InterVISTAS
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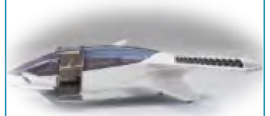
The Future of Advanced Air Mobility (AAM)

and What it Means for Airports

Electrification of aircraft with innovation-driven engineering advances and high degrees of automation are enabling new ways of transporting goods and people in urban, suburban, and rural environments, in an environmentally sustainable and cost-effective way.

This new mode of air transportation is often referred to as Advanced Air Mobility (AAM), and it is expected to revolutionize segments of the aviation industry. So, it is probably not surprising that interest in this evolution is growing globally, both from investors and engineering startups, to be part of what is already a multi-billion-dollar industry. (More than $6 billion in capital has been invested in the AAM sector in 2020 and to date 2021, alone.) According to the latest estimates by the Vertical Flight Society, there are more than 300 electric and hybrid-electric vertical and landing aircraft concepts being developed worldwide.[1]

[1] eVTOL Aircraft Directory by the Vertical Flight Society, https://dev.vtol.org/aircraft/

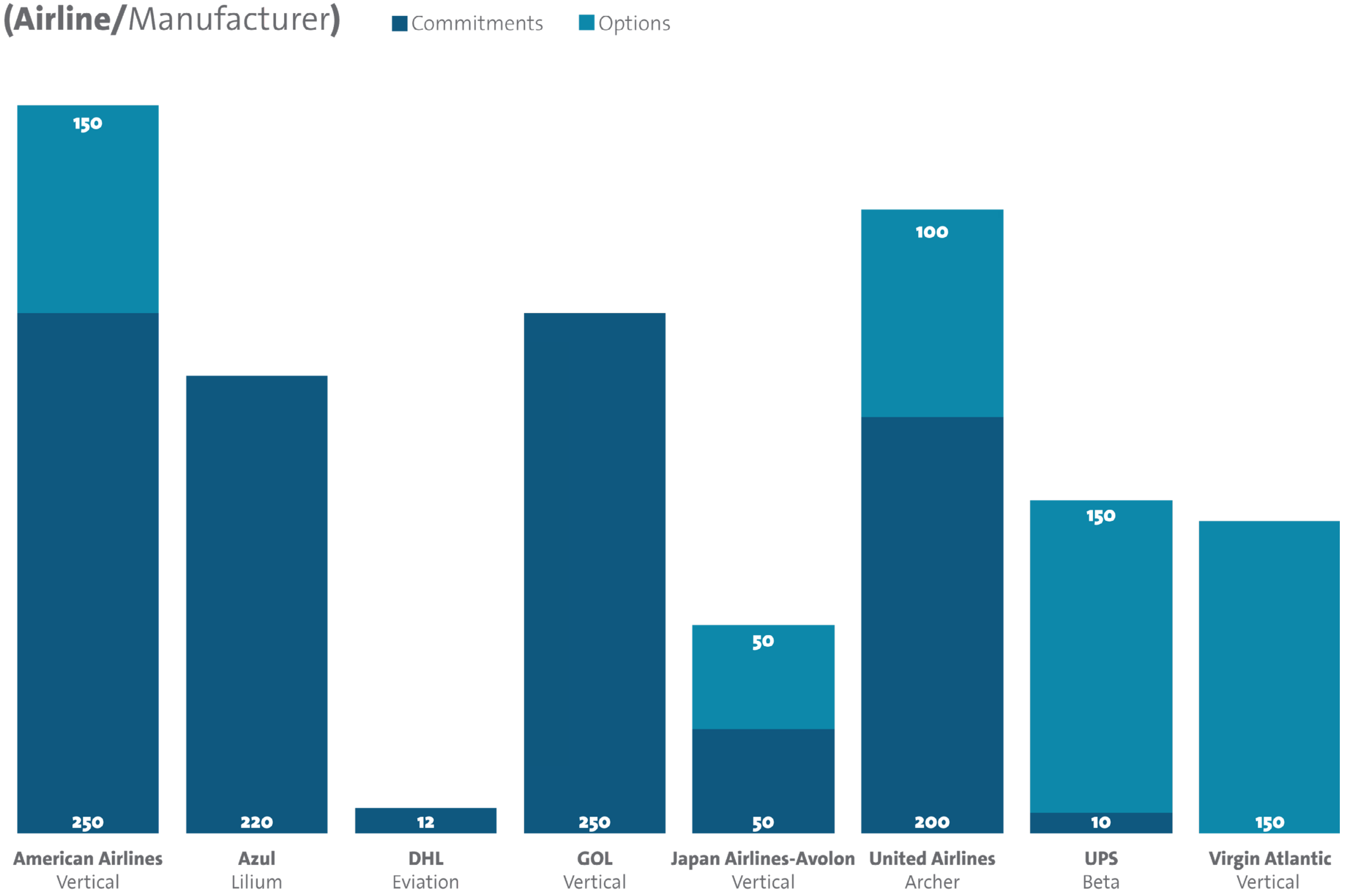
							
	VOLOCOPTER	**ARCHER**	**JOBY**	**VERTICAL AEROSACAPE**	**LILIUM**	**BETA**	**EHANG**
Country	Germany	CA, USA	CA, USA	United Kingdom	Germany	VT, USA	China
Market Cap	$620M	$1.6B	$5.3B	$2.2B	$2.6B	$1.4B	$1.4B
Number of Passengers	1 passenger	4 passengers	4 passengers	4 passengers	6 passengers	Cargo or 5 passengers	2 passengers
Operation	Piloted	Piloted	Piloted	Piloted	Piloted	Piloted	Autonomous
Range, speed	25 miles, 70 mph	60 miles, 150 mph	150 miles, 200 mph	100 miles, 200 mph	155 miles, 175 mph	250 miles	25 miles, 80 mph
Entry into service	2023	2024	2024	2024	2025	2024	2022

What is AAM and where will it be deployed first?

The first AAM use cases will likely include cargo and medical transport services, with passenger transport following. Clearly, air cargo may prove an early case, given issues regarding safety, insurance, and cautious operating models. Cargo is also more likely to operate between airports, warehouses, and distribution centers located away from residential areas, gradually building confidence and growing acceptance of these new type of vehicles among the public. As three-dimensional mobility (adding a vertical airspace component to two-dimensional ground surface travel) is expected to provide significant travel time savings, passenger transport will focus on intra-city (companies like EHang, Volocopter), inter-city (companies like Archer and Joby), and regional air mobility (companies like Vertical and Lilium). This means that large hub airports near congested cities may see AAM first as a form of shuttle service between the airport and downtown, starting with premium clientele before a wider adoption among the public. Perhaps in the more mid-term, regional and general aviation airports are also likely to benefit from AAM, preserving or enhancing regional connectivity, making flights to smaller markets a possibility. AAM could connect communities that have historically been underserved or not served at all, without substantial investment costs or real estate footprints.

AAM involves new types of aircraft operating in the airspace. In the urban environment, electric Vertical Takeoff and Landing (eVTOL) aircraft with a typical seating capacity of three to four passengers will likely be the first to enter the market. These aircraft can takeoff and land like a helicopter, but they do so with a significantly less noise and at a lower operating cost. Initially most of these aircraft are expected to be piloted (leading to faster certification and entry to market) and as technology matures, they are likely to become autonomous later in time. In the suburban and regional context eVTOL, electric Conventional Takeoff and Landing (eCTOL) and electric Short Takeoff and Landing (eSTOL) aircraft are all likely to operate. eSTOL aircraft are similar to conventional aircraft, as they do need a runway, but the required runway length can be as little as 100 to 300 feet, meaning that existing athletic fields, open spaces, and rooftops of warehouses or large buildings could serve as potential “runway” candidates.

Major Airline Orders



The promising low operating cost and the new capabilities provided by these aircraft are also attracting airlines who are committed to decarbonizing aviation in their future plans. United Airlines, American Airlines, Azul, GOL, Japan Airlines, Virgin Atlantic and UPS, among others, have already expressed interest to purchase over a thousand eVTOL aircraft. Even if only a small fraction of these orders become actual deliveries, there is no doubt that airlines see this new kind of air mobility as a key part of their product and service offerings.

Infrastructure: Crucial enabler and biggest hurdle for AAM

Infrastructure will be a crucial enabler for AAM. As a recent study by the European Union Aviation Safety Agency (EASA) found, the biggest challenge for AAM is expected to be infrastructure (ground infrastructure needed to takeoff and land, park and charge vehicles, as well as to perform necessary maintenance), followed by safety, and noise.[2] The infrastructure for AAM will have requirements both from the customer (passenger experience) and aircraft (operations) perspective.

In cities, existing heliports (helicopter takeoff and landing areas) provide an opportunity for eVTOL aircraft operations. However, the number of public use heliports is relatively low and their locations are often not ideal given that they were designed with helicopter noise footprints in mind. (The latest FAA heliport design guide, *Advisory Circular 150/5390-2C*, is based on risks associated with helicopter operations with single rotors that may not be fully applicable to AAM aircraft. The FAA's Office of Airports is currently developing a new vertiport Advisory Circular for regulatory guidance specifically for eVTOL aircraft related infrastructure, expected to be published in the coming years. Meanwhile, an interim Engineering Brief guiding document is expected in 2022.) As a result, many AAM companies are taking a different approach to infrastructure planning by designing their own vertiports (eVTOL aircraft takeoff and landing area) and forming strategic partnerships with real estate developers and operators. For example, Archer and Joby Aviation recently announced their partnership with REEF Technology to develop takeoff and landing sites for their aerial ridesharing services.[3,4] REEF is one of the largest parking garage operators in the U.S., giving access to Archer and Joby to operate from hundreds if not thousands of garage rooftop locations across large metropolitan areas in the country. In Florida, Lilium has partnered with Tavistock and the City of Orlando to build a network of vertiports and to create Lilium's first AAM network in the U.S.[5] Other companies, like Beta, are building and deploying their own network of charging stations across the country. It appears that no matter what path AAM companies take to establish the necessary ground infrastructure that supports their operations, they are mostly aiming for exclusive use, highly specialized facilities that provide the best experience to their passengers and the optimal ground support for their aircraft.

One environment, however, where multiple AAM operators and aircraft of different types and sizes may all converge, is at airports. Airports face the challenge of accommodating eVTOL, eSTOL, and eCTOL aircraft of various size and capability with various battery charging or swapping needs, into their current and future operations. As the leading aircraft manufacturing companies are targeting certification, testing, and initial entry to market completed as early as 2024, airports need to start planning for the arrival of AAM today.

[2] Study on the societal acceptance of Urban Air Mobility in Europe, EASA, May 19, 2021

[3] https://www.jobyaviation.com/news/joby-aviation-announces-infrastructure-partnership/
[4] https://investors.archer.com/news/news-details/2021/Archer-and-REEF-Team-Up-To-Tackle-Urban-Congestion-with-Vertiports-and-Urban-Air-Mobility-Networks/default.aspx
[5] https://lilium.com/newsroom-detail/lilium-partners-with-tavistock-and-orlando

Integrating AAM into the airport environment is a complex task, touching everything from parking to airspace

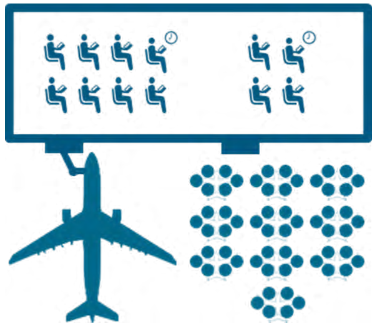
While integrating AAM aircraft into existing airport operations has the potential to bring significant benefits to the airport and the surrounding communities, maximizing the long-term added value requires early planning. Initial proof-of-concept type flights and low service volume operations may require no to very little changes to current airport infrastructure, but as more and more AAM aircraft will be deployed, the requirements and challenges associated with these operations are likely to grow as well.

Airspace integration will be a key first step toward AAM operations at airports. Just like for conventional aircraft, airports (and air traffic control services) will need to provide controlled airspace access to AAM aircraft, allowing them to operate safety and independently from each other. Large airports in busy metropolitan areas may already have rotary arrival and departure procedures established that can provide a foundation for AAM operations. However, the operational and flight performance differences between eVTOL aircraft and helicopters will need to be considered. For example, helicopters typically have a longer endurance and are capable of hovering for a longer time than eVTOL aircraft. For eVTOL aircraft vertical flight is the most battery draining phase of flight, therefore minimizing the arrival and departure stages of the journey should be key. Takeoff and landing areas will need to remain clear to minimize delays or interruptions to air traffic. Battery performance of eVTOL aircraft can be significantly extended if one end of the flight can be performed on a runway as a conventional aircraft.

Once AAM aircraft are on the ground, they will need a place to drop-off and to board passengers while charging and servicing the vehicles. Since the AAM industry is built around the idea of time savings, the aircraft staging area will need to be located such that taxi in and taxi out times for aircraft and walking distances for passengers are minimized. This will require an obstacle free environment, preferably in close proximity of passenger terminals. At large hub airports, available land is often limited, which means that repurposing existing infrastructure for AAM use is more likely than building brand new facilities. A future vertiport will likely replace an existing facility that currently serves a different function. Finding such a location or facility may be a challenge given that most airports are space constrained, and any new real estate takes careful planning and a long lead time to implement.

Terminal-based AAM operations can improve passenger connectivity, but security and other operational challenges exist

One plausible airport area for AAM operations is on the secure airside of the airport. Such locations will, of course, require that arriving passengers on eVTOL or eSTOL aircraft have already gone through some level of security screening prior to arrival. Whether a downtown hotel or a city parking garage rooftop will provide the necessary security screening service remains a question and challenge, but it appears that airside AAM operations are likely the preferred choice of location for airlines when it comes to transfer passengers. In a recent interview, United Airlines emphasized their vision of a frictionless airport transfer experience for AAM passengers, arriving on their eVTOL aircraft from New York City to Newark Airport, landing on the airside and connecting to a flight to Europe on one of the airline's new Boom supersonic jets. The costs and logistics associated with widely decentralized security "checkpoints" are not insignificant and likely to require an entirely different approach to facilitate the security of AAM departures from a myriad of locations.



Repurposing airside facilities will not be an easy task as AAM operations are fundamentally very different from traditional air carrier operations. Let's take a single boarding gate and its corresponding holdroom as an example. For simplicity, we can assume that the passenger gate can accommodate a single narrowbody jet with 180 seats and a turnaround time of 60 minutes. If this single gate were to be converted to an AAM boarding area, it would support roughly the same passenger throughput, 180 passengers per hour. Assuming that most eVTOL aircraft will carry three passengers, the equivalent AAM throughput would be 60 aircraft departures per hour. Assuming a 10-minute turnaround time for eVTOL aircraft (accounting for deplaning, boarding, and battery charging) approximately ten eVTOL departures would need to occur simultaneously from a single boarding gate to match the passenger throughput equivalent of a narrowbody jet. As mentioned earlier, time savings are the essence of AAM so it's reasonable to assume that while the narrowbody jet passengers would be at the gate 30 to 45 minutes before departure, AAM passengers would arrive only 15 to 20 minutes prior. This means that at any given time there would be approximately 30 AAM passengers boarding and additional 60 waiting for a total of 90 passengers.

As this theoretical example illustrates, AAM operations will be high frequency and low passenger volume, which creates very different facility requirements from the traditional airline setting. A repurposed boarding gate could support considerably more aircraft operations but the corresponding holdroom could be sized much smaller compared to its equivalent narrowbody airliner passenger capacity.

Fixed-base operators provide many of the requisite services, but will likely need to adapt their business models

Another airside airport location worthy of consideration for AAM operations may be at fixed-base operators (FBOs). FBOs already provide a wide range of aeronautical services, including fueling, hangar storage, and aircraft maintenance among others. Depending on local conditions, FBOs can accommodate some level of AAM demand, and some air mobility service providers have already partnered with them to lay the groundwork for future eVTOL operations. For example, Sheltair Aviation (the FBO in this instance) and Blade (the mobility service provider) have announced a strategic partnership to build the future infrastructure together.[6] Sheltair already provides helicopter landing sites for Blade at New York's JFK and LaGuardia airports.

For FBOs the most common source of income is fuel sales while additional income comes from services, such as aircraft maintenance, ground handling fees, and from real estate (mostly hangar rentals and tie-down fees).

[6] https://sheltairaviation.com/news/news-archive/

Given that AAM heavily relies on electric power, FBOs will need to work with utility providers and AAM operators to find ways of replacing the lost revenue from jet fuel and aviation gasoline sales. Some FBOs are already taking steps to accommodate electric aircraft. For example, Clay Lacy Aviation, a California-based FBO, recently signed an agreement with Eviation Aircraft to provide charging infrastructure for the Alice eCTOL aircraft at all its locations.[7] This partnership is one of the first that involves FBO support for the operations of electric aircraft. Ground handling fees and hangar rentals will likely remain important revenue streams but finding new hangar space for AAM aircraft may require new investment as at most airports, where ramp and hangar space is already at a premium, and hangar wait lists are getting longer by the day. Further, the demand for AAM facilities could also fundamentally alter the pricing structure for the general aviation segment of aviation at many airports.

[7] https://www.claylacy.com/eviation-partners-with-clay-lacy-aviation-for-alice-all-electric-aircraft-charging-stations/

Landside facilities, like garages, are attractive, but structural and operational considerations must be addressed

Landside airport locations are also a possibility for AAM operations. Many of the eVTOL aircraft manufacturers have published conceptual designs of future operations from the rooftops of airport parking garages. This location seems like an ideal choice given that parking garages are often adjacent to terminal buildings, and the elevated structure makes avoiding airspace obstructions easier. However, there are still significant challenges that need to be addressed. First, car parking is one of the pillars of airport revenue and is often the airport's largest source of non-aeronautical income. Second, as the post-pandemic air travel recovery continues, customer demand for airport parking is likely to remain strong. Repurposing parking garage rooftops for AAM operations would reduce car parking capacity and the associated revenue. If airports choose to repurpose parking garage rooftops despite continuing demand for car parking, they will need to start thinking about how best to replace the lost car parking capacity and how to generate revenue from AAM operations to offset the likely reduction in car parking income.

Considerations will also need to be given to the potential limitations of the physical garage structure itself. For example, eVTOL vehicles and passengers together with the supporting ground infrastructure (waiting area, boarding area, maintenance equipment, charging stations, etc.) may place a higher load on the structure than cars. The available space for AAM operations would be limited by the roof area of the garage. This space will need to provide the necessary takeoff and landing zones and aircraft parking positions. Space will need to be allocated for aircraft maintenance and irregular operations as well. An aircraft requiring maintenance will need to be parked outside of the operating area and may need to be moved for servicing or repairs. In addition, parking garages typically have roof-top light poles and some (such as the Boston Logan – Terminal B garage) have solar panels installed on the roof of garages that would need to be relocated to provide space for AAM operations. Since most AAM aircraft use electric batteries, airports will need to provide electric aircraft charging solutions, in this case, installed on the top of parking garages.

The power requirements vary based on the equipment loading, the charger power and the electrical grid infrastructure capacity and size along with the unique characteristics of each AAM aircraft (different type of eVTOL aircraft may have different battery sizes, different charge rates, and different plug types). Airports should engage with local authorities and electricity providers early to evaluate power grid capabilities and to make the necessary utility infrastructure upgrades to ensure that sufficient power will be available at the selected sites. Such considerations may also need to account for the additional power requirements associated with future electric car chargers located on other levels of the parking garage. These utility investments will need to integrate renewable energy sources to meet the sustainability goals of both AAM providers and forward-thinking airport operators. Last, but not least, the hazards associated with electric aircraft, and lithium-ion battery storage and charging are also different from those associated with liquid fuels. Therefore, new emergency response procedures will need to be developed with consideration for suppression methods and agents, as well as for clean-up operations.

Integration of AAM into existing operations and the related facility requirements will require airports to start planning early as the challenges associated with this new type of air mobility are unique.

However, this also provides an excellent opportunity to reinvent the passenger experience and to build a welcoming and supportive infrastructure that enhances the broader transportation network. Airport operators should embrace this innovation to enhance their business, leverage investment capital from the AAM manufacturers, and evolve their service offering.

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