LOOKING FORWARD TO TOMORROW'S WORLD

A BRIEF JUMP THROUGH THE JOURNEY OF VERTICAL FLIGHT, FROM BALLOONS TO eVTOLS

by Richard Hakes, Ashleigh Standen & Daniel Sahraee

Takeaways

- Advanced air mobility has the potential to bring about the next significant change in mobility, and many players have already developed and financed viable aircraft
- $8 billion of capital has flowed into the development of electric vertical take-off and landing (eVTOL) aircraft over the last five years, with the cargo market expected to reach $58 billion by 2035
- AAM feeds nicely into the current hot topic of ESG as this new form of transport will reduce the environmental impact by minimising emissions and noise pollution

Captain Vincenzo Lunardi with his Assistant George Biggin, and Mrs. Letitia Anne Sage, in a Balloon.
Oil on copper by John Francis Rigaud (1785) - Yale Center for British Art, Paul Mellon Collection

When in 1784 Vincenzo Lunardi, the 'Daredevil Aeronaut', demonstrated a hydrogen balloon flight from the Artillery Ground of the Honourable Artillery Company in London, a short walk from Reed Smith's London office, he found instant fame as he completed the first manned flight over England. Watched by other luminaries of the day, including the then Prince of Wales and, reportedly, a crowd of 200,000, he travelled as far as Hertfordshire, fuelling in the process a ballooning fad that gripped the nation. Lunardi travelled with a slightly under-inflated balloon (taking off prematurely because of the crowd's impatience), a dog, a cat and a (caged) pigeon (although he did stop briefly to release the by-then rather airsick cat). By this stage the French had been ballooning for a year, but many of the attempts had been so heroically unsuccessful as to lead to significant scepticism for this new fad and many dismissed Lunardi's experiment as merely an amusing entertainment. Not all of Lunardi's experiment went according to plan: he had anticipated being able to row the balloon through the air and so had brought along a variety of oars with him to do so. Perhaps it is unsurprising against this backdrop that Lunardi's efforts were met with a mixture of admiration, fear, amazement, pity, incredulity and disbelief.

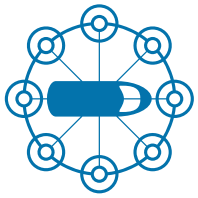
Today, like Lunardi's crowd, the Prince of Wales, and the cat, we stand at the dawn of a new era of aviation. Advanced air mobility represents the next inflection point in aviation's continual evolution. Despite our clear cultural affection for the vertical take-off – from balloons, to the Harrier jump jet, through to Elphaba's broomstick and Superman – we have a hard time accepting that it could become part of our daily lives. Mention the prospect of delivery drones, unmanned aerial vehicles, or of hopping on an electric-powered flight to go to the pub and you are likely to be met with a look that says "dream on". But, despite a lack of real awareness of this technology, AAM has the potential to bring about the next significant change in mobility and perhaps the global economy, promising to transform how people and cargo are moved. In the United States alone, the AAM market is forecast to be worth $115 billion annually by 2035, creating more than 280,000 high-paying jobs.

The ‘aircraft’

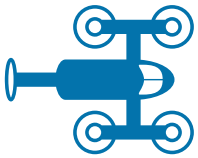
Developing out of small, unmanned (drone) aircraft a race is underway to develop larger electric vertical take-off and landing (eVTOL) aircraft, which will be capable of operating between places not currently or readily served by surface transportation or existing aviation.

Expected to eventually be unmanned and autonomous, eVTOL aircraft are runway independent, and incorporate non-traditional electric or hybrid propulsion. As anyone with an electric car will have realised, electric motors (and potentially, eventually, hydrogen fuel cells) and streamlined controls can greatly simplify a propulsion system and improve mechanical reliability, while in the process substantially reducing costs. This reduces the environmental impact by minimising emissions and noise pollution.

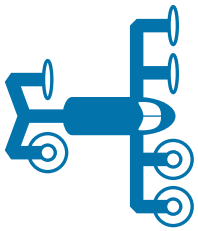
There are several configurations being developed in the eVTOL market. These include:



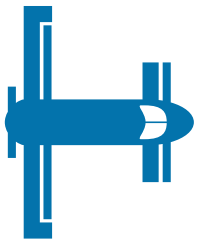
Multi-rotor – efficient to take off and land (but less so to cruise due to the lack of aerodynamic lift). These are slower and have the shortest range, but are easiest to certify.



Lift and cruise – a simple design and arguably the most reliable. These aircraft are expected to be easier to certify and easier to maintain, but are less efficient (due to the extra mass and drag coming from the lifting rotors) and so have a shorter range.



Tilt rotor – capable of higher speed and longer range, but more complex and thus more challenging to certify.



Vectored – efficient, long range but energy intensive and noisy (and may require new battery technology to be truly viable).

Market landscape

As Domhnal Slattery, chief executive of the aircraft leasing company Avolon, told Reuters in an interview this year, "If you think about transportation strategically this is the next big frontier". It is a frontier being explored by a combination of entrepreneurs, giants of aerospace and global logistics companies, like Airbus and Boeing (Aurora), Amazon Prime, DHL, a major U.S. postal company and even an online food ordering and delivery service.

Much like the early aeronauts and their balloon designs, at present there is no single dominant design or business model in the eVTOL market. Broadly, each of the key players is targeting certification before 2026, but there has to be real uncertainty around the timeline for those manufacturers that have no experience of certifying an aircraft, let alone the challenges of entering mass production.

However, there have been significant developments and commitments that give us an indication of what is possible. For example, one of the top three global leasing companies has signed an order for up to 500 eVTOLs valued at $2 billion with Vertical Aerospace, an eVTOL maker backed by investors including major airlines. Vertical reportedly has pre-orders for up to 1,000 eVTOL aircraft, along with a pre-order option from Virgin Atlantic, all valued at up to $4 billion.

The designer and manufacturer/developer Wisk is noteworthy as it has achieved a number of 'firsts', in particular the first flight of an all-electric, autonomous eVTOL aircraft designed for passenger use in the United States. Boeing has invested in the company, and it is telling that while some companies building eVTOL aircraft are starting with a manned aircraft with the goal of later transitioning to an unmanned aircraft, Wisk is going straight to self-flying notwithstanding that will mean it is later to the market. Wisk has surpassed 1,500 test flights, entered a partnership with NASA, partnered with Boeing (Aurora), and built and flight-tested two new aircraft, bringing Wisk up to nine full-scale aircraft.

Germany's Lilium Jet first flew its full-size, two-seat Eagle prototype in 2017, and a five-seat version in 2019. Lilium has already achieved more than 100 flights, and has more than 700 employees. A six- or seven-seat production version is planned for 2025 as a flying taxi, with a range of more than 150 miles.

Jody is intended to be a four-passenger commercial aircraft with a pilot, capable of travelling up to 150 miles, and Joby Aviation and the parent company of a leading American mobility provider have agreed to integrate their services (Joby will now transport passengers in the New York area to JFK airport), and the American mobility provider must invest $125 million.

Archer is developing multiple models of eVTOL aircraft focused on improving mobility in cities. Its five-seat eVTOL aircraft is capable of carrying four passengers for up to 60 miles using today's battery technologies. In February 2021, Archer announced it would start an air taxi service in Los Angeles by 2024. Los Angeles is also one of United Airlines' major hubs, so it should come as no surprise that United Airlines now has an agreement to work with Archer, contributing its expertise in airspace management to assist Archer with the development of battery-powered, short-haul aircraft, together with a commitment to a purchase agreement worth potentially in excess of $1 billion to acquire a fleet of 200 eVTOLs, which are expected to give customers a quick, economical and low-carbon way to get to United's hub airports and commute in dense urban environments within the next five years.

Brazilian aircraft manufacturer Embraer has designed, developed and certified close to 50 aircraft models, delivering over 8,000 aircraft to over 100 countries. Embraer formed EVE as a breakaway subsidiary from its EmbraerX technology incubator, having already signed letters of intent for over 1,000 aircraft, with the number still growing, which is arguably the largest order book in the market. For example, Avantto, the largest operator of Embraer executive jets in Latin America, has signed a letter of intent with Eve for 100 of its eVTOL aircraft, and Bristow, a Texas-based helicopter operator, has similarly placed a conditional order for up to 100 aircraft from Eve, with deliveries expected to start in 2026.

CityAirbus NextGen is an all-electric, four-seat 'lift and cruise' configuration eVTOL with an 80 km range and a cruise speed of 120 km/h, making it well-suited to flight operations in major cities, providing city commuting and an efficient air transport service between strategic locations in urban and suburban environments. Given their market position in commercial aviation, Airbus is, perhaps unsurprisingly, also focussed on a comprehensive approach that goes beyond just the aircraft to the rest of the ecosystem, including traffic management, routing, and noise mapping.

Attractive asset class

Some $8 billion of capital has flowed into the development of eVTOL aircraft over the last five years, with the average deal size growing from approximately $20 million in 2019 to over $300 million in 2021. It has been estimated that the global addressable market for eVTOLs will reach $1 trillion in 2040, increasing to $9 trillion by 2050, with applications including urban transportation, 'final mile' logistics, short-haul airline flights and defence. Indeed, by 2040, 830,000 eVTOL units are expected to be operating in the skies above the U.S. alone. KPMG examined 25 developed countries to gauge their readiness for the use of 'air taxis' in short-haul passenger transport and concluded that eVTOLs will likely revolutionise urban mobility around the world in the coming decades.

Market commentators consistently forecast a compound annual growth rate of well over 10 percent for the urban air mobility (UAM) market in the near future. The drone package delivery market alone is projected to grow from $2.1 billion in 2023 to $27.4 billion in 2030. By 2026, eVTOL air taxi developers Joby Aviation and Archer each predict annual revenue in excess of $2 billion. Lilium and Archer have gone further with their predictions, with Lilium anticipating nearly $6 billion in revenue in 2027 and Archer targeting more than $12 billion by 2030. To put that into perspective, the world's leading helicopter manufacturer (Airbus Helicopters), which has a large certified product line and established support business, has revenue of around $6.2 billion. In addition, PitchBook forecasts that the global air taxi passenger mobility market will grow from approximately $1.5 billion in 2025 to more than $150 billion by 2035.

SPAC to the future?

The eVTOL companies that secured significant investments prior to the COVID-19 pandemic typically raised capital through seed, Series A, Series B and Series C funding rounds with external investors who were offered equity or part ownership in the company. A growing number of companies across the AAM industry are looking to merge with a special purpose acquisition company (SPAC) that is already publicly traded to raise funds. Since late 2020, at least a half-dozen companies active in the AAM sector have announced, or it has been rumoured, that they intend to complete a business combination with a SPAC.

Archer was the first eVTOL developer to jump on the SPAC bandwagon, announcing its plans in early February 2021, followed not long after by Lilium, which agreed to go public via a reverse merger with a SPAC, Qell Acquisition, founded by former General Motors executive Barry Engle. Joby, Archer, and Lilium are all part of a wave of technology start-ups going public through combinations with SPACs. Archer, Jaby and Lilium alone had an aggregate post-money valuation in excess of $13 billion.

Freight and cargo

AAM will bring cutting-edge, dual-use technologies that promise to provide affordable mobility for various commercial, civil, and defence purposes. Whether through the delivery of goods in urban environments, improving accessibility for remote population centers through passenger and cargo mobility, or providing an entirely new (and green?) passenger travel mode within a city, AAM can make these flights a part of daily life.

The AAM cargo market is hotly tipped to grow and achieve scale before the passenger market, and is expected to reach $58 billion by 2035. In some respects, cargo delivery – especially in less populated areas – is a much safer space in which to develop eVTOL technology, so that lessons learned in safety and reliability can then be applied to passenger services, such as air taxis, for which there is expected to be high demand in more populous urban centers. Such demand would generate high passenger load factors and revenue yields, it is hoped.

It is important to note that even though the technological factors driving passenger and cargo mobility are similar, the adoption curves will likely be different, primarily due to the uncertainties surrounding regulation and overall societal acceptance. Cargo mobility could have significantly greater near-term adoption than passenger mobility due to the lower psychological barriers and fewer regulatory hurdles related to safety. The primary driver for cargo AAM adoption and usage will likely be the level of autonomy, speed, and efficiency with which cargo eVTOLs can operate. Transporting people in autonomous eVTOL aircraft will then in due course build on the success of transporting cargo. From there, the technology will be able to facilitate missions beyond passenger and cargo mobility, including public safety operations, humanitarian relief, and infrastructure inspection.

Green dreams

It is all too apparent that aviation needs to be reimagined to align with the global environmental agenda. Twenty countries launched the International Aviation Climate Ambition Coalition (IACAC) at COP26 on 10 November 2021, committing to working with each other and through the International Civil Aviation Organization (ICAO) "to reduce aviation CO_2 emissions at a rate consistent with efforts to limit the global average temperature increase to 1.5 degrees C". A major focus of this commitment will be the development of more fuel-efficient aircraft, and less reliance on carbon derivative fuels.

As we emerge from the COVID-19 pandemic, air travel will be materially reshaped with airlines needing to embrace emerging technologies that decarbonise air travel. NASA has expressed the view that the advent of greener technology will make smaller, cleaner aircraft more affordable, and that it expects more passengers to take to the air for 50-500 mile journeys. The imperative to look for more sustainable forms of transport offers a springboard for the global aviation industry, an opportunity rather than a threat. McKinsey has forecast that this activity will center in underused regional airports rather than the big hubs, which is no surprise when in the United States, 90 percent of the population lives within 30 minutes of a regional airport (compared to 60 percent being within 30 minutes of a major airport). Even in Europe, 50 percent of people live within this 30 minute travel time. Overall, more affordable and greener air travel using less busy, more accessible airports will be a spur to air travel. This places AAM squarely at the forefront of a more sustainable aviation industry, accelerating the commercial roll-out of zero-emissions aircraft, enabled by eVTOLs. With its electric propulsion technology and new green fleet, coupled with an ability for point-to-point operations, AAM can advance progress toward zero-emission flight, enabling the aviation industry to lead in the creation of a more sustainable mode of transport.

Regulatory position

A self-flying aircraft is a new concept for everyone, including the regulators, and the complexities and costs associated with certifying eVTOLs make Lunardi's battles with rowing oars and airsick cats seem simple in comparison.

The European Aviation and Space Agency (EASA) has pioneered VTOL certification through the issuance of a Special Condition on 2 July 2019. In the preamble to the Special Condition, EASA summarises the problems many certification authorities currently face when attempting to draft type certification regulations: "[VTOLs have] the design characteristics of aeroplanes, rotorcraft or both" meaning that EASA was "not able to classify these new vehicles as being either a conventional aeroplane or a rotorcraft as covered by the existing certification specifications".

Notwithstanding these challenges, EASA has developed certification requirements, which apply to "small VTOLs" with the Special Condition applying to aircraft with:

1. A passenger seating configuration of nine or fewer; and
2. A maximum certified take-off mass of 3,175 kg.

This is of course just a step in a process that will enable a regulatory framework for the safe operation and certification of VTOL aircraft in Europe. Elsewhere, the Civil Aviation Administration of China (CAAC) has announced that it will issue guidance on unmanned aerial vehicle airworthiness certification after consulting with five Chinese VTOL manufacturers. The extent to which the CAAC regulations will also cover manned VTOL operations is still under consideration.

There are significant differences in the certification requirements of EASA and the U.S. Federal Aviation Authority (FAA) and the 'baseline FAA aircraft' may require some limitations or changes to the design to gain EASA certification. Requirements from all regulators are being collated and considered, with provisions of mandatory modifications and Service Bulletins to be incorporated to remove any limitations in the future. Delays to EASA certification could have a wider impact, limiting global application.

Legal governance and legislative development

The legal issues surrounding UAM and eVTOLs are myriad and include:

- Risk allocation and liability for damage caused by accidents (as to which, see below)
- Contractual arrangements with end users (i.e., passengers or shippers)
- Cyber security and physical safety due to closer operating proximity to potentially malicious actors
- Environmental law applicable to noise and land uses
- Responsibility for inspection (particularly of unmanned eVTOLs)

Regulators must also consider the longevity of SPAC vehicles, the rigorous and costly certification process and whether current regimes are fit for purpose. In particular, the U.S. Securities and Exchange Commission (SEC) has warned that SPACs and the companies they combine with may face liability risks for projections they make during the combination process, despite the widespread impression that forward-looking statements made during the 'de-SPAC' transaction do not carry the same liability exposure as they would in a conventional initial public offering. In a statement published in April 2021, John Coates of the SEC commented that "any simple claim about reduced liability exposure for SPAC participants is overstated at best, and potentially seriously misleading at worst". He feared that "participants may not have thought through all the legal implications of these statements under the circumstances of these transactions".

Insurance coverage

The liability regimes for the carriage of passengers and cargo on board traditional civil aircraft have developed since the origin of commercial flights in the 1920s. International efforts have led to the development of recognised legal regimes, such as the Warsaw Convention 1929 and the Montreal Convention 1999, with principles from both conventions regularly incorporated into national laws concerning domestic carriage. However, recent lessons learnt by the insurance community from developments in the UAV/drone market have demonstrated that traditional policy wordings (such as AVN1C) are probably not fit for purpose when it comes to insuring new technology, such as eVTOLs, and new insurance policy wordings will need to be developed.

While hull and physical damage coverage is likely to be similar to existing aviation coverage, liability will be different by virtue of eVTOLs operating at lower altitudes above densely populated areas. Operators' liability exposures could be significant in the event that an accident occurs in a busy urban environment, due to the potential to cause injury to not just passengers but also property and individuals on the ground or in nearby buildings. Whilst historically air crashes have thankfully been infrequent, with eVTOLs operating more like a road-going car, there is clearly an exponentially greater risk of accidents, and the associated costly claims. Can this be met with a traditional aircraft policy with new endorsements, or will it, as we assume, be a new policy and product altogether?

Manufacturers and operators will also need to consider how to apportion liability among themselves, as well as the risks that can be passed on to end users via their contractual ticketing arrangements. A careful balance will need to be struck because overly robust indemnity and liability wording could significantly undermine confidence in the industry and would no doubt be met with resistance from regulators and legislators (if not already fettered by consumer protection legislation). It seems likely that new laws will be required to deal with matters such as minimum liability requirements, which will be crucial to the development of a safe environment in which the industry can develop and generate revenue, while also overcoming a barrier to the public's adoption.

Closing thoughts

The vertical take-off has come a long way since Lunardi's flight in 1784.

Like the balloon, the jet engine and other technology before and since, it is anticipated that AAM will revolutionise air transportation in the coming years, and there is a pressing need to act now to understand the legislative, regulatory, and infrastructure needs of this emergent technology.

In the United Kingdom, the government has stated its intention for the UK to be a world leader in shaping the future of transport, passing the Air Traffic Management and Unmanned Aircraft Act 2021 in April 2021. Going further, in October 2021 the UK Civil Aviation Authority announced an industry consortium looking into eVTOL safety, with members including Virgin Atlantic, Joby, Vertical Aerospace and NATS (the primary provider of air traffic control services). In the United States, in November 2021, two new bills were passed in the United States, focussed on the AAM sector. In particular, the House of Representative's Advanced Air Mobility Coordination and Leadership Act calls for the development of an interagency working group to help the federal government develop a strategy to promote AAM. The bipartisan legislation is expected to help advance the sector in the expectation that AAM will provide additional transportation options, create jobs and advance environmental sustainability. A similar bill was passed by the Senate Committee on Commerce, Science and Transportation. Beyond aircraft certification, these bills reflect the ever-increasing recognition of this exciting emerging sector, which brings economic, infrastructure and workforce opportunities, but also potential physical and digital security risks that will need to be carefully identified and mitigated.

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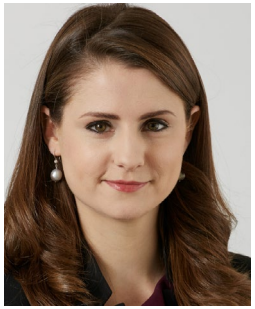

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