FLORIDA ADVANCED AIR MOBILITY

ADVANCED AIR MOBILITY PLANNING

Sarasota/Bradenton International Airport
Airport Compatibility Considerations

FDOT AVIATION

Photo source: Woolpert

CONTENTS

OVERVIEW

Photo source: Lilium

1. Overview

Integrating advanced air mobility (AAM) into Florida's air transportation system requires early compatibility planning to help assure it does not affect the state's existing airport system's ability to meet legacy aviation demands and capacity requirements. The early entrants into AAM in Florida are electric vertical take-off and landing (eVTOL) aircraft using battery-powered propulsion systems, and their range will be limited to local and regional missions. Many of these operators are targeting the same market areas served by legacy aviation, with the potential for new vertiport infrastructure proposals to be located near existing airports that already serve these markets. This report has been prepared to assist in identifying incompatible locations for vertiports relative to legacy airports. The analysis includes five areas or uses around airports that are incompatible for siting an off-airport vertiport.

a. Airport Traffic Pattern:

No vertiport should be located within an existing airport's traffic pattern without coordination with the associated airport sponsor and coordination and approval by the FAA. While traffic patterns can be adjusted for right turns to mitigate certain conflicts, standard patterns are to the left and the standard is always preferred. These areas are shown in red on the compatibility maps developed in Section 7.

b. Instrument Approach Procedures:

No vertiport should be located under the airport instrument approach area to the point where an aircraft on an instrument approach procedure can generally be considered to be in transitional airspace, without coordination with the airspace's associated airport sponsor and coordination and approval by the FAA. This area is shown in red on the compatibility maps developed in Section 7.

c. Controlled Airspace:

No vertiports should be located in the portion of Federal Aviation Administration (FAA) controlled airspace classes B, C, D, and E that begin at the ground surface without coordination with the airspace's associated airport sponsor and coordination and approval by the FAA. These areas are shown as yellow on the compatibility maps developed in Section 7.

d. Tall Structures:

Tall structures (e.g., antenna towers, high-rise buildings) can present a hazard to aeronautical operations. Structures in the FAA-Aeronautical Information Services' Digital Obstacle File dataset that are over 50 feet are shown in red on the compatibility maps developed in Section 7.

e. Landfills:

Landfills can also pose a hazard to aeronautical operations if they attract large quantities of birds. Solid waste landfill facilities from the Florida Department of Environmental Protection are shown in yellow on the compatibility maps developed in Section 7.

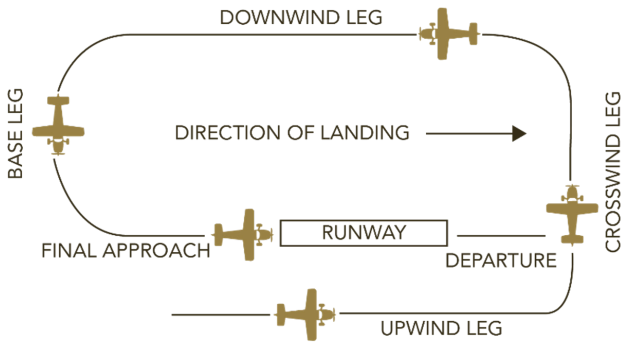
There are other areas surrounding an airport that may be considered incompatible for locating a vertiport. Federal Regulation Title 14 Part 77 standards could be applied but not all objects that penetrate this airspace are considered hazards. Additionally, "IFR-Radar Airport Airspace Requirements" from FAA FO 7400.2N Procedures for Handling Airspace Matters, could be applied but these are quite large (in some cases 30 miles by 10 miles), and precluding all this airspace may be unnecessary if the FAA can mitigate conflict. Finally, a full analysis under FAA Order 8260.3E, United States Standard for Terminal Instrument Procedures (TERPS), could be conducted but this is complex and costly. The methodology chosen for this analysis is considered logical for the level of effort needed in the advanced planning stage to identify the most incompatible locations. Ultimately the FAA has the final authority over the safe and efficient use of airspace and a non-objectional airspace determination from them will be needed for a sponsor to safely site a new vertiport.

Photo source: Lilium

METHODOLOGY

Photo source: Joby Aviation

Exhibit 2.1 Traffic Pattern Legs



Source: FAA Aeronautical Information Manual

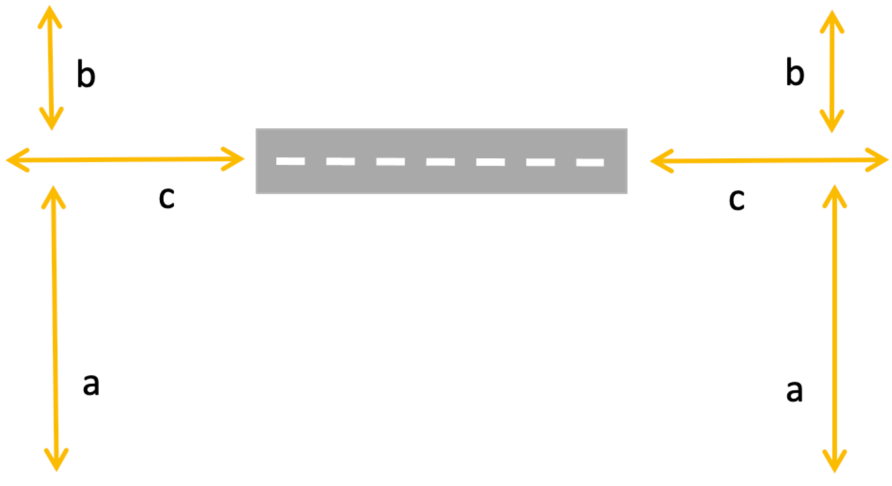
2. Airport Traffic Pattern

The airport traffic pattern serves to ensure the safe movement of aircraft to and from an airport. A common altitude for all incoming and outcoming traffic helps minimize the risk of midair collisions at airports without control towers. The standard airport traffic pattern is rectangular in shape and has left-hand turns but local conditions may dictate the need for right-hand turns. The recommended pattern altitude is 1,000 feet above the airport elevation for propeller-driven aircraft. Large or turbine aircraft are advised to enter the pattern at 1,500 above the surface or 500 ft above the established pattern. The legs of an airport traffic pattern are shown in **Exhibit 2.1**.

Photo source: Lilium

There is a pattern established for each runway. The dimensions of the traffic pattern depend on the approach speed of the aircraft, which is generally 1.3 times its stall speed at maximum takeoff weight in landing configuration. For obstruction evaluation in the airport traffic pattern, the FAA uses the dimensions shown in **Exhibit 2.2**:

Exhibit 2.2: Airport Traffic Pattern Dimensions



Aircraft Approach Speed	*Distance in Nautical Miles* a	b	c	d*
A - Less than 91 kts.	1.25	.25	1.25	.375
B - 91 kts. or greater but less than 121 kts.	1.5	.25	1.5	.5
C - 121 kts. or greater but less than 141 kts.	2.25	.5	2.25	.875
D - 141 kts. or greater but less than 166 kts.	4.0	.4	3.0	1.0
*E – 166 kts or greater**	Generally, includes extremely high-speed aircraft in military, experimental, or civil categories.			

Note: when traffic patterns are flown on both sides of the runway, apply distance "a" on both sides of the extended runway centerline.

**Increase "c" by adding the distance specified in "d" for each aircraft over 4 (of the same category) anticipated to be operating in the traffic pattern at the same time.*

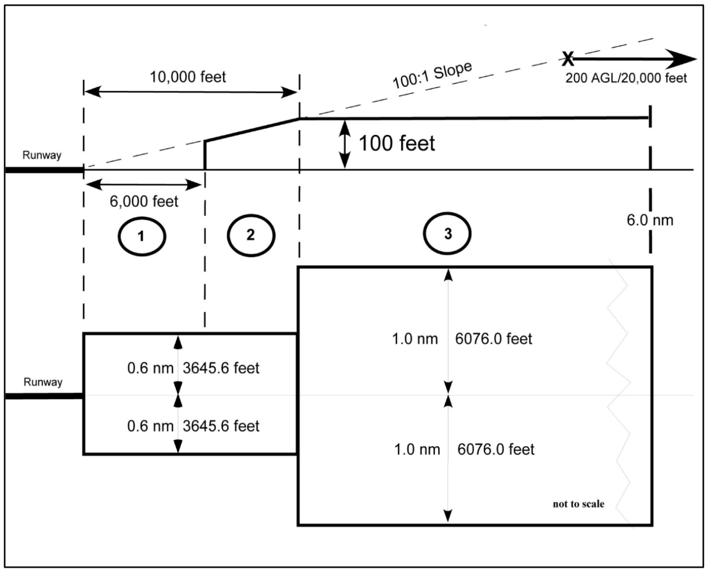
Source: FAA Order 7400.2N


Photo source: Lilium

The FAA applies the dimensions in **Exhibit 2.2** for VFR operations in relation to spacing between landing facilities. FAA guidelines state that the traffic pattern airspace of one airport may touch but should not overlap the traffic pattern airspace of another airport. Note that the traffic pattern airspace at an airport that has more than four aircraft of the same category operating at the same time is enlarged by a factor denoted in the footnote in **Exhibit 2.2** above. For the purposes of this analysis, this enlargement has not been applied because the traffic pattern for the existing airport has been developed based on the largest aircraft expected to use the facility on a regular basis (i.e., 500 operations annually). For VFR operations, the likelihood of having four simultaneous aircraft in the pattern at the same time will be in the lower approach speed aircraft (Category A) for flight training purposes. The traffic pattern for the larger aircraft is already building in a buffer for additionally smaller aircraft operating simultaneously, therefore alleviating the need for the multi-aircraft enlargement factor.

For this analysis, no vertiport should be located within the traffic pattern of an existing airport unless it is under the control of the existing airport's ATCT, should it have one. While traffic patterns can be adjusted for right turns to mitigate certain conflicts, standard patterns are to the left and the standard is always preferred.

Exhibit 3.1: Airport Instrument Approach Notification Area



3. IFR Approach Procedures

For aircraft to land in instrument meteorological conditions, instrument approach procedures (IAP) must be established for an airport. The FAA designs IAPs based on United States Standard for Terminal Instrument Procedures (TERPS). Analyzing an object's impact on an IAPs via TERPS is a very complex and lengthy process that is not replicated as part of this project. However, the FAA has established an Airport Instrument Approach Area (AIAA) where certain criteria are applied from TERPS when evaluating how structures may impact IAPs, which can be easily applied to this project. This area is defined by four segments of airspace measured in feet from the runway threshold (threshold to 6,000 feet, 10,000 feet, 36,457 feet, and beyond 36,457 feet). (See **Exhibit 3.1**.)

Source: Adapted from JO 7400.2N

Photo source: Wisk

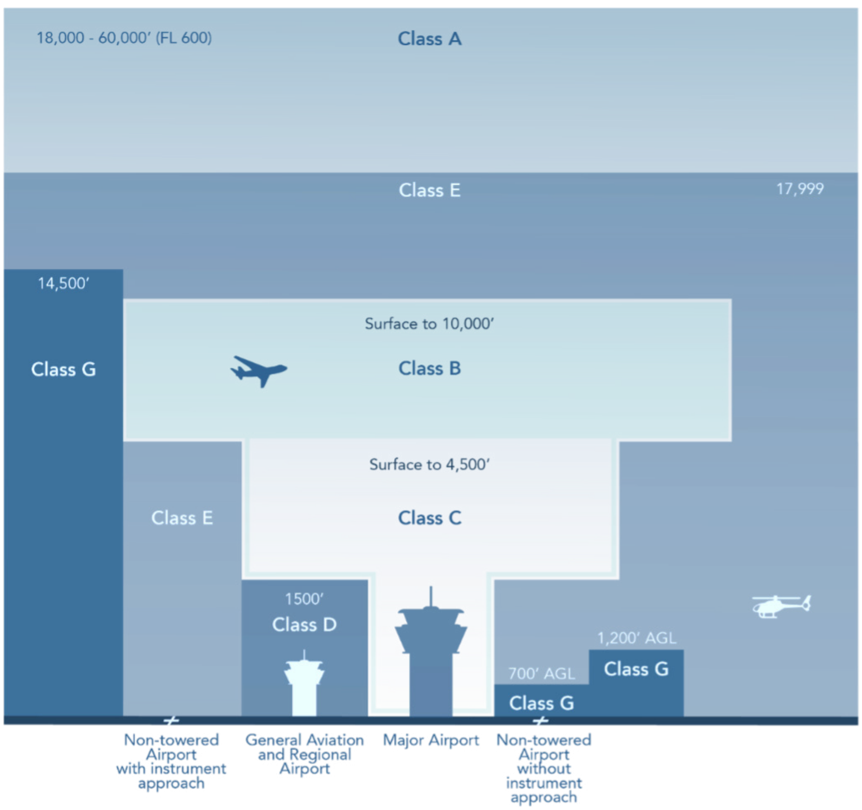
For the purposes of this analysis, segments 1-3 of the AIAA are developed for each runway with an IAP, which generally extends to the point where an aircraft on an instrument approach procedure can largely be considered in transitional airspace. The IAP with the lowest minimums and visibility is shown for reference also. No vertiports should be located under these segments of the AIAA as they may interfere with existing instrument approach procedures.

Photo source: Wisk

4. Controlled Airspace

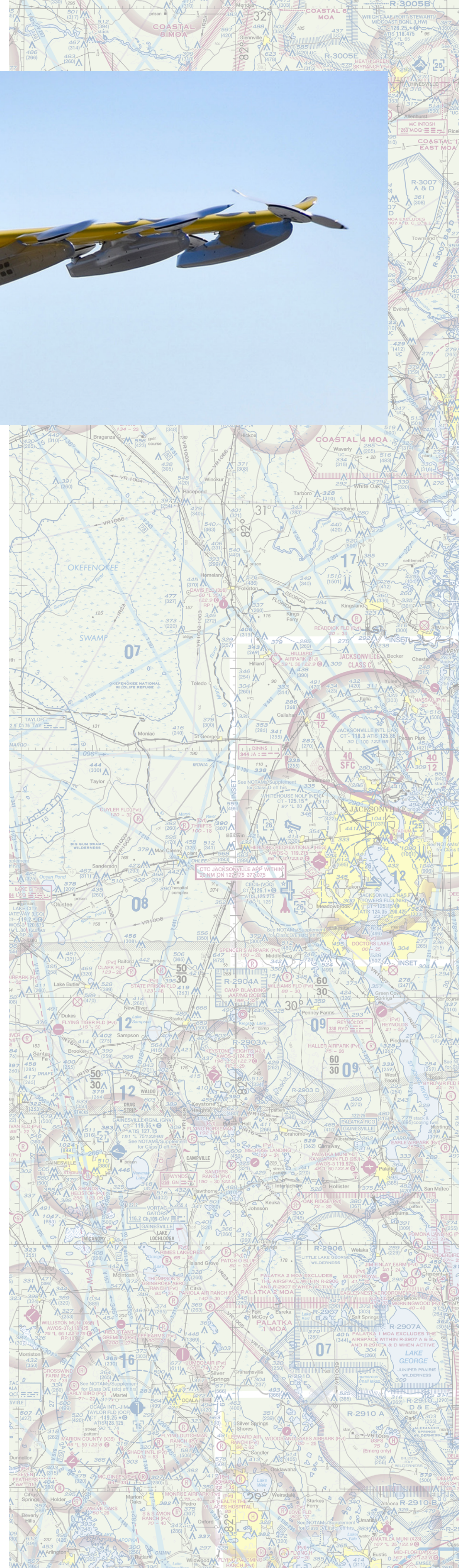
FAA Controlled Airspace is atmospheric space of specifically defined dimensions where Air Traffic Control services are provided to flights conducted in either instrument flight rules (IFR) or visual flight rules (VFR) in accordance with an airspace classification. Within this airspace, all aircraft operations must meet specific requirements. A graphic display of FAA airspace classifications is shown in **Exhibit 4.1**:

Exhibit 4.1: Controlled Airspace



Source: FAA Aeronautical Information Manual

The classification of airspace by the FAA is considered a rulemaking action subject to the Notice of Proposed Rulemaking (NPRM) process and the opportunity for public comment. The existing airspace classifications in Florida have undergone the rulemaking process, have their own legal descriptions, and are considered final rules. The different airspace classifications applicable to this study are Classes B, C, D, and E. These categories are described in detail below.



Class B Airspace:
Class B airspace is generally designed to increase flight safety by decreasing the potential for midair collisions in the airspace surrounding airports with high–density air traffic. Any aircraft operating in Class B airspace is bound by specific operating rules and equipment prerequisites. The airspace that makes up Class B around a high-density airport is designed by the FAA for safe and efficient air traffic control management to and from any airports contained within it.

Class B airspace generally exists from the surface up to 10,000 feet MSL surrounding Florida's busiest airports in terms of passenger enplanements and aircraft operations. The configuration of the airspace is individually tailored for each location and includes a surface area and two or more layers. It is designed to contain all published instrument procedures. A clearance is required from Air Traffic Control (ATC) to operate in Class B airspace, and all aircraft cleared for operation in the area receive separation services within the airspace. The cloud clearance requirement for VFR operations is "clear of clouds."

Class C Airspace:
Class C airspace is generally designed to increase flight safety by decreasing the potential for midair collisions in the terminal area of airports that have an operational ATCT, are serviced by a radar approach control, and that have a certain number of IFR operations (currently 75,000 at the primary or 100,000 at the primary and secondary airports) or passenger enplanements (currently 250,000). The airspace enhances the management of air traffic operations within it. Any aircraft operating in Class C is bound by specific operating rules and equipment prerequisites.

Class C airspace generally extends from the surface to 4,000 feet above the airport elevation. While each Class C area is individually tailored, it usually consists of an area that goes to the surface within a 5 NM radius of the airport and an outer circle with a 10 NM radius that extends from no lower than 1,200 feet up to 4,000 feet above the airport elevation. An aircraft operator must establish two–way radio communications with air traffic control before entering Class C airspace and maintain communication while within it. All instrument procedures are not required to be contained within Class C.

Class D Airspace:
Class D airspace is generally established to provide controlled airspace for terminal visual flight rules and instrument flight rules at airports with an operational ATCT. It can also be found at non-towered airports with instrument procedures if justified or within the public's interest. Class D airspace generally exists from the surface to 2,500 feet above the airport elevation and, while individually tailored for each airport, it will normally contain the airport's instrument procedures. It is designed to contain IFR arrivals while between the surface and 1,000 feet above the surface and IFR departures while between the surface and the base of adjacent controlled airspace. Arrival extensions for instrument approach procedures may be in the form of either Class D or Class E airspace (see below).

Unless otherwise authorized, each aircraft operator must establish two–way radio communications with the air traffic control facility serving the airspace prior to entering the airspace and maintain communications while within it. Generally, air traffic separation services are not provided to aircraft in the airspace operating under visual flight rules.

Class E Airspace:
Class E airspace is used to provide controlled airspace for terminal operations to non-towered airports or where a control tower is not in operation. When designated, the airspace will generally be configured to contain all instrument procedures. Class E airspace can also include transitional areas (from either 700 or 1,200 feet above the surface) used to transition to/from the terminal or en route environment. These extended areas are designed to provide controlled airspace for standard instrument approach procedures without requiring communication constraints on pilots operating under visual flight rules. Class E airspace generally extends from the surface to a designated altitude, usually 1,200 feet above the surface, or the base of overlying controlled airspace.

For the purposes of this analysis, the appropriate FAA airspace classification is shown for each airport only where it touches the ground surface as provided by the FAA Class Airspace GIS layer. No vertiports should be located in any portion of Class B, C, D, or E airspace that begins at the ground surface without coordination with the airspace's associated airport sponsor and coordination and approval by the FAA.

5. Tall Structures

Tall structures (e.g., antenna towers, high-rise buildings) can present a hazard to aeronautical operations. While pilots have the responsibility to see and avoid these types of structures, the ability to detect them early enough to avoid them is often limited by their visual conspicuity and the aircraft's ground speed. FAA AC 90-48D, Pilots' Role in Collision Avoidance, states that "the performance capabilities of many aircraft, in both speed and rates of climb/descent, result in high closure rates limiting the time available for detection, decision, and evasive action. Research has shown that the average person has a reaction time of 12.5 seconds." Many towers below 200 feet above ground level are not marked and lighted.

The FAA-Aeronautical Information Services' Digital Obstacle File dataset is the source used in this analysis for identifying tall structures. It contains all known man-made obstacles of interest to aviation users in the United States but does not purport to indicate the presence of all obstructions that may be encountered. For this analysis, structures above 50 feet are shown in red. (Note: Fifty (50) feet represents the point in an AAM general mission profile (1) developed by NASA where the eVTOL aircraft transitions from horizontal to vertical flight on takeoff and vice versa on landing.)

6. Landfills

Municipal solid waste landfills (MSWLF) can attract birds. 49 U.S.C. § 44718 (as amended) places limitations on locating MSWLFs near airports because these birds pose a hazard to aircraft (2). The vast majority of aircraft collisions with birds happen near airports because they are both flying at the same altitude and the pilot has minimal time to see and avoid the bird. Section 44718(d), as amended, requires the distance between a new MSWLF and a public airport be a minimum of six statute miles. Additionally, FAA AC 150/5200-33, Hazardous Wildlife Attractants on or Near Airports, recommends all airports be five statute miles from any hazardous wildlife attractant that would result in birds being in the approach or departure airspace.

The Florida Department of Environmental Protection's (FDEP) Solid Waste Landfill Facility database is used for this analysis. All solid waste facilities are shown in yellow. Before a vertiport is located near one of these facilities, further research into the status of the facility and the type of waste received is warranted.

COMPATIBILITY MAPS

Photo source: Lilium

7. Sarasota/Bradenton International Airport – Compatibility Maps

The technical data discussed in the previous five sections have been applied to the Sarasota/Bradenton International Airport (SRQ) to develop an airspace compatibility map. **Exhibit 7.1** summarizes the aviation conditions applied to the airport and each runway. **Exhibits 7.2-7.4** provide the resulting airspace compatibility maps for siting off-airport vertiports (it is assumed on-airport vertiports will be properly coordinated and approved with the airport sponsor). The areas in red and the areas in yellow will require additional analysis by a proponent and the FAA to determine if these locations are suitable for vertiports.

Exhibit 7.1: SRQ Conditions

Controlled Airspace at Surface	Runway ID	Right Hand Traffic Pattern	Approach Code	Instrument Approach Procedure
Class C	4	No	B	Yes
	22	No	B	Yes
	14	No	D	Yes
	32	No	D	Yes

Photo source: Lilium

Exhibit 7.2: SRQ Airspace Compatibility Map - Full Extent

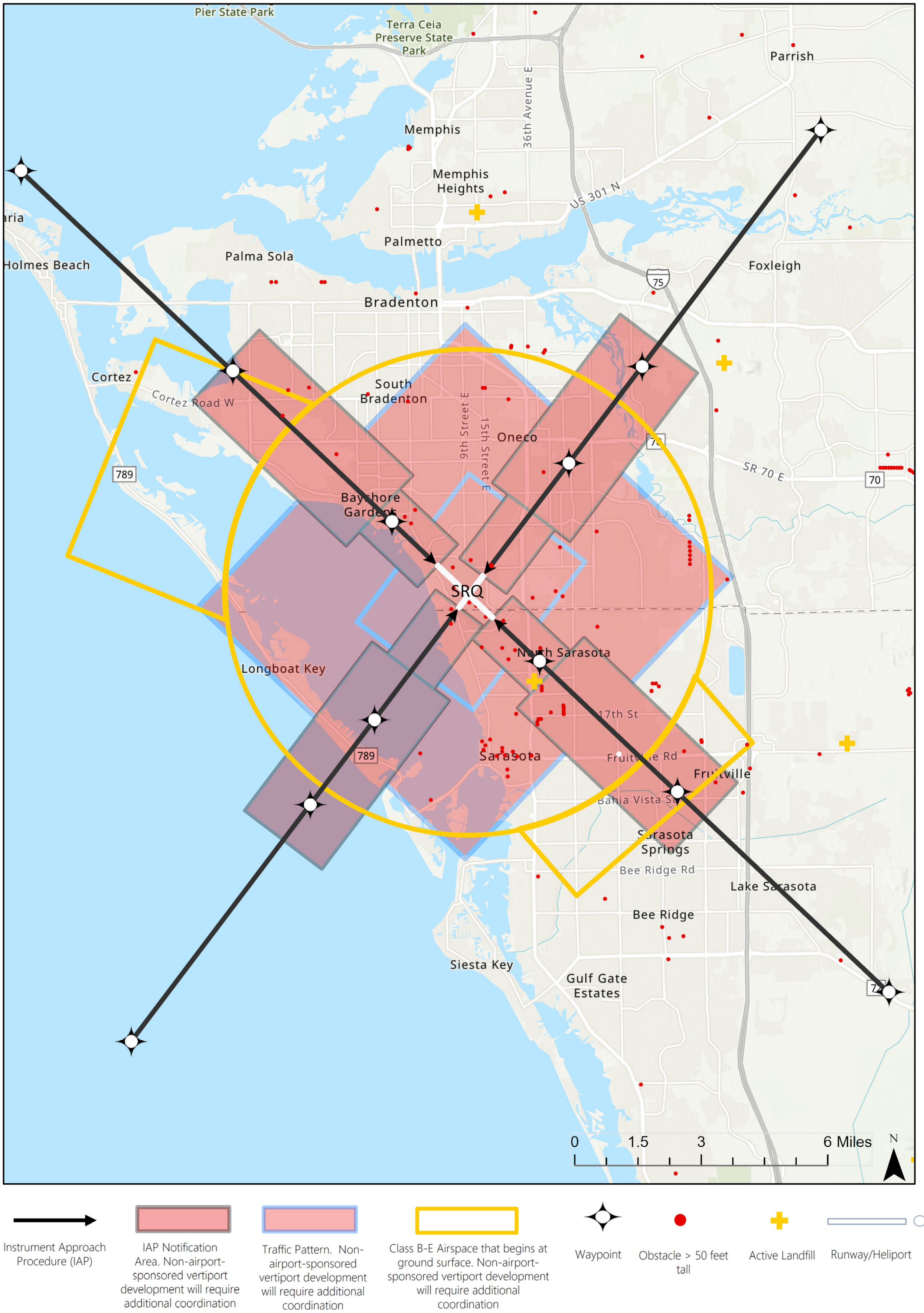


Exhibit 7.3: SRQ Airspace Compatibility Map – Zoom to AIAA Extent

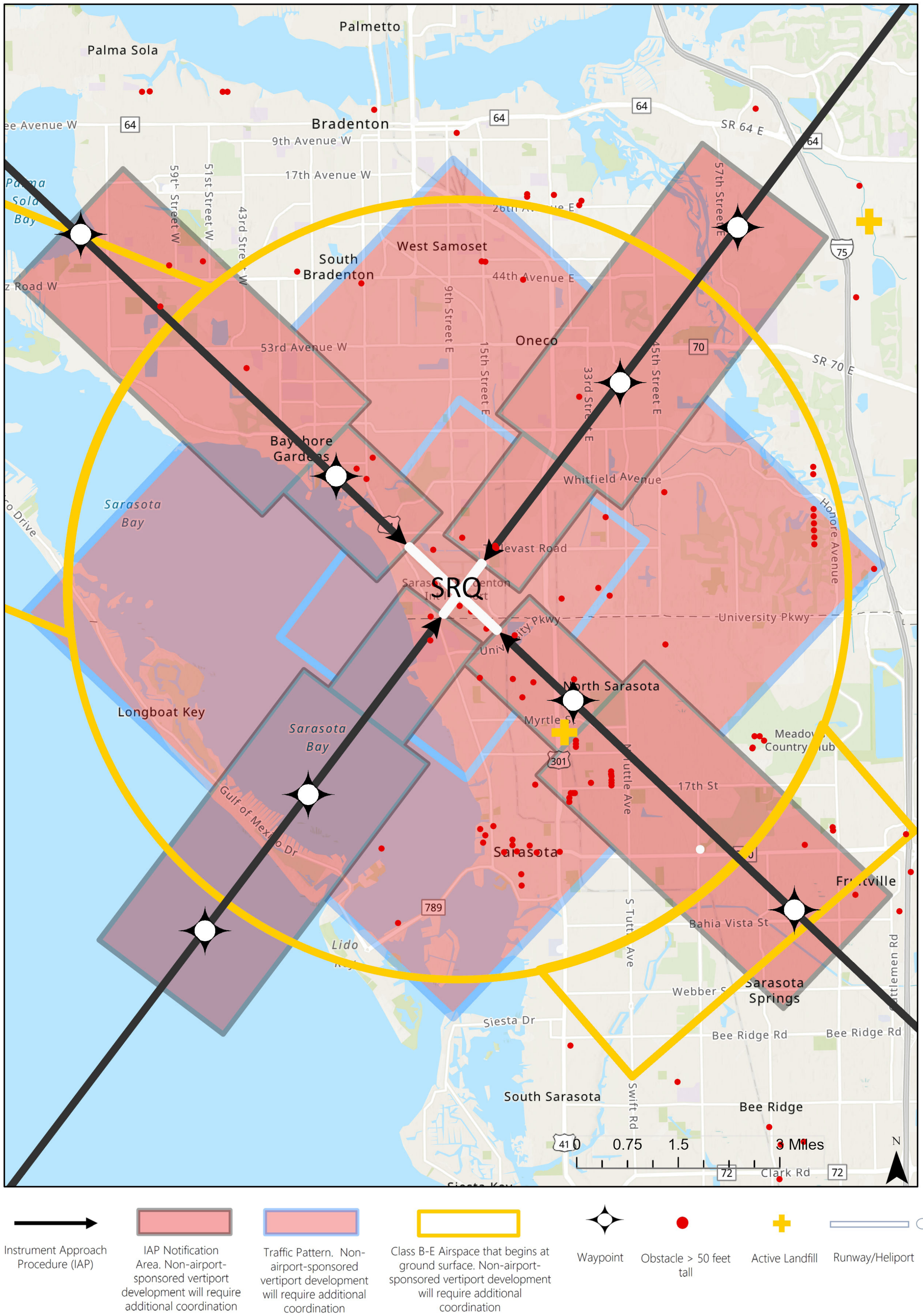
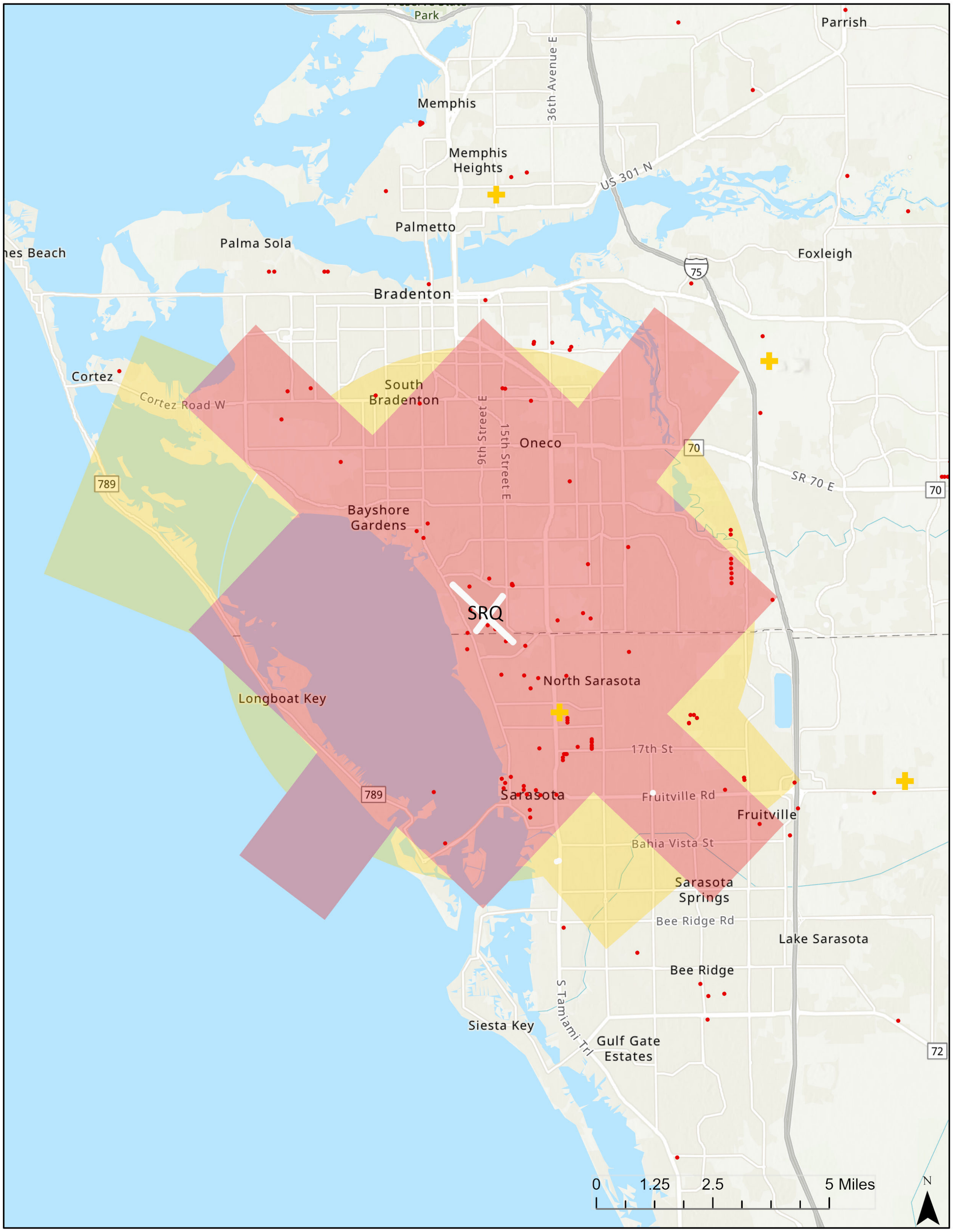


Exhibit 7.4: SRQ Airspace Compatibility Map – Composite Map



Class B-E Airspace that begins at ground surface. Non-airport-sponsored vertiport development will require additional coordination

IAP Notification Area & Traffic Pattern. Non-airport-sponsored vertiport development will require additional coordination

Obstacles > 50 feet tall

Active Landfill

Runway/Heliport

8. Potential Infrastructure Elements to Accommodate eVTOL

Takeoff and Landing Area

Many eVTOL configurations are capable of taking off and landing horizontally on a runway like a fixed-wing aircraft. Others can land like a helicopter flying an approach to the existing runway or to a specific landing pad on the airport. They can use taxiways for ground or hover taxi operations. An airport sponsor should review their Airport Layout Plan and their critical design aircraft to determine whether eVTOL can operate effectively on their airport. If the eVTOL cannot use the existing runways and taxiways for some reason (e.g., standards or capacity) and a dedicated landing location is needed, the sponsor should follow FAA guidance on vertiport design. While the FAA's long-term plan is to develop a performance-based vertiport design Advisory Circular, in the interim they have provided relatively prescriptive guidance in Engineering Brief (EB) 105, Vertiport Design, for on-airport and off-airport vertiport development.

Charging Infrastructure

While there is an ample supply of electricity in Florida, not all potential vertiport sites have the necessary infrastructure in place to meet the voltage and charging rate demands of eVTOL aircraft. According to the National Renewable Energy Laboratory, aircraft electrification could include 820-kilowatt-hour (kWh) batteries, which would require megawatt-level charging to recharge in less than 30 minutes. (3) Solutions to this need may require cable and battery cooling and electromagnetic shielding for avionics.

According to the NIA-NASA Urban Air Mobility Electric Infrastructure Study, conducted by Black & Veatch in 2019, the typical airport electrical infrastructure requirements for charging three aircraft include a concrete pad 500 feet long by 170 feet wide for the electrical components and a minimum of three 600kW eVTOL vehicle chargers. (Note: FAA EB 105, Vertiport Design, published in September of 2022, specifies a larger Final Approach and Takeoff Area than this study.) Depending on the number of chargers and power demand, the utility distribution system for an airport may need to be upgraded to alleviate overloading the equipment during peak charging.

Another issue to contend with is Florida's unique climate. Eve Air Mobility Systems states in Concept of Operations for Sustainable Urban Air Mobility In Rio De Janeiro (April 2021) that "The high humidity and salinity of some cities around the world can reduce the lifespan of the Charging Stations and their mounting and fixing accessories.

There are obvious challenges for airports in servicing eVTOL aircraft. Regardless, early infrastructure should provide for high-voltage, fast charging at each parking position. Each OEM is different, but early contenders in this arena offer some insights into their charging needs. **Exhibit 8.1** provides key charging information publicly available from Beta Technologies, which has begun installing charging stations at some airports along the east coast and in the Midwest.

Photo source: Lilium


Photo source: Wisk

Exhibit 8.1: Beta Charging Needs

Component	Requirement
AC Voltage Connection	480 Vac, 3 Phase, 60 Hz
AC Grid Current	450 Amps
Continuous Power	350 kVA
Battery Charge Range	Up to 950 Vdc
Continuous Charge Current	350 Amps
Boost Charge Current	500 Amps
Charging Protocol	CCS and CHAdeMO
Demand Response Interface	ADR 2.0

Battery Swap Capability

Battery swapping is an option for OEMs in the design of their aircraft. It entails exchanging a fully or partially drained battery system for a fully charged system between flights. This process would theoretically take less time than recharging a battery. A few OEM designs are based on a battery swapping system. If an OEM chooses to swap batteries versus recharging, certain capabilities and equipment will be required at the airport for this to happen. A battery swap right after a flight will have high temperature, ergonomics, and safety implications to be considered. This would also likely necessitate battery-swapping stations to support the operation.

Thermal Management

Fast charging will create heat which is commonly thought to require battery pack thermal management. During the high-power charging process, the components of the charging system and battery experience high temperatures at the points of resistance (i.e., contact interfaces and cable terminations) along the path the high voltage travels. Providing cooling during this process should help manage the charge/discharge rate, which can contribute to improved battery health and lifespan. Also, the ability to control the aircraft cabin climate may also be necessary to maintain a comfortable environment between passengers deplaning and enplaning.

Maintenance, Repair, and Overhaul (MRO) Services

eVTOL aircraft utilize highly advanced technologies that must comply with safety standards and maintenance procedures. If AAM reaches the operational scales predicted by the OEMs to be successful, MRO activity will need to scale also. Their all-electric propulsion systems will require high-voltage electrical components, which have not historically existed in the aviation industry and will necessitate a unique maintenance skillset. MROs will be needed around the country to service these aircraft. Since dedicated vertiport locations will likely be pressed for space, MRO activities may be better suited for airports where ample space is more often available.

Battery Cells Recycling

Large lithium batteries are the initial primary source of energy for eVTOL aircraft. Waste buildup from lithium batteries that have reached the end of their lifecycle will increase the waste stream if not appropriately recycled, which is a difficult and hazardous task for this type of battery. The lifespan of the battery may be considerably shorter than in the automotive industry because of the higher daily usage rates anticipated for eVTOL aircraft. Some OEMs claim they can achieve up to 10,000 cycles per battery pack; however, the range of the flight will impact the amount of the battery's depth of discharge, which in turn impacts battery lifespan.

Aircraft Rescue and Firefighting (ARFF)

ARFF is required at Part 139 airports, but the need for firefighting exists for all airports and often falls to the local fire station. Firefighters must be trained and equipped to handle the dangers associated with electric propulsion. Battery or electrical fires, toxic gas emissions, or high voltage electrical arcing all present unique issues for firefighters when it comes to electric aircraft.

High-Speed Data

How high tempo AAM operations will be integrated into the National Airspace System is still an evolving plan. In Electric Vertical Takeoff and Landing (eVTOL) Aircraft Technology for Public Services – A White Paper (August 2021), NASA recommends immediately promoting "the development of 5G vehicle-to-vehicle (V2V) communication for enhanced autonomous detect and avoid (DAA) airspace deconfliction when multiple UAS are supporting tactical operations. Near term development and deployment of these technologies will accelerate application in eVTOL aircraft for human transportation systems." The ability to provide high-speed data will likely be a requirement for eVTOL AAM operations beyond visual flight rules if large-scale, high aircraft turnover is to be achieved.

Photo source: Wisk

BIBLIOGRAPHY

1. A Proposed Approach to Studying Urban Air Mobility Missions Including an Initial Exploration of MIssion Requirements. Patterson, Michael, Antcliff, Kevin and Kohlman, Lee. s.l. : NASA, 2018.

2. Federal Aviation Administration. AC 150/5200-34, Construction or Establishment of Landfills Near Public Use Airports. Washington, DC : U.S. Department of Transportation, Federal Aviation Administration, 2006.

3. National Renewable Energy Laboratory. Electrification of Aircraft: Challenges, Barriers, and Potential Impacts. Goldon, CO : National Renewable Energy Laboratory, 2021.

4. Doo, Johnny, et al. NASA Electric Vertical Takeoff and Landing (eVTOL) Aircraft Technology for Public Services – A White Paper. National Aeronautics and Space Administration. s.l. : National Aeronautics and Space Administration, 2021. NASA Document Number 20205000636.

5. Federal Aviation Administration. Aeronautical Information Manual. Washington, DC : U.S. Department of Transportation, Federal Aviation Administration, 2021.

6. JO 74002N Change 1: Procedures for Handling Airspace Matters. Washington, DC : U.S. Department of Transportation, Federal Aviation Administration, 2021.

7. Black & Veatch. Powered for Takeoff: NIA-NASA Urban Air Mobility Electric Infrastructure Study. November 2019.

8. BETA Technologies. Charging. BETA Technologies. [Online] 2022. [Cited: January 17, 2022.] https://www.beta.team/recharge/.