Presented by
David Williams, P.E.

OREGON AVIATION INDUSTRIES (ORAVI) SUMMIT 2022

PLANNING FOR ELECTRIC AVIATION:
STEPS IN MOVING FROM PETROL TO WATTS

April 22, 2022

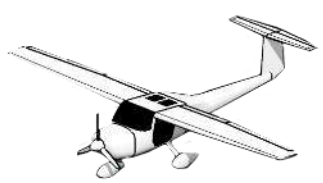
Kimley»Horn
Expect More. Experience Better.

INTRODUCTION AND AGENDA

- Defining the Market
- Recent Developments
- Impacts on Airports
- Next Steps

Defining the Market

AIRCRAFT OVERVIEW




Attributes (Average)	General Aviation and Recreational Flying	Regional and Commuter Aircraft	Vertical Takeoff and Landing Capability	Large Commercial Aircraft
MTOW (kg)	745	6,292	1,170	24,948
Near-term capacity (passengers)	1 – 9	9 – 19	1 – 5	70 – 186
Range (km)	545	870	147	2,834
Cruise speed (kt)	100	200	105	275
Power requirements (kW)	81	960	400	2,000
Anticipated market entry	Existing	2024	2024	2040+

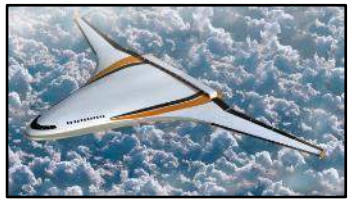
Source: Electric and Hybrid Aircraft Platform for Innovation (E-HAPI), accessed October 2021. Data reflects 42 aircraft under development (non-exhaustive list).

PATHWAY TO MARKET ADOPTION

Volocopter completed its first manned flight over Singapore in 2019, with the city set to offer flying taxi service by 2023.

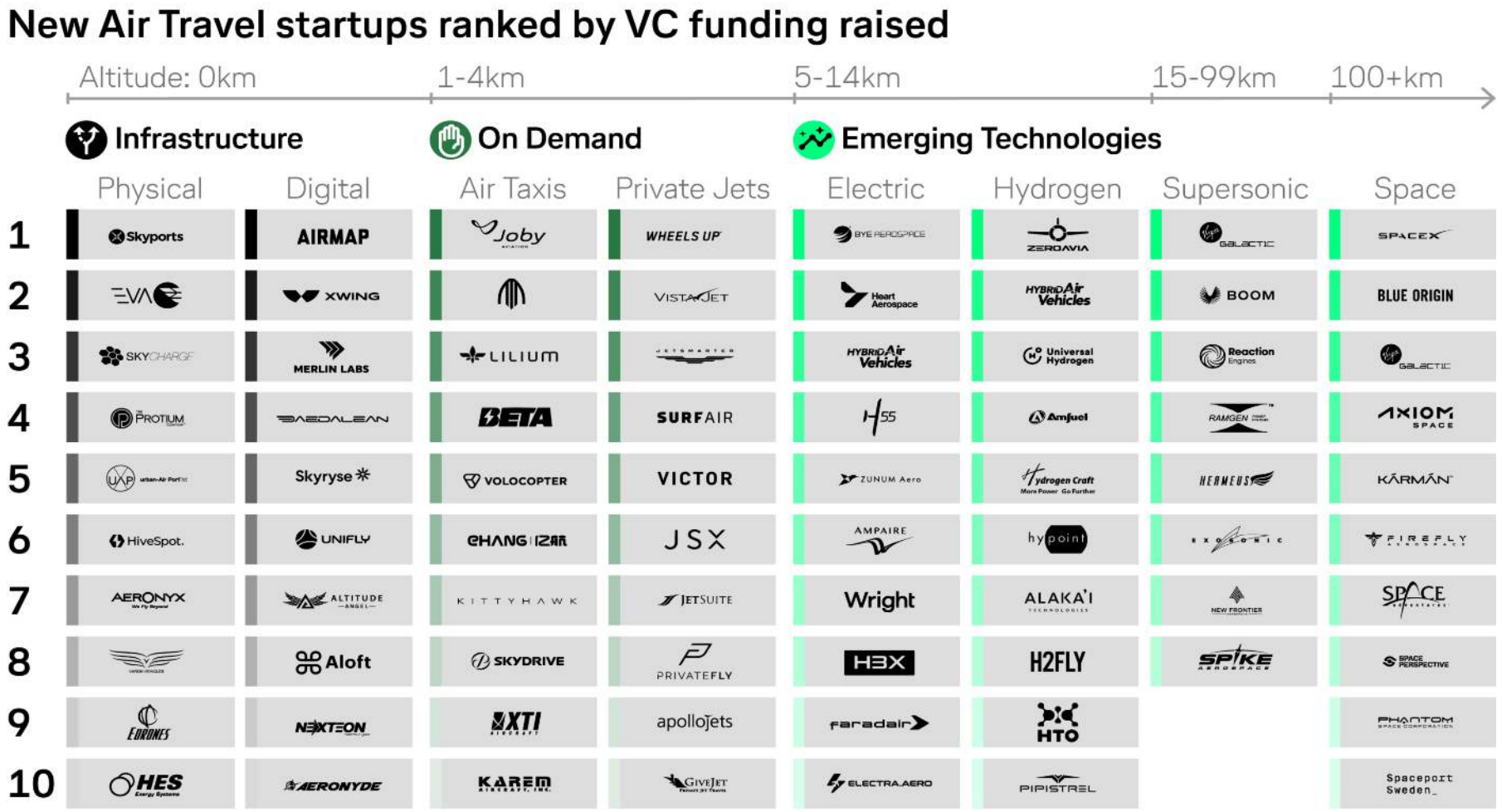
magniX and AeroTEC flew the "eCaravan", magnified by a 750-horsepower (560 kW) magni500 propulsion system, from the AeroTEC Flight Test Center at the Grant County International Airport (MWH) in May 2020.

Pipistrel Velis Electro earned the first Type Certification from European Union Aviation Safety Agency in June 2020.



Major body redesign may be required for the future passenger electric aircraft, such as this blended wing body design by NASA and Boeing.

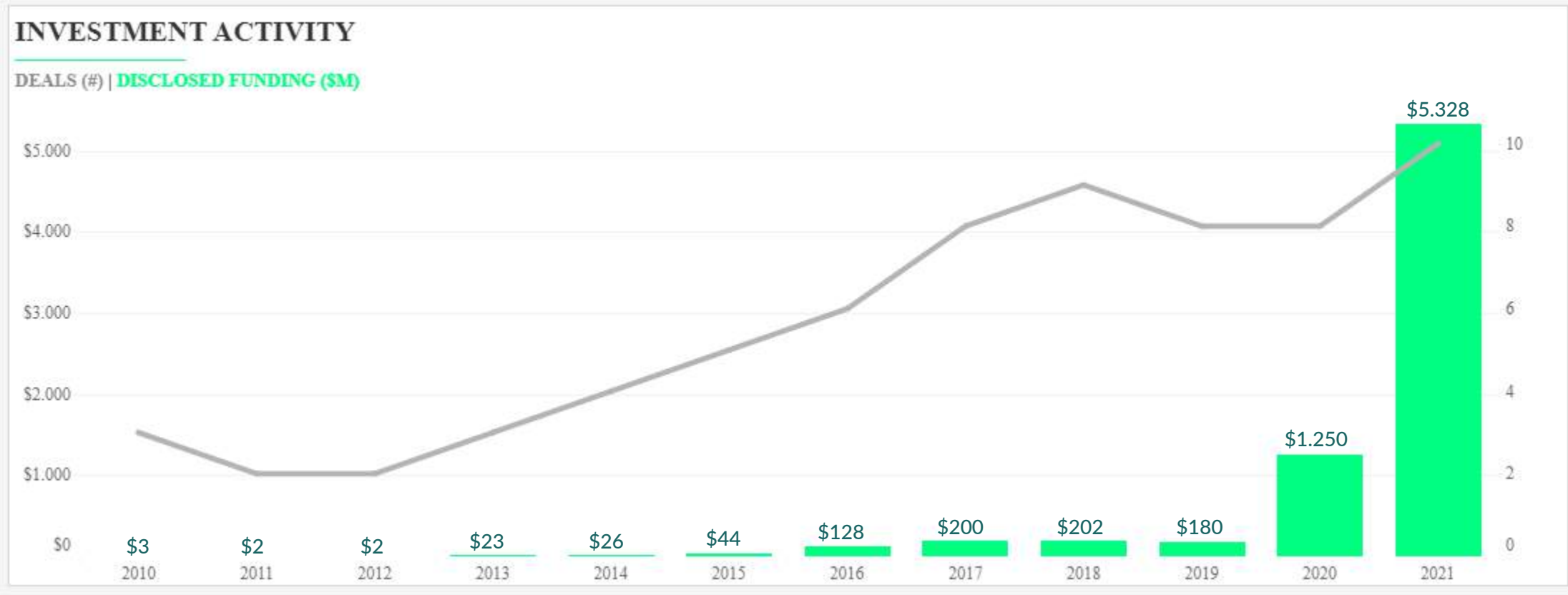
INVESTMENT LANDSCAPE



Sources: Lufthansa Innovation Hub, TNMT.com, PitchBook Data Inc.

EXPONENTIAL INDUSTRY GROWTH

Advanced Air Mobility Investment Dashboard



Source: Lufthansa Innovation Hub, TNMT.com, accessed October 2021

KEY TAKEAWAYS

- While the timeline for the electrification of regional aircraft is uncertain, significant advancements are anticipated in the next 3 – 5 years.
- The first FAA-certified electric aircraft, the Pipistrel Velis Electro, is already flying.
- Investment is increasing, including several companies securing deals in excess of $3.0B.

RECENT DEVELOPMENTS

National Renewable Energy Laboratory (NREL):
Electrification of Aircraft: Challenges, Barriers, and Potential Impacts (Oct 2021)

- Development Trajectory of Aircraft Electrification
- Case Study: Denver Int Airport

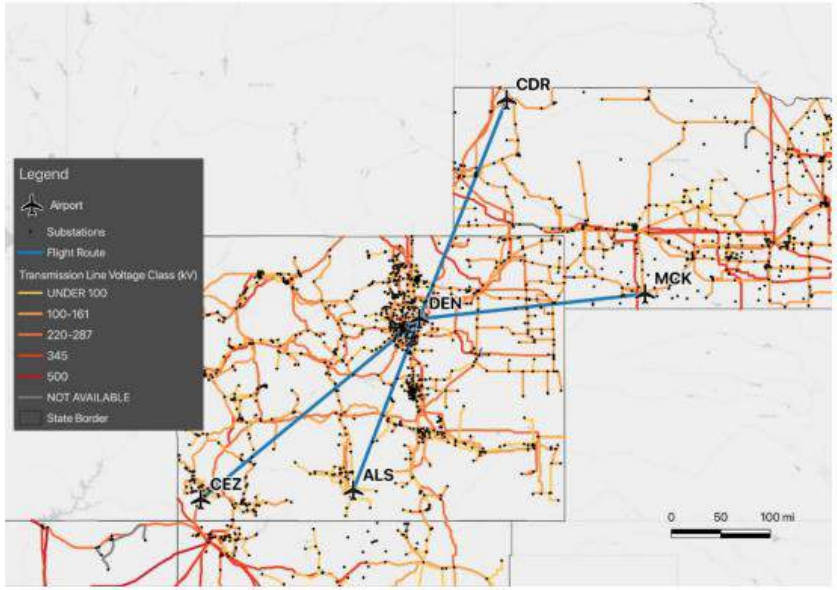


Figure 2. Case study area
Illustration by Emma Robertson, NREL

Table 1. Development Trajectory of Aircraft Electrification

Timing	Use case	Description	Companies
2020–2025	**Pilot Training**	• 1 pilot and 1 passenger • Cruise speed: ~125 mph	• Pipistrel • Bye Aerospace • Rolls-Royce
	General Aviation /Personal and Business	• 1–6 passengers • Average flight time: 43 minutes	• Pipistrel • Bye Aerospace
2025–2040	**Regional Commuter (<5 passengers)**	• Air taxi under 20 miles • Up to 4 passengers and 1 pilot • Closer to 50-mile range (eVTOL)	• Joby • Bell • Hyundai • Jaunt • Archer • Lillium • Elios • Beta Technologies • Many others (Blain 2020)
	Light Air Cargo	• Maximum payload: 7,500 pounds • Cruise speed: ~200 mph • Custom cargo deliveries (e.g., United Parcel Service, medical products, and military)	• Ampaire • magniX • Beta Technologies
	Regional (<15 passengers)	• Up to 15 passengers for scheduled and/or unscheduled operations/Federal Aviation Administration (FAA) Part 121 Commuter air service	• Ampaire • Eviation (Reid 2019); Siemens/magniX (2022) • magniX
2040–2050	**Commercial Aircraft**	• 186-seat electric aircraft	• Wright/EasyJet (2030)

https://www.nrel.gov/docs/fy22osti/80220.pdf

Airport Cooperative Research Board (ACRP):
Preparing Your Airport for Electric Aircraft and Hydrogen

- 170 electric aircraft/propulsion system project underway as of February 2020.
- 45% of all airline flights are less than 500 miles – projected range of electric aircraft by 2030.
- Regional aircraft currently in development (Eviation Alice) will likely require chargers capable of power ratings of approximately 1 Megawatt (MW)
- Larger airports may experience peak electricity demand of 10-20 MW
- Many smaller regional and local airports do not have access to high voltage transmissions lines required for fast charging.


ACRP RESEARCH REPORT 236

Preparing Your Airport for Electric Aircraft and Hydrogen Technologies

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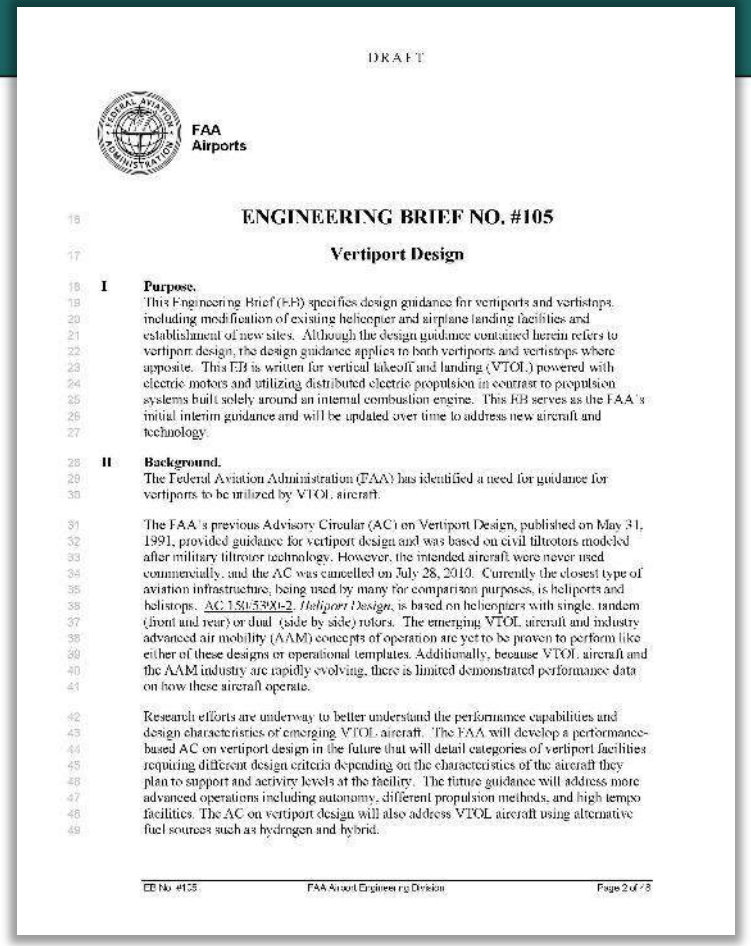
2022

Draft Engineering Brief #105, Vertiport Design

- Engineering Brief #105, Veritport Design
  - Draft released this Spring
  - Final version expected June 2022
  - Guidance for Airport Owner Operators
  - For Vertical takeoff and landing (VTOL) operations
  - Significant design details



DRAFT

FAA
Airports

ENGINEERING BRIEF NO. #105

Vertiport Design

I Purpose.
This Engineering Brief (EB) specifies design guidance for vertiports and vertistops, including modification of existing helicopter and airplane landing facilities and establishment of new sites. Although the design guidance contained herein refers to vertiport design, the design guidance applies to both vertiports and vertistops where apposite. This EB is written for vertical takeoff and landing (VTOL) powered with electric motors and utilizing distributed electric propulsion in contrast to propulsion systems built solely around an internal combustion engine. This EB serves as the FAA's initial interim guidance and will be updated over time to address new aircraft and technology.

II Background.
The Federal Aviation Administration (FAA) has identified a need for guidance for vertiports to be utilized by VTOL aircraft.

The FAA's previous Advisory Circular (AC) on Vertiport Design, published on May 31, 1991, provided guidance for vertiport design and was based on civil tiltrotors modeled after military tiltrotor technology. However, the intended aircraft were never used commercially, and the AC was cancelled on July 28, 2010. Currently the closest type of aviation infrastructure, being used by many for comparison purposes, is heliports and helistops. AC 150/5390-2, *Heliport Design*, is based on helicopters with single, tandem (front and rear) or dual (side by side) rotors. The emerging VTOL aircraft and industry advanced air mobility (AAM) concepts of operation are yet to be proven to perform like either of these designs or operational templates. Additionally, because VTOL aircraft and the AAM industry are rapidly evolving, there is limited demonstrated performance data on how these aircraft operate.

Research efforts are underway to better understand the performance capabilities and design characteristics of emerging VTOL aircraft. The FAA will develop a performance-based AC on vertiport design in the future that will detail categories of vertiport facilities requiring different design criteria depending on the characteristics of the aircraft they plan to support and activity levels at the facility. The future guidance will address more advanced operations including autonomy, different propulsion methods, and high tempo facilities. The AC on vertiport design will also address VTOL aircraft using alternative fuel sources such as hydrogen and hybrid.

EB No. #105 FAA Airport Engineering Division Page 2 of 18

https://www.faa.gov/airports/engineering/engineering_briefs/drafts/media/eb-105-vertiport-design-industry-draft.pdf

IMPACTS TO AIRPORTS

ELECTRIFICATION OF EXISTING SMALL TO MIDSIZE AIRPORTS

Opportunities

- Improved multimodal access for all Oregon citizens
- Re-engagement of small airports into the multimodal network to reinvigorate potentially under-utilized facilities
- Enhanced connectivity between western and eastern Oregon via distributed air service

Advantages

- Established land use for aviation and air traffic control
- Published land use zoning ordinances and noise abatement procedures (as required)
- Established community relationships familiar with airport operations
- Existing infrastructure and utility connectivity that can be leveraged to support new aircraft

AIRSIDE AND LANDSIDE CONSIDERATIONS

Airfield geometry

Aircraft storage

- Hangars
- Parking ramps

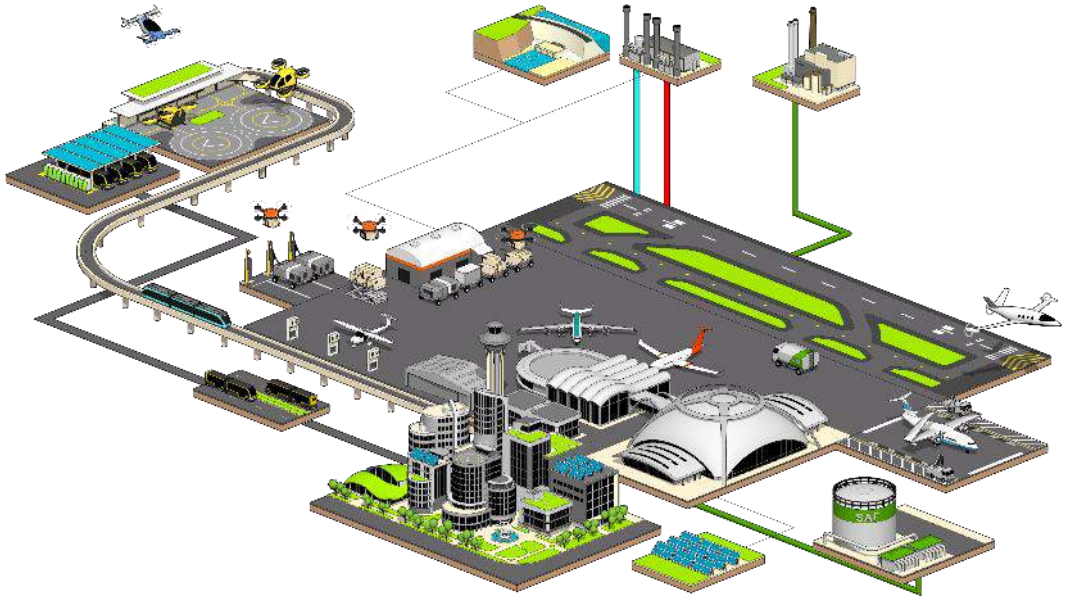
Emergency response capabilities

Passenger and pilot amenities

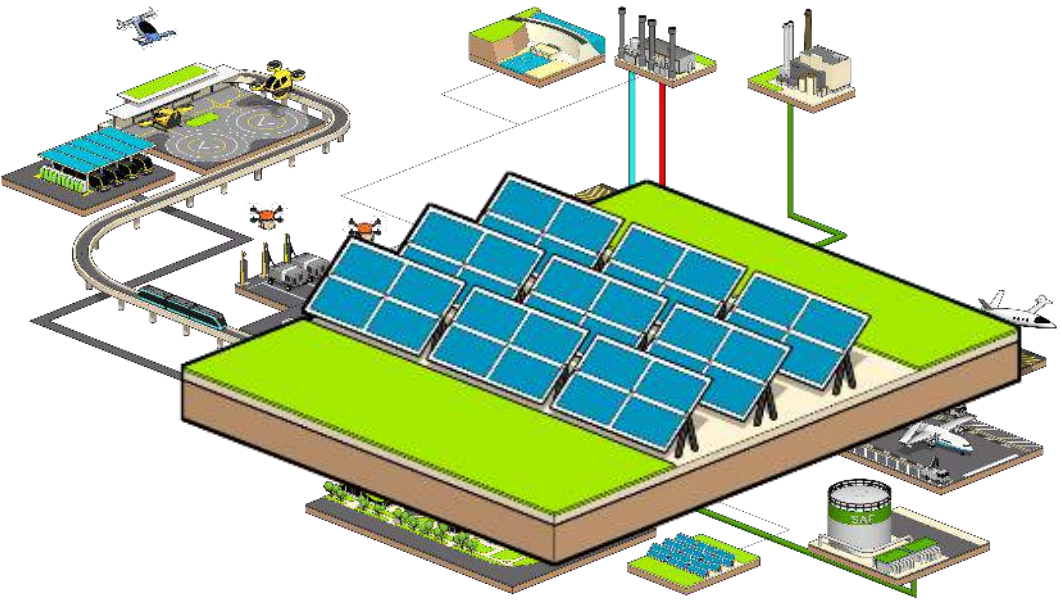
- Automobile parking
- Terminal building
- Security requirements

Air cargo handling facilities

Electrical capacity



ELECTRICAL GRID CAPACITY AND CHARGING CAPABILITY

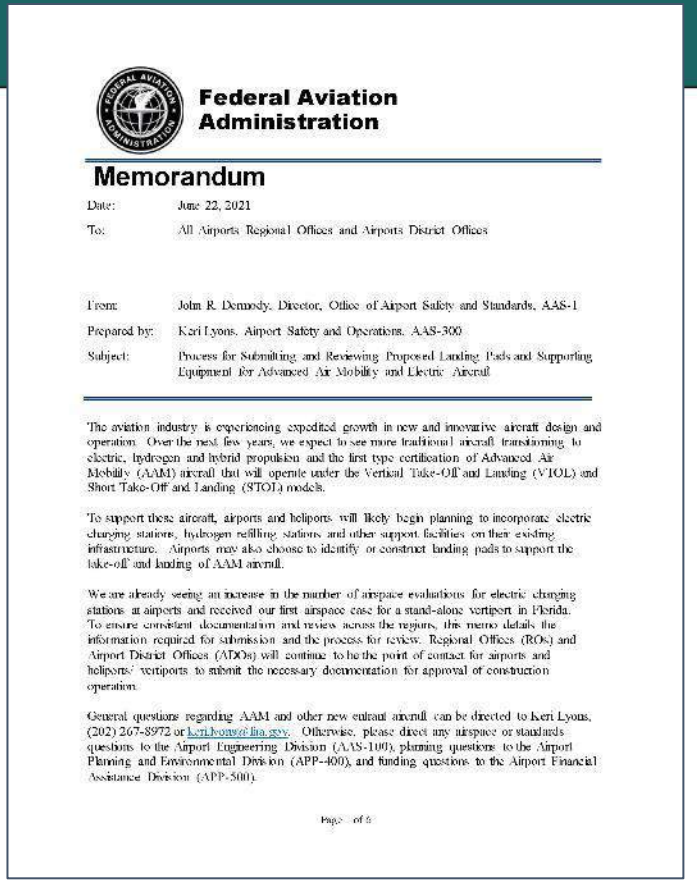


Option	Batteries	Fuel Cells
Fixed Airport Units	Charging stations	Hydrant system
Mobile Airport Units	Superchargers on trucks or trailers	Tankers or Trucks
Swap of Energy Containers	Battery swap	Container swap

POWER SUPPLY REQUIREMENTS

Configuration	Mission	Capacity	Power Requirements (Order of Magnitude) Per Number of Simultaneous Aircraft Charging Assuming Full Recharge in 45 min.				
			1	5	10	20	50
SMALL ALL ELECTRIC AIRCRAFT	Flight training, Private, Recreational	1 Pilot 1 Passenger	20 kW	100 kW	200 kW	400 kW	1 MW
	Very Short (420 miles)	1 Pilot 3 Passengers	60 kW	300 kW	600 kW	1.2 MW	3 MW
ALL ELECTRIC COMMUTER	Short (650 miles)	2 Pilots 9 Passengers	400 kW	2 MW	4 MW	8 MW	20 MW
HYBRID ELECTRIC REGIONAL	Short (700 miles)	2 Pilots 39 Passengers	600 kW	3 MW	6 MW	12 MW	30 MW

Source: WSP 2021



Federal Aviation Administration

Memorandum

Date: June 22, 2021

To: All Airports Regional Offices and Airports District Offices

From: John R. Dermody, Director, Office of Airport Safety and Standards, AAS-1

Prepared by: Keri Lyons, Airport Safety and Operations, AAS-300

Subject: Process for Submitting and Reviewing Proposed Landing Pads and Supporting Equipment for Advanced Air Mobility and Electric Aircraft

The aviation industry is experiencing expedited growth in new and innovative aircraft design and operation. Over the next few years, we expect to see more traditional aircraft transitioning to electric, hydrogen and hybrid propulsion and the first type certification of Advanced Air Mobility (AAM) aircraft that will operate under the Vertical Take-Off and Landing (VTOL) and Short Take-Off and Landing (STOL) models.

To support these aircraft, airports and heliports will likely begin planning to incorporate electric charging stations, hydrogen refilling stations and other support facilities on their existing infrastructure. Airports may also choose to identify or construct landing pads to support the take-off and landing of AAM aircraft.

We are already seeing an increase in the number of airspace evaluations for electric charging stations at airports and received our first airspace case for a stand-alone vertiport in Florida. To ensure consistent documentation and review across the regions, this memo details the information required for submission and the process for review. Regional Offices (ROs) and Airport District Offices (ADOs) will continue to be the point of contact for airports and heliports/ vertiports to submit the necessary documentation for approval of construction operation.

General questions regarding AAM and other new entrant aircraft can be directed to Keri Lyons, (202) 267-8972 or keri.lyons@faa.gov. Otherwise, please direct any airspace or standards questions to the Airport Engineering Division (AAS-100), planning questions to the Airport Planning and Environmental Division (APP-400), and funding questions to the Airport Financial Assistance Division (APP-500).

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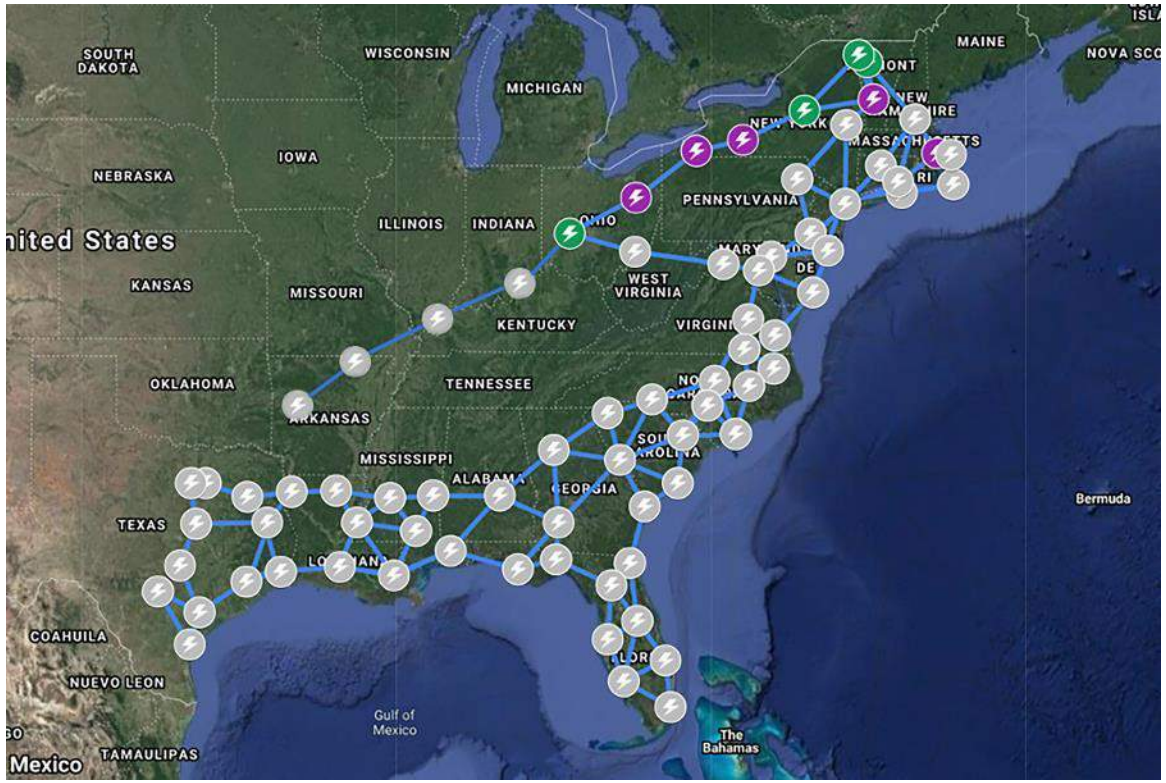
FAA Memo, Process for Submitting and Reviewing Proposed Landing Pads and Supporting Equipment for AAM and Electric Aircraft (June 22, 2021)

Electric Aircraft Manufactures – Building Out A Network

- Development of charging network
  - Small hubs/non hubs/larger GA
  - They have identified airports for their network
  - They typically know where they want to be located on the airfield
  - Typically work with either the Airport or FBO once the airport is identified
- Cost Concerns
  - Prefer locations where infrastructure in place (apron)



KEY FUNDING CONSIDERATIONS

- Electrification will impact governments' current mechanism for funding transportation infrastructure (i.e., fuel taxes)
- Questions remain as to if electric charging infrastructure is eligible for public funding
- Federal funding programs
  - Build Back Better Regional Challenge
  - Zero Emissions Vehicle Programs
  - Voluntary Low Emissions (VALE) grants (as eligible)

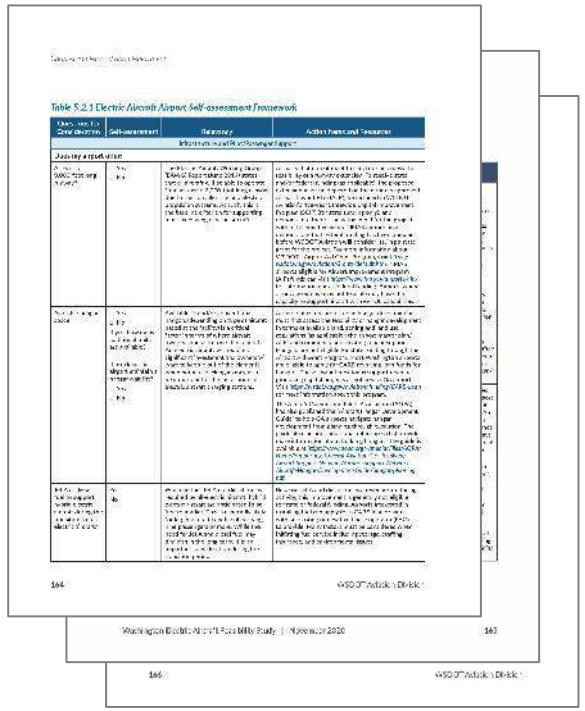
Potential Airport Funding Strategies

- Public/Private Partnerships (P3s)
- E-aircraft registration fees
- Ramp and landing fees
- Charging infrastructure user fees
- Battery swapping fees
- New opportunities for revenue generation associated with additional users, including pilots, passengers, and air cargo providers

NEXT STEPS

NEXT STEPS

- Evaluate your airport's current ability to support electric aircraft and proactively identify strategies to prepare for their arrival
  - Work with local energy company to determine what the capacity is from the transformer/substation to airport
- Participate in various emerging technology working groups, including those organized by the Vertical Flight Society, NASA, Transportation Research Board, Community Air Mobility Initiative (CAMI), and American Association of Airport Executives
- Engage local and statewide policymakers
  - Public investment for future e-aircraft infrastructure
  - Zoning and land use considerations
  - Community outreach



The Electric Aircraft Self-assessment Framework is available in the Washington Electric Aircraft Feasibility Study, Chapter 5: Demand and Deployment (Table 5.2) available on the WSDOT Aviation website

THANK YOU!

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