setting. These operations will require an additional layer of coordination and planning between local, state, and federal entities. Steps made in early stages of UAM proliferation, such as interdisciplinary and cross-boundary coordination, will benefit overall implementation in the long-term.

As presented in **Section 3.4**, there are numerous considerations for UAM implementation, including infrastructure, land use compatibility, noise and visual pollution, and safety and security that will also need to be evaluated on a statewide basis. In other words, standards for safe, secure, and sustainable UAM operations will need to be established and enforced beyond the boundaries of Miami-Dade County. For a UAM ecosystem to flourish in Miami-Dade County and across the state of Florida, a statewide systems approach is essential. The value of a statewide systems approach for transportation assets is evident in other statewide system planning efforts conducted by the FDOT. FDOT publishes statewide plans for intermodal policy, highway safety, EVs, freight mobility, rail, seaports, and other aviation assets. This comprehensive list of statewide mobility and transportation planning efforts points to the importance of creating a broader systemwide perspective when planning for future transportation needs.

In addition to statewide studies pointing to the necessity of a broader systems approach to transportation development planning, there are a number of other reports, specifically related to UAM, that provide further opportunities for integration across agencies and jurisdictional boundaries. FDOT published the AAM Roadmap and AAM Working Group Report, MDAD completed the AAM Strategic Plan, and the City of Orlando has undertaken the AAM Transportation Plan. Miami-Dade County should identify opportunities for cross-coordination between these and future planning efforts. Cross-jurisdictional coordination will promote consistency, safety, and efficiency in UAM implementation.

3.4. Considerations for Implementation

As part of the fourth and final phase of this study, a general framework will be developed for UAM policy, local and regional planning, stakeholder coordination, and public outreach in Miami-Dade County. To set the stage for this framework and to add to the previous sections on cost considerations, funding, and systemwide collaboration, this section presents additional considerations for UAM implementation. These considerations are grouped into three categories: regulatory, operational, and social.

Due to the emerging nature of the industry, technologically and regulatorily, some considerations remain without clearly defined solutions. Therefore, the overall framework for UAM in Miami-Dade County should be treated as fluid and evolving, as it will be dependent upon future innovations, best practices, and industry developments.

Many of the considerations within this section appear as recurrent themes throughout this study. Notably, some considerations were included as UAM challenges or opportunities in Technical Memorandum #1, and others as "key factors" that influenced the development of the recommendations in Technical Memorandum #2. The recurring nature emphasizes the critical importance of these considerations and represents consistent opportunities and challenges that must be included in advanced planning efforts for UAM implementation.

Regulatory Considerations

Evaluating the regulatory considerations for implementing UAM provides an opportunity to better understand how existing rules or regulations that currently govern safe and efficient operations within navigable airspace may correspond or not correspond to the UAM environment. Evaluating the existing regulatory framework for airspace operations may also contribute to identifying gaps in existing rules and regulations that will need to be addressed before UAM implementation can occur. Regulatory considerations around aircraft certification, compatible land use, safety regulations, and federal funding eligibility may all play a role in impacting UAM implementation in Miami-Dade County and are explored in more detail in the following subsections.

Aircraft Certification

The FAA is responsible for overseeing the aircraft certification, or airworthiness, process. Under this process an aircraft must meet three levels of certification, including type certification, production certification, and airworthiness certification. The existing regulations included in the current aircraft certification process were not developed with VTOL aircraft in mind, nor does the certification process consider lower-altitude passenger moving operations within urban areas, which is a key component to UAM.

Currently, VTOL aircraft undergoing the aircraft certification process must seek approval under CFR Part 21.17(b) which is specific to special classes of aircraft. However, due to the differentiation of these aircraft to other aircraft in this category, like gliders, the FAA must handle the VTOL evaluation on a case-by-case basis through the filing of issues papers. Some components of UAM aircraft that may not fall within the current aircraft certification regulations are:[25]

- Automation (unpiloted)
- Unique aircraft configurations
- Electric distributed propulsion
- Energy storage and distribution systems
- High voltage architecture
- Fly-by-wire flight control systems
- Crashworthiness requirements
- Noise standards

As of November 2022, the FAA published revised airworthiness criteria for type certification of VTOL aircraft and used the Joby JAS4-1 five-seat model as the type aircraft for developing requirements. While this is a step in the right direction, the Joby JAS4-1 is a manned aircraft. Therefore, the newly published requirements still do not account for unpiloted aircraft, which the FAA has indicated will be considered in the future as UAM matures.[26]

Local Land Use and Zoning

A number of federal and local guidelines inform land use policies related to development within the airport environment or in ways that impact navigable airspace. Chapter 33, Section 33.333 of Miami-Dade County's Code outlines the land use compatibility and airspace regulations for the county. The section establishes regulations for developments and certain land uses within designated restriction zones established at each airport. This section establishes different restriction zones around an airport environment, which are more or less demanding depending on proximity to the airport. Within these zones, restrictions for new development are placed on buildings for public assemblage, hospitals, and other medical facilities, as well as landfills, establishments that emit smoke, gas, or dust, or create electrical interference or produce glare. However, this section does not indicate what those restriction zones may be, or what the regulations for development may be, surrounding a vertiport. Currently, these regulations only pertain to traditional airports utilizing traditional aircraft. This indicates that local land use and zoning policies are not currently prepared for the proliferation of vertiports or to determine compatibility with this type of development or related UAM activity. Decision makers

[25] Trock, J., Matthews, A. (2022). Regulation and Certification of eVTOL Aircraft. Baker McKenzie. https://www.bakermckenzie.com/en/i nsight/publications/2022/01/regulation-certification-evtol-aircraft

[26] Alcock, C. (2022). FAA Reveals EVTOL Airworthiness Criteria in Proposed Type Certification Basis for Joby's Aircraft. Future Flight. https://www.futureflight.aero/news-brief/2022-11-08/faa-reveals-evtol-airworthiness-criteria-proposed-type-certification-basis

should consider the impact of UAM operations on existing land uses and determine appropriate solutions for establishing land use and development guidelines for this technology.[27]

Before local land use policies can be amended to support UAM development, decision makers will need to consider guidance from the FAA in regard to final vertiport design standards, which have yet to be finalized. Through the articulation of vertiport design standards will come an understanding of the safety zones required for this development. Local agencies may consult existing FAA guidance to develop land use and zoning policies and amend existing land use policies. Without proper FAA guidance, it will be challenging to know where vertiports can be developed, how much space they require, and what surrounding developments may or may not be compatible. Future FAA guidance produced will need to be considered prior to amending current local zoning ordinances to support vertiport development and UAM proliferation.[28]

Regulatory Guidance and Safety Standards

Progress cannot be made in advancing UAM until regulatory and safety standards guidance is clear and implementable. New safety standards and certification processes for autonomous aircraft systems and their operators will need to be determined. Additionally, standards related to detect and avoid technologies—which allow unmanned aircraft to operate safely within airspace, and avoid collisions with buildings, aircraft, powerlines, birds, and other obstacles—need to be established and consistently applied before UAM operations can scale. Another important component related to safety standard considerations is the need to integrate VTOL and UAM operations within the traditional aviation system.[29] More information regarding UAM integration into existing navigable airspace is shared in the Operational Considerations section as it relates to the discussion of air traffic management.

The United States Department of Transportation (USDOT) established an AAM interagency working group in October 2022. The working group's mission is to plan and coordinate efforts related to safety, infrastructure, physical security, cybersecurity, and federal investment as necessary to support the UAM ecosystem. While this is a favorable development, it is also evidence that the regulatory framework by which UAM and AAM is intended to operate is not yet established. Without a federal framework imposed for safety standards of UAM and AAM operations, there will continue to be obstacles with UAM integration.[30]

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[27] Code of Miami-Dade County (2022). Section 33-33 Land Use Compatibility and Height/Airspace Regulations; Nonconforming Issues;
Disclosures.https://library.municode.com/fl/miami__dade_county/codes/code_of_ordinances?nodeId=PTIIICOOR_CH33ZO_ARTXXXVIIAIZO_S33-333LAUSCOHEAIRENOUSDI

[28] Alcock, C. (2022). Ground Infrastructure Experts Wrestle with Vertiport Challenges. Future Flight.
https://www.futureflight.aero/news-article/2021-12-20/ground-infrastructure-experts-wrestle-vertiport-challenges

[29] Uniting Aviation (2023). Advancing the Adoption of Unmanned Aircraft to Improve Air Mobility. Uniting Aviation.
https://unitingaviation.com/news/safety/advancing-the-adoption-of-unmanned-aircraft-systems-air-mobility/

[30] U.S Congress (2022). S.516 – Advanced Air Mobility Coordination and Leadership Act. https://www.congress.gov/bill/117th-congress/senate-bill/516

Funding

Private funding solutions will likely be more feasible over public funding sources in the early stages of UAM development and implementation. While some progress has been made in establishing UAM-related public funding opportunities, very few of these opportunities are available today. This results in a more significant funding burden being placed on the private sector, which can secure private investment for VTOL and infrastructure development in ways that the public sector cannot. As noted in **Section 3.2**, there has already been significant investments made by the private sector to support an emerging UAM ecosystem.

Operational Considerations

Operational considerations for UAM integration relate to the ways in which these aircraft intend to operate within the existing environment. UAM operations occur at low altitudes within an urban or suburban context. Connection points across cities with supporting infrastructure (e.g., charging/refueling facilities, storage areas) will be needed. With this need comes a number of operational considerations related to noise and visual pollution, air traffic management, battery technology, safety and security, and utility infrastructure.

Noise and Visual Pollution

VTOL aircraft will have lower noise profiles than legacy aircraft and helicopters. However, due to anticipated high-frequency, low-altitude operations in urban and suburban environments, noise and visual pollution concerns must be considered, especially during the takeoff and landing phases of flight.[31] Discourse related to environmental justice and equitable urban spaces, for instance, continues to be at the forefront of local and regional planning. With concerns of noise and visual disturbances brought on by UAM integration, local planning agencies and vertiport developers should be sensitive about the location of these facilities.

The FAA measures noise exposure from legacy aircraft operations using the day-night average sound level (DNL) metric, which represents an individual's cumulative exposure to sound over a 24-hour period. Currently, there is no standard metric to measure sound exposure of VTOL aircraft operations. It is recognized that the noise profile of a VTOL will be greatest during the takeoff and landing phases of flight, and least during the cruise and hover phases. However, the data input for a traditional DNL analysis—including characteristics of an aircraft design fleet, public perception of the sound, and frequency of operations—are not yet available for VTOL aircraft. It is understood that high-frequency operations of numerous VTOL aircraft may represent a nuisance for some communities, but comprehensive noise studies will be required to determine true impacts and acceptable thresholds.[32]

[31] Clarke, D. (2020). UAM Visual Noise Pollution – What the Industry Must Consider Now. Aerocar. https://aerocarjournal.com/uam-visual-noise-pollution/

[32] Tegler, J. (2020). Noise Alert! Aerospace America. https://aerospaceamerica.aiaa.org/features/noise-alert/

In addition to noise impacts, factors related to visual pollution must also be considered. A built-out, fully integrated UAM network may consist of dozens of VTOL aircraft traversing a city. Concerns related to overcrowded skies, light pollution, privacy, and visual intrusions are consistently raised. However, it is important to note that UAM integration will occur in phases, with public demand and perception influencing the further advancement of UAM. Proactive strategies for advanced planning and public engagement can help address visual pollution concerns and promote the proposed benefits of UAM.

Air Traffic Management

ATM plays a crucial role in enabling safe and efficient UAM operations. While traditional aircraft seamlessly operate within navigable airspace due to legacy ATM protocols, UAM networks will require advanced ATM systems to accommodate increased VTOL aircraft and BVLOS operations, and to ensure new airspace users may integrate into existing operations. Effective ATM solutions will become even more imperative as UAM maturation moves from piloted to autonomous operations.

According to the FAA's UAM ConOps, Version 2.0 (April 2023), future ATM systems must include considerations for ATC, traffic flow management (TFM), advisories, communication, navigation, and surveillance. Though near-term operations are expected to utilize existing air traffic services and NAS infrastructure, NASA, the FAA, and various organizations are developing a regulatory framework to support high-frequency, autonomous UAM operations in the future.

Safety and Security

Safety and security are some of the most significant considerations for UAM implementation. Given the low-altitude and high-frequency nature of UAM, a simple systems failure or security breach can put passengers, crew, the general public, and high-value assets at severe risk. Safety precautions must be considered for every aspect of UAM operations, including lithium-ion batteries, rotors and propellers, communication and navigation systems, airspace, emergency response personnel, and people and infrastructure on the ground. Rigorous testing, robust certification processes, advanced planning, and adherence to stringent safety protocols are vital for OEMs, government agencies, and all stakeholders to minimize risks.

Public perception—whether VTOLs are a safe and reliable mode of transportation—is critical to the overall advancement of UAM. Through public demonstrations, a proven safety track record, and strict aircraft certification requirements, stakeholders will need to win over the trust of the general public for an integrated UAM transportation system to become a reality. Stakeholders must also invest in transparent communication, education, and collaboration with regulatory bodies to ensure that safety standards are consistently met and exceeded.

Comprehensive security measures are also crucial to protect against potential threats. UAM relies on advanced digital systems and highly interconnected technologies, making it susceptible to cyberattacks and unauthorized access. Safeguarding these systems from threats

ensures the integrity of the entire UAM ecosystem, protecting passengers, operators, and critical infrastructure. A commitment to safety and security measures can help build credibility, soften concerns, and encourage public support for UAM.[33]

Utility and Fueling Infrastructure

The adequacy of existing utility infrastructure and additional utility needs to support a UAM ecosystem will need to be analyzed. Unlike EV charging stations, eVTOL charging infrastructure will require high-voltage power to the charging site (i.e., thicker, longer, and heavier cables), integrated cooling systems, and the ability to bank power on site from both a grid and on-site generation from other sources, such as solar. The systems required for electric aircraft charging are still in early development and many electrical grids may not be able to support the power needs.[34]

Some OEMs are designing VTOL aircraft with hydrogen or hydrogen-electric propulsion systems. Given current battery technology, hydrogen fuel cells offer more range and endurance than existing electric powertrains. However, hydrogen fuel cell technology as an aviation fuel source is in its infancy and many infrastructure and utility requirements are still unknown. Hydrogen's highly flammable nature posits a number of safety considerations, particularly as it relates to VTOL refueling and transportation operations. Nonetheless, hydrogen is emerging as a potential alternative to traditional aviation fuel. Should this fuel become more commonplace on airfields in the future, OEMs and UAM service providers operating at airports may choose to take advantage of the availability of existing hydrogen infrastructure to power VTOL aircraft.

Social Considerations

As with other modes of transportation, or the provision of public goods more broadly, UAM implementations brings with it numerous social factors that must be considered. Throughout the history of the U.S., certain planning decisions and policies inadvertently resulted in low-income and/or minority groups having limited access to economic centers, open spaces, health services, grocery stores, and more. A positive aspect to UAM operations is that it can be used to bridge the gap between disconnected suburban and urban communities, making access to critical services and opportunities available to the broader population, regardless of where they may live. In order to achieve an equitable UAM environment, a number of considerations related to social equity, privacy, and public opinion will need to be closely evaluated. More information regarding these social considerations is shared in the following subsections.

[33] WindRiver. (2021). Meeting the Challenges of Next-Generation Advanced Urban Air Mobility Systems. WindRiver. https://www.windriver.com/resource/meeting-the-challenges-of-next-generation-advanced-urban-air-mobility-systems

[34] Huber, M. (2023). Electric Charging for eVTOL Aircraft is Different from Cars. AIN Online. https://www.ainonline.com/aviation-news/general-aviation/2023-01-02/electric-charging-evtol-aircraft-different-cars

Social Equity

The term "equity" refers to justice and fairness in society. Unlike equality, which suggests sameness, equity considers disproportionate impacts to certain communities based on social, economic, and environmental factors.[35] Due to the high costs of early VTOL manufacturing and operations, it is anticipated that initial UAM passenger transportation services will be limited to predominately higher income earners. However, as the industry matures and operations scale up, costs will decrease, creating a more equitable environment that caters to a wider range of income earners. In addition to cost of services, equity considerations in the context of UAM include vertiport locations, accommodations for people with disabilities, impact to property/land value, environmental justice, and the fair allocation of negative impacts.[36]

Stakeholders from both the public and private sectors should collaborate to ensure UAM services and new connectivity options can provide broad public benefit. Governments at all levels can foster infrastructure planning that considers underserved areas, ensuring that vertiports and charging stations are strategically located to provide equal access to UAM services. Extensive public engagement initiatives can help ensure that specific community needs and challenges are addressed. And workforce development programs, including training and education, may be designed to equip individuals from all backgrounds with the necessary skills for jobs in the AAM industry. By considering social equity as a fundamental pillar, the public and private sectors alike can build an UAM ecosystem that reduces existing disparities and fosters inclusivity.

Public Acceptance

As previously noted, securing public acceptance for this emerging technology is vital for the advancement of UAM. As an innovative mode of transportation that can fundamentally alter the urban landscape, the public may express concerns over UAM, particularly as it relates to safety, noise, security, privacy, social equity, and environmental impacts. According to the U.S. Government Accountability Office, public acceptance is a leading challenge in UAM becoming a reality.[37] Additionally, a 2021 EASA study found that the general public is open to the proposed benefits and solutions of UAM. However, this acceptance is dependent upon a number of assurances, including strict safety and security standards, environmental protections, the ability to maintain quality of life (i.e., avoid adverse impacts from noise and visual pollution), and the prevention of disproportionate impacts to any community or group of people.

To generate acceptance, the public and private sectors should partner on community engagement and education initiatives. These efforts can help educate the general public on

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[35] American Planning Association (2023). Social Equity. https://www.planning.org/knowledgebase/equity/

[36] Mendoca, N., Murphy, J., Patterson, M. et al. (2021). Advanced Air Mobility Vertiport Considerations: A List and Overview. NASA. https://ntrs.nasa.gov/api/citations/20220007100/downloads/Vertiport%20Considerations%20Paper%20Final%20v2.pdf

[37] U.S. Government Accountability Office (2022). Transforming Aviation: Stakeholders Identified Issues to Address for 'Advanced Air Mobility'. https://www.gao.gov/products/gao-22-105020

the benefits of UAM while also boosting their confidence in the safety, reliability, and accessibility of this emerging technology. Decision makers will also need to consider how public acceptance or public opinion may change as UAM operations transition from piloted to autonomous.

From the standpoint of the private sector, public acceptance can drive market viability, encourage investment, and facilitate the commercial success of UAM. From the public sector's perspective, widespread acceptance of UAM allows governments to explore this innovative technology as a way of enhancing transportation services, creating jobs, and attracting business.

[Chapter 4 Cover Placeholder]

4.1. Framework and Roadmap Overview

Drawing on the current state of the industry, numerous publications, and ongoing dialogue with subject matter experts through the Study Advisory Group, many key considerations, recommendations, and best practices related to the evolution and integration of UAM are highlighted throughout this study. This report, Technical Memorandum #4, is intended to refine, summarize, and prioritize this study's overall findings and recommendations to provide an initial framework and roadmap for the advancement of UAM in Miami-Dade County. Additional discussions on stakeholder engagement and educational outreach build upon the discourse of previous technical memorandums to further emphasize the importance of these elements. The recommendations within this report are intended to serve as valuable resources for policymakers, planners, and other stakeholders seeking to navigate the complex landscape of UAM implementation and integration within the County and beyond.

4.2. Educational Outreach

One of the most significant challenges and greatest opportunities to advancing UAM is educating the public and key stakeholders about its proposed benefits and challenges. Therefore, educational outreach is recommended as an immediate priority for Miami-Dade County. A robust and targeted educational outreach strategy can help familiarize members of the public and other stakeholders with the proposed benefits of UAM—and more broadly, AAM—including reduced travel time, increased mobility, and improved public services. It can also foster excitement for this emerging mobility solution and help develop the industry's future workforce, including the next generation of engineers, designers, and UAM service providers. Similarly, educational outreach can help address concerns and misconceptions about UAM, including issues related to noise safety, pollution, and privacy. This process can bring together members of the public, local governments, and industry leaders to discuss and shape policies and regulations in a way that benefits everyone.

A comprehensive educational outreach program must include several strategies and a multi-media approach to reach a broad audience. Examples of such strategies include, but are not limited to:

- **Creating online content**, such as informational videos, articles, and webinars, to be shared on social media and other websites.
- **Hosting public events**, in partnership with the private sector, such as open houses and VTOL aircraft demonstrations, to educate the public and generate interest. Providing accessible lines of communication and hosting community engagement sessions is essential for building an AAM system supported by a wide range of stakeholders.

- **Partnering with universities, technical colleges, and schools** to provide AAM-related courses, seminars, and workshops to educate students on career opportunities within the industry. Investing in AAM education at the collegiate level will prepare qualified candidates to contribute to the future success of the local industry.
- **Collaborating with industry groups**—such as the Vertical Flight Society (VFS), the General Aviation Manufacturers Association (GAMA), and the National Business Aviation Association (NBAA)—to raise awareness among local members and promote support for local AAM initiatives.
- **Engaging with policymakers** at the local, state, and federal levels to promote development priorities and the advancement of AAM.
- **Establishing partnerships with businesses** that can benefit from AAM, such as transportation companies, logistics providers, and emergency services. These partnerships can help build support for AAM and accelerate its development.

Educational outreach is essential in advancing the development and adoption of UAM. By investing in a comprehensive educational outreach strategy, Miami-Dade County can promote the emerging technology's benefits, raise awareness of future economic and workforce development opportunities, and gain the support needed for it to become a reality.

4.3. Stakeholders

UAM development and implementation requires significant stakeholder engagement from a wide range of public and private entities. Unlike legacy aviation where the FAA is primarily responsible for regulating operations and airspace, UAM is expected to have a significant impact on local transportation systems and bring new aviation technologies to urban and rural areas. To prepare for this disruption, it is crucial for state, regional, and local governments to proactively engage with a comprehensive set of stakeholders throughout all stages of development and implementation. This engagement will ensure that local needs are met, and challenges are effectively addressed.

Stakeholder Roles and Responsibilities

Federal Government

Several federal agencies play critical roles in the advancement of UAM, providing the overall regulatory framework, funding support, research and development, and partnerships necessary to support the safe and efficient development of these technologies. The FAA is establishing certification and operational requirements for VTOL aircraft, vertiports, airspace procedures, and other UAM-related infrastructure to promote safety and compatibility with existing aviation operations. The FAA, NASA, and Department of Defense are actively involved in UAM and AAM research and development efforts. These agencies are working to advance key technologies

such as electric propulsion systems, BVLOS operations, autonomous flight control, and other various modeling and simulation advancements.

Federal agencies are also actively engaged in strategic partnerships to contribute to the advancement of UAM. NASA's AAM National Campaign brings together aircraft manufacturers, airspace service providers, and other government agencies to conduct studies and demonstrations that will test and validate UAM vehicles and operations.[38] Additionally, the USDOT recently established the AAM Interagency Working Group (AAM IWG), a multi-agency collaboration to coordinate efforts to integrate AAM into the country's transportation network and leverage related economic opportunities.[39]

State Governments

State governments can contribute to the growth of UAM by supporting policy and regulation, economic incentives, workforce development, and regional planning and infrastructure investment. While consistency between federal and state regulations is critical, state governments may elect to further refine federal guidance to address needs and challenges specific to regions and local communities. For example, state governments can work with industry stakeholders and community groups to address concerns related to noise, privacy, and public acceptance of this technology.

Workforce development is another important area where states can play a role in supporting UAM. This may include funding for training and education programs, as well as partnerships with universities and other educational institutions. By building a skilled workforce, states can help ensure that talent is available to support the growth of a UAM ecosystem. State governments can also provide economic development incentives to attract OEMs, UAM service providers, and private developers. This may include tax incentives, workforce training programs, and infrastructure investments.

Additionally, states may prepare long-range planning documents, such as aviation system planning, to identify potential operating locations, policy recommendations, and infrastructure funding and development priorities. Examples of statewide planning efforts in Florida include the FASP, the FDOT AAM Roadmap report, and the FDOT AAM Report and Recommendations document from the FDOT AAM Working Group.

Local Governments

Local governments, including municipal and county agencies, have a large role to play in the implementation of UAM operations, particularly as it relates to local planning, policy development, community engagement, and infrastructure investment. To foster an efficient, sustainable, and equitable UAM ecosystem, local governments should begin incorporating UAM

[38] NASA, AAM Project National Campaign Overview (2020). https://www.nasa.gov/aeroresearch/aam/description.html

[39] U.S. DOT, Advanced Air Mobility Interagency Working Group (2023). https://www.transportation.gov/mission/office-secretary/office-aviation-and-international-affairs/advanced-air-mobility/advanced

considerations into advanced planning efforts, especially in transportation, land use and zoning, and environmental planning. As part of this effort, local policies may include provisions for noise-abatement, safety, and other operational procedures based on local needs and concerns.

Local governments also have the primary responsibility to engage, educate, and understand the specific needs of local communities to maximize the benefits of an integrated UAM network. As emphasized in **Section 4.2**, thoughtful public engagement throughout the planning and development process can support the implementation of a sustainable UAM system that becomes an asset within the community.

Additional UAM-related responsibilities that fall within the purview of local governments include identifying and addressing utility improvement needs, seeking opportunities for funding support via federal/state grants and/or P3s, implementing economic and workforce development programs, coordinating with other agencies and stakeholders, and developing emergency response plans and training personnel to respond to possible VTOL-related incidents.

MPOs and TPOs

Long-term transportation planning plays a critical role in identifying mobility needs and opportunities for the future of transportation networks. Incorporating UAM into long-range planning efforts can help advance multimodal improvement opportunities, steer funding priorities, and drive overall system integration. With a primary objective of conducting transportation planning at the regional level, Metropolitan Planning Organizations (MPOs) and TPOs are well positioned to assess the feasibility and potential regional impacts of UAM, and integrate UAM considerations into planning efforts to help foster future UAM-related priorities and investments. These planning efforts may involve significant stakeholder coordination with groups such as local governments, community groups, airports, OEMs, UAM operators, and other MPOs/TPOs, which will also aid in accomplishing overall community engagement and educational outreach objectives.

Private Industry

The private sector is leading key investments in new aircraft development, manufacturing processes, vertiport infrastructure, UAM services, and overall market growth. Stakeholders in the private sector—including OEMs, service providers, and developers—must work closely with regulators to ensure that UAM systems meet all relevant safety and performance standards. These organizations are responsible for ensuring their innovative technologies can enable safe and efficient transportation solutions, both for UAM users and members of the public on the ground.

In conjunction with governments and other public stakeholders, the private sector shares the responsibilities of stakeholder coordination, educational outreach, and public engagement. Engaging with stakeholders is important as it allows private companies to build partnerships that can support the development and deployment of UAM systems. For example, engaging with

governments and regulators can help companies navigate the complex regulatory environment, ensuring that their systems are compliant with relevant safety and performance standards. Similarly, community engagement and educational outreach are important for building trust and support for UAM, which can help to overcome any concerns or resistance to the technology.

UAM Working Group and Stakeholder Coordination

Successful implementation of an integrated UAM ecosystem will involve continuous engagement among many stakeholders and coordination of numerous variables and components. Therefore, it is recommended that Miami-Dade County establish a working group to lead all UAM-related coordination efforts in the County. This group may be an extension of the County's existing UAM Working Group or a new entity altogether.

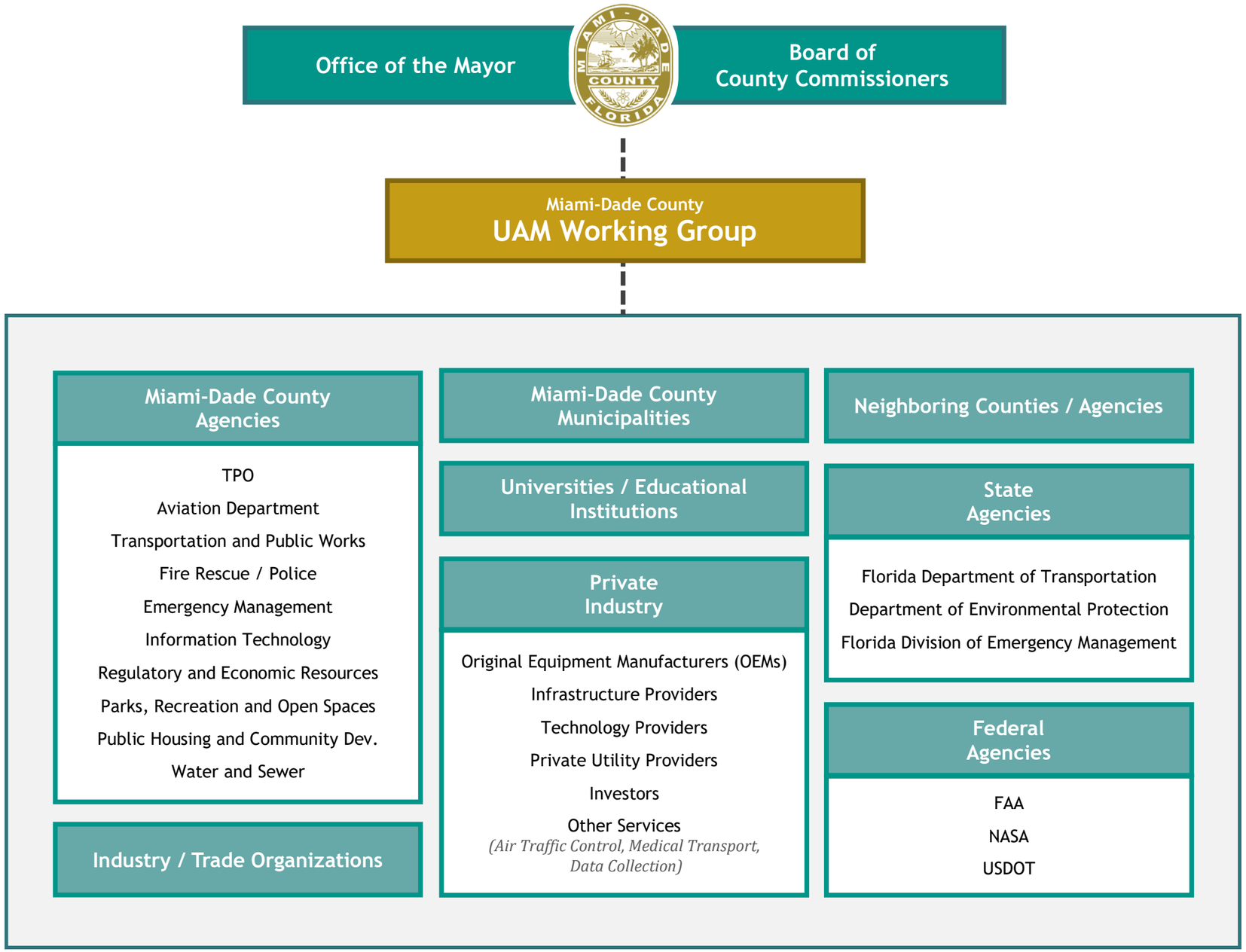
As recommended, the primary responsibilities of the UAM Working Group include coordinating with all stakeholders, developing and strengthening relationships with partner agencies and private organizations, staying informed on developments related to UAM, informing UAM-related planning and policy, recommending responsible departments and agencies to lead implementation priorities, and championing overall UAM implementation in the County. These responsibilities are critical to ensuring that UAM implementation is carried out efficiently and effectively.

The success of the working group depends on the participation of individuals with diverse technical knowledge and perspectives. Like the County's existing UAM Working Group, this group should include representatives from government agencies at all levels, private industry, and community leaders. By bringing together a variety of stakeholders, the working group can ensure that UAM-related planning and policy are informed by a range of perspectives.

Figure 4.1 provides a visual representation of UAM-related stakeholder coordination in the County. The UAM Working Group is represented as a central body charged with managing coordination between all industry stakeholders and the Miami-Dade County Office of the Mayor and Board of County Commissioners. This role is essential to ensuring that all stakeholders are kept informed and that UAM implementation is carried out in a coordinated and effective manner. Of note, a high level of coordination is anticipated with the stakeholders included in Figure 4.2. However, this is not representative of a comprehensive list of UAM-related stakeholders. As part of its responsibilities, the UAM Working Group should keep abreast to changes in the industry and local market to identify new stakeholders with whom to coordinate.

The recommendation of a central group to coordinate UAM-related matters is consistent with the recommendations of the FDOT AAM Roadmap report, MDAD AAM Strategic Plan, and other AAM publications as highlighted in Technical Memorandum #1.

Figure 4.1 - UAM Working Group and Stakeholder Coordination



Note: *This graphic represents stakeholders with which a high level of coordination is anticipated. This does not represent a comprehensive list of all stakeholders.*

4.4. UAM Implementation Priorities

Based on industry research, County objectives, stakeholder engagement, and the existing state of associated technologies and regulations, this report identifies a list of refined priorities for implementing UAM infrastructure and operations in Miami-Dade County. These priorities were shaped by the discourse and recommendations provided throughout this study, especially those highlighted in Technical Memorandum #2. Additionally, the final recommendations and associated timeline were heavily influenced by input from the Study Advisory Group, and were developed for consistency with two recent reports that are relevant to UAM in Miami-Dade County: FDOT's AAM Roadmap and the MDAD's AAM Strategic Plan. It is crucial that these recommendations align with those of state, regional, and local agencies to ensure a cohesive UAM ecosystem.

As illustrated in **Figure 4.2**, UAM implementation priorities have been assigned specific timeframes within which they should be initiated and in which the majority of effort should occur. However, based on emerging technologies and the regulatory environment, these recommendations should be continuously reviewed, updated, and prioritized in perpetuity.

The listed priorities represent specific action items for Miami-Dade County, its agencies, and local municipalities upon securing an OEM's committed contract for operations within the County. Other critical action items and milestones, such as VTOL certification and air traffic management solutions, primarily fall under the purview of the private sector and federal government. Although Miami-Dade County should support and monitor the progression of these key industry components, this study's recommendations emphasize action items within the immediate horizon of the County and its partner agencies at the local and regional levels.

As noted in **Section 4.3**, the Miami-Dade County UAM Working Group will be critical in supporting these priorities and promoting subsequent action. Due to the rapidly emerging nature of the UAM industry, this report's recommendations do not explicitly assign responsible parties to champion or lead each action item. It is envisioned the UAM Working Group will collaborate with County leadership and partner agencies to identify appropriate organizations and individuals to execute the recommended action items.

It is important to note that action items associated with UAM infrastructure and operations will depend on numerous contributing factors, including the County securing an OEM for future operations, the regulatory landscape, technological advancements, public acceptance, and industry investment. Therefore, at the time of writing, any timeline for UAM is speculative and subject to change. Miami-Dade County should stay up to date on industry developments and market changes to determine appropriate revisions to these priorities and timeline.

Figure 4.2 - Implementation Priorities and Timeline

Implementation Priorities	Phase I			Phase II			Phase III				
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Phase I - Priorities to Implement Before Securing an OEM											
Develop UAM local proof of concept in Miami-Dade County											
Incorporate UAM into Miami-Dade TPO transportation planning efforts *											
Identify strategic partnerships with government agencies and private organizations in the critical path to UAM integration											
Identify initial use cases and operating locations *											
Develop and initiate educational outreach programs *											
Identify utility needs and grid capacity to support VTOL operations, especially in rural and underserved communities *											
Update county and municipal zoning, land use plans, and building codes to accommodate vertiports, VTOL operations, and other infrastructure *											
Develop workforce training programs											
Incorporate UAM into long range transportation plans and comprehensive plans, with emphasis on the SMART Program corridors *											
Develop emergency response procedures and train personnel *											
Phase II - Priorities to Implement After Securing an OEM											
Promote the installation of VTOL charging/fueling infrastructure											
Endorse the review and development of standalone (off-airport) vertiports, charging/fueling facilities, and communications infrastructure											
Support the deployment of initial UAM services in select locations in conjunction with the recommendations of MDAD AAM Strategic Plan *											
Explore infrastructure and policy considerations for autonomous UAM operations *											
Refine county and municipal zoning, land use plans, and building codes to accommodate high-frequency off-airport VTOL operations*											
Promote the development of additional UAM infrastructure to support scaled operations and local/regional transportation goals											
Integrate UAM services into Miami-Dade County's public transportation network, with emphasis on the SMART Program corridors											
Phase III - Continuation of AAM Connectivity											
Development of a regional and state AAM network											

Notes:
**Implementation priority is consistent with the recommendations of the FDOT AAM Roadmap and/or MDAD AAM Strategic Plan.*
This timeline represents approximate timeframes in which tasks should be initiated and in which the majority of initial effort should be spent. Ultimately, these recommendations should be continuously reviewed, updated, and prioritized in perpetuity. Miami-Dade County should stay up to date on industry developments and market changes to determine appropriate revisions to these priorities and timeline.

Glossary of Terms

Advanced Air Mobility (AAM) | An air transportation system that moves people and property using aircraft with advanced technologies in both controlled and uncontrolled airspace.[40]

Beyond Visual Line of Sight (BVLOS) | The operation of an unmanned aircraft (i.e., drone) beyond the visual capability of flight crew members (i.e., remote pilot, a visual observer).[40]

Concept of Operations (ConOps) | A document that describes a proposed system concept and how that concept would operate in an intended environment, with a particular focus on how the operational system will be used to meet the goals of its end-users.

Electrical vertical takeoff and landing aircraft (eVTOL) | Electric aircraft capable of vertical climbs and/or descents and of using very short runways or small areas for takeoff and landings.[40]

FAA Engineering Brief 105, Vertiport Design (EB 105) | The FAA released EB 105 in September 2022 to provide guidance for the design of vertiports. EB 105 includes design elements for VTOL use, standards for electric and charging infrastructure, and safety considerations for vertiport siting.

National Airspace System (NAS) | A network of both controlled and uncontrolled airspace, both domestic and oceanic. The NAS also includes air navigation facilities, equipment and services; airports and landing areas; aeronautical charts, information and services; rules and regulations; procedures and technical information; and manpower and material.[40]

Original Equipment Manufacturer (OEM) | In the context of AAM, a company or organization that manufactures VTOL aircraft.

Regional Air Mobility (RAM) | An air transportation primarily utilizing VTOL aircraft to carry passengers, cargo, or provide services in a regional setting.[41]

UAM Ecosystem | Technologies, infrastructure, and systems associated with urban air mobility, including aircraft, airspace management systems, vertiports, and electric charging stations.

Unmanned Aerial Systems (UAS) | An aircraft, such as a drone, that is operated without the possibility of direct human intervention from within or on the aircraft.[40]

Urban Air Mobily (UAM) | A subset of AAM, referring to an air transportation system utilizing highly automated aircraft to transport passengers or cargo in urban and suburban areas.[40]

Vertical takeoff and landing aircraft (VTOL) | Aircraft capable of vertical climbs and/or descents and of using very short runways or small areas for takeoff and landings.[40]

Vertihub | An area consisting of multiple takeoff/landing areas, security checkpoints, passenger amenities, multimodal connections, and support infrastructure.

Vertiport | 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.[42]

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[40] FAA (2023). Pilot/Controller Glossary. https://www.faa.gov/air_traffic/publications/atpubs/pcg_html/
[41] FDOT (2023). AAM Working Group Report and Recommendations.
[42] FAA (2022). Engineering Brief 105, Vertiport Design.