Recommended Minimum Standards for Vertiports, Suggested Document Changes, and GAP Analysis for eVTOL Unique Aircraft Needs

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Recommended Minimum Standards for Vertiports and Suggested Document Changes

Empirical data on electric vertical takeoff and landing (eVTOL) aircraft performance is limited and applicable only to the design and testing phases for the original equipment manufacturers (OEMs) of these aircraft. No eVTOL aircraft have reached Federal Aviation Administration (FAA) certification yet, and the data available is inadequate to inform performance-based infrastructure minimum design geometrics. Because of this absence of data, the FAA developed interim guidance for vertiports, **Engineering Brief (EB) 105, Vertiport Design** (currently in draft mode), until a full vertiport design Advisory Circular can be developed: The chart below compares EB 105 to FDOTs standards for licensed heliports.

FDOT Licensed Heliport and EB 105 Comparison

Units in Feet	**FDOT Licensed Heliports (14-60.007)**	**FAA EB**
TLOF (centered w/i FATO)		
Width	24	1CD
Length	24	1CD
FATO (weight-bearing)		
Width	V 42 NP 500 P 1000	2CD
Length	V 42 NP 500 P 1000	2CD
Safety Area	20 (all edges of FATO)	3CD
Primary Surface	Coincides with FATO	Coincides with FATO
Approach/Departure Surface	V 8:1 slope - FATO IW - 4000 L - 500 OW NP 34:1 slope - FATO IW - 10000 L - 5000 OW P 50:1 slope - FATO IW - 25000 L - 6000 OW	8:1 slope - FATO IW - 4000 L - 500 OW
Transitional Surface	V 2:1 to 250 vertical NP 4:1 to 350 vertical P 7:1 to 350 vertical	2:1 slope 250 from CL of primary & app. surface
Marking	H TLOF 12" wide solid FATO 12" wide dashed	Broken Wheel Size/Weight Limit TLOF 12" wide solid FATO 12" wide dashed
Lighting	Optional	Night Ops Requirement
TLOF	TLOF **or** FATO TLOF and FATO not lit concurrently Yellow	Night Ops Requirement Green 5 min. each side for square 8 min. for circle
FATO	TLOF **or** FATO TLOF and FATO not lit concurrently Yellow	Optional Green 5 min. each side for square 8 min. for circle
Beacon		Night Ops Requirement white/yellow/green
Wind Cone	Lit if heliport is lighted	1 min. Orange, yellow, or white Within 500 ft. of TLOF Outside safety area Does not penetrate app./dep./trans. surface

TOLF-Touchdown and Lift Off Area; FATO-Final Approach and Takeoff Area; V-Visual; NP-Non-precision; P-Precision; CD-Controlling Dimension

We recommend Florida follow EB 105 until such time that eVTOL aircraft are certified and safety and performance data is available to inform revised standards. In addition, the following standards, regulations, and documents should be reviewed and updated as needed to reflect the incorporation of vertiports and eVTOL aircraft:

- Statute Chapter 330
- Rule Chapter 14-60
- Airport Airspace and Land Use Guidebook
- Airspace Obstruction Brochure
- Airspace Obstructions Construction Notification and Permitting
- Form 725-040-12 Aviation OGC – 02/04
- Private Airport Registration & Site Approval - www.floridaprivateairport.com
- Security Planning for General Aviation Airports
- Eight Steps to Building a New Airport with Federal and State Funding
- Airport Sustainability Guidebook
- Statewide Airport Stormwater Best Management Practices Manual
- Standard Specifications for Construction of General Aviation Airports
- Aviation Emergency Response Guidebook
- Aviation Emergency Response Guidebook Basic Aircraft Guide

GAP Analysis for eVTOL Unique Aircraft Needs

CHARGING INFRASTRUCTURE
While there is an ample supply of electricity in Florida, not all potential 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.[1] 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 Urban Air Mobility (UAM) charging include a concrete pad 500 feet long by 170 feet wide for the electrical components and a minimum of three 600kW eVTOL vehicle chargers. 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:

Lilium Charging Needs

Component	Requirement
Grid	Supply of ~1MW per inverter cabinet.
Transformer	~20kV down-ward transformation.
	Transformer size needed will be 1MVA per 1MW of connected load.
	Voltage-controlled is preferred; in instances where voltage fluctuation needs controlling, autotransformers can be added.
AC-DC Converter	800-900V output voltage.
Charging box	Maintain voltage, power and ensure load management. Needs to be able to handle ~1200A @ ~900V.
Plug	Operated by pilot or ground staff (potentially mechanically assisted). Needs to handle power and currents. Handle and cable must be liquid-cooled.

Source: Lilium Key Vertiport Requirements, April 2, 2020

[1] National Renewable Energy Laboratory, *Electrification of Aircraft: Challenges, Barriers, and Potential Impacts*, October 2021, pg. 20

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

Source: www.beta.team/recharge/, May 2, 2022

Joby Charging Needs

Component	Requirement
AC Voltage Connection	480V, 3 Phase
AC Grid Current	300 Amps

Source: Session 1 UAM Joby Aviation.pdf (calairports.com), http://www.calairports.com/Session%201%20UAM%20Joby%20Aviation.pdf

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. Volocopter's design is 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 Advanced Air Mobility (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.

While Joby claims it will achieve 10,000 cycles for its battery packs, 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 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 undoubtedly be a requirement for eVTOL AAM operations beyond visual flight rules if large-scale, high aircraft turnover is to be achieved.