Title

A comprehensive overview of global start-ups for Advanced Air Mobility

Abstract

An electric revolution is taking place in the aircraft sector. Rapid advances in the energy density and production costs of lithium-ion cells are enabling a new category of electric aircraft that can take off and land vertically like a helicopter, but with less noise, no emissions, at a much lower price, and with greater safety.

These so-called eVTOL (electrical Vertical Takeoff and Landing) aircraft do not require complex infrastructure and are thus paving the way for a new market segment in aviation, which NASA refers to as **Advanced Air Mobility (AAM)**.

NASA defines AAM as **sustainable air transport** at **low altitudes** up to 3000 m and over **short distances** of up to 800 km. Typical applications are the transport of people and goods, as well as work in the air.

More than **30 eVTOL** start-ups have already been founded worldwide for **passenger transport alone**, hoping to tap into new business opportunities. The **diversity of designs** is reminiscent of the Cambrian explosion, an era in Earth's history characterized by particularly high species diversity: There are eVTOLs with and without wings, those with fixed and those with tiltable propellers, small ones for private use and larger ones for commercial aviation.

In our presentation, we provide a comprehensive, ***vendor-independent*** overview of all major AAM startups involved in **passenger transportation**. We will structure them according to their technical design, use cases, and business models. Although companies are reluctant to disclose technical details, we will attempt to summarize the battery and lithium-ion cell technology used.

Like in other high-tech areas such as chip manufacturing or the production of lithium-ion batteries, there is a technological race and a fierce **geopolitical competition** in which North America, Asia, and Europe are vying for market dominance.

The United States and China are massively accelerating their AAM ecosystems through significant government funding, regulatory support, and early operational deployment. China has announced that its government will actively promote the development of the **low-altitude aviation economy** as a strategic growth engine in its latest **five-year planning** documents.

The challenges in Europe are underscored by recent developments, as the German pioneer **Lilium** filed for insolvency, while the assets of **Volocopter** were acquired by the Chinese Wanfeng Group via its Austrian subsidiary Diamond Aircraft, highlighting a strategic shift in control.

Europe must urgently harmonize its certification and infrastructure efforts to avoid losing the AAM race to international competitors and to regain a strategic foothold in this critical future industry.

1. Introduction

Fig.1 – AAM use-cases illustrated in NASA reference document
(Source NASA)

Figure 1 illustrates typical AAM use-cases listed in the Nasa reference document [1], which are

- passenger transports from the airport into the city center,
- on-demand transport by air taxis,
- emergency response to accidents,
- cargo transport by drones, and
- aerial assignments, e.g., construction work or firefighting.

Of course, the increase in air traffic in urban areas is putting new demands on how to coordinate manned and unmanned air traffic control. **U-space** is Europe's digital framework for managing Uncrewed Aircraft Systems (UAS) and passenger eVTOLs. Simultaneously, NASA in the US is actively developing and testing systems for AAM airspace management and system-wide safety with industry and government partners like the FAA.

In addition, a certain amount of **ground infrastructure** is required for eVTOL takeoff and landing. The new term "**vertiport**" has become established here, referring to landing pads on the ground or on buildings.

Both aspects, flight regulation and AAM ground infrastructure, are not covered in this publication, as we will focus on the flying devices here. Readers who are more interested in the U-space concept are referred to the ESA documents [2], while those who would like to learn more about AAM ground infrastructure are recommended to read a recent overview article by Di Mascio [3].

1.1 AAM aircraft designs

AAM – Aircraft Properties

*Including Pilot

eVTOL – electric Vertical Takeoff and Landing
eCTOL – electric Conventional Takeoff and Landing
eSTOL – electric Short Takeoff and Landing

VFR – Visual Flight Regulation
IFR – Instrument Flight Regulation

EV-Portal.net

Type	Multicopter	Wingbased eVTOL			E-Plane
Propeller Configuration	Vertical rotors, wingless	Horizontal and vertical rotors	Vertical and tilting rotors	Tilting rotors	Horizontal rotors, BEV or hybrid powertrain
Takeoff / Landing	eVTOL	eVTOL	eVTOL	eVTOL	eCTOL, eSTOL
Agility	+++ Very high	++ High	+ Medium	+ Medium	0 Normal
Capacity [#Passengers]	2 - 3*	4 - 6*	4 - 6*	4 - 6*	4 - 30
Range	~50 km	~200 km	~200 km	~200 km range	~400 to 800 km
Flight Regulation	VFR	VFR + IFR	VFR + IFR	VFR + IFR	IFR
Manufacturer	Ehang, SkyDrive, Volocopter	Airbus, Autoflight, Beta Tech., ERC, EVE Air, Horizon Air, Jaunt Air	Archer Aviation, Vertical Aero, Wisk Aero	Joby Aviation, Supernal Aero	Beta Tech., Electra, Heart Aero., Vaerdion
Roots	Toy drones	Helicopter/Plane	V-22 Osprey	V-22 Osprey	Plane

Fig. 2 – Aircraft types for AAM passenger transport

Figure 2 shows the different types of AAM aircraft designs currently being developed by start-ups and their typical properties such as the propeller configuration, takeoff-and-landing properties, agility, capacity, mission types and range, and flight regulations.

At the highest level, we can distinguish between **three classes**. **Multicopter**, **wing-based eVTOL** and traditional **planes** equipped with an electric drive train:

- **Multicopter** are wingless aircraft that are directly derived from toy drones. They are extremely agile in the air and can fly in all directions—forward, backward, sideways—at the same speed. They have a limited range because, since they have no wings, the vertical propellers must constantly provide lift, which requires a lot of energy.
- **Wing-based eVTOLs** have more range than multicopter, as they have wings which provide lift during horizontal flight. However, their agility is lower compared to multicopter, as their capability to fly backwards or sidewards is limited.
  There are three design variants for the propeller configuration (PCx), which we will examine in more detail in section 3.
- **E-planes** are like conventional aircraft with conventional takeoff and landing characteristics (eCTOL), but with an electrified powertrain. They have the longest range among AAM aircraft because they do not take off vertically, which saves a lot of energy.

The different aircraft classes influence each other. The emergence of eVTOLs with their horizontal takeoff capabilities has led to a new type of electric aircraft that requires only a very short runway.

This innovative aircraft variant is called eSTOL, which stands for "electric, Short TakeOff and Landing." The idea behind this new variant is to combine the advantage of eVTOLs with its limited need for ground equipment without the burden of high energy consumption for vertical takeoff.

1.2 AAM business models

Start-ups engaged in the development of AAM passenger aircraft are using two different business models: **commercial aviation** and **private aviation**. There is a correlation between the aircraft type and the business model:

- Start-ups addressing commercial aviation typically develop wing-based eVTOLs or e-planes, as these aircraft types offer greater passenger capacity and longer range than multicopters.
- Start-ups targeting private aviation typically develop multicopters.

However, as always, there are exceptions to every rule.

1.2.1 AAM for commercial aviation

Fig. 3 – AAM use case commuter flights illustrated by Job Aviation
(Source Joby)

Commercial aviation comprises scheduled passenger transport by aircraft offered by airlines.

A typical AAM use case is commuter flights from the city to the airport and vice versa. In Figure 3, the expected time savings for flying from JFK airport to Manhattan is illustrated by **Joby Aviation**, one of the leading eVTOL pioneers.

Off course, leading US airlines such as **Delta Airlines** and **United Airlines** are already collaborating with eVTOL start-ups, as they will benefit from these use-case.

However, AAM is not limited to urban areas, but will also play a role in **rural areas** with challenging road and rail conditions, such as Norway with its high mountains, fjords, and islands. AAM aviation will also not be limited to scheduled flights but also cover **on-demand flight operations**, often referred to as air taxi.

A special eVTOL use-case is **emergency operations**, e.g. in case of car accidents. In Europe and the USA alone, around **2,200 helicopters** are used for accident rescue operations, which could be supplemented or replaced by eVTOLs in the medium to long term.

The market potential of AAM is the subject of several **market studies**. They predict strong growth potential and often estimate the market to be worth **several billion dollars** by 2030.

However, most of these forecasts are based on optimistic assumptions about certification timelines, infrastructure readiness, and public acceptance. Global studies from sources such as Morgan Stanley and McKinsey often differ in terms of the size and timing of the projected market, reflecting uncertainty rather than consensus.

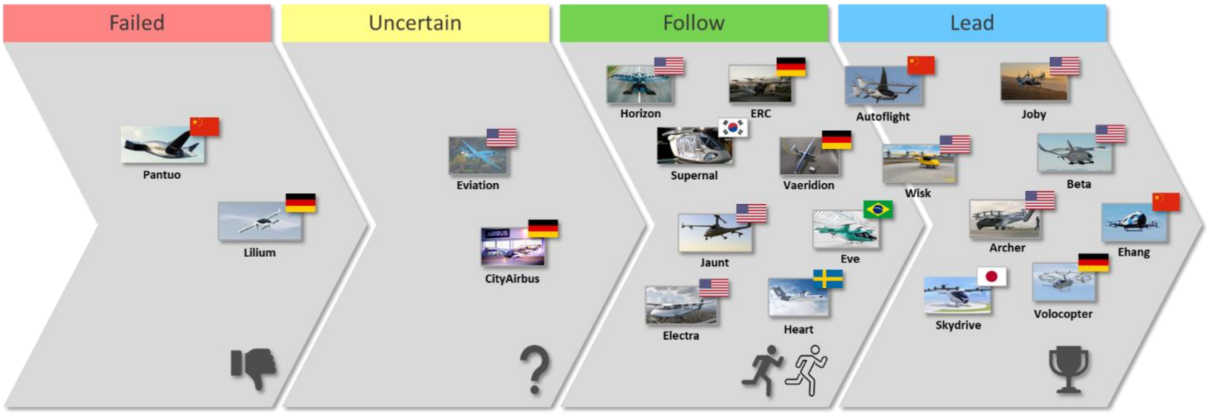

Fig. 4 – Competition status of AAM start-ups targeting commercial aviation

The competition status of worldwide AAM start-ups addressing commercial aviation is depicted in Figure 4. As all companies are covered in more detail in the following, we just give a summary here:

Start-ups in the **Lead** field have succeeded in developing full-scale aircraft that have already completed manned test flights. **Ehang** is the leader in this group, as the company even has already received the type and the production certification from the Chinese aviation authorities.

Start-ups in the **Follow** sector are still working on fully-fledged prototypes. **Autoflight** and **Wisk** are somewhere in between, as they have already developed full-scale aircraft models, but so far only unmanned flights have been carried out. The order within the Follow sector is difficult to determine, as it would be based solely on forecasts made by the start-ups.

Start-ups in the **Uncertain** field have ceased their AAM activities for financial or technical issues. **Airbus** has already conducted flight tests but then halted further development of eVTOL due to what Airbus considers to be the limitations of current lithium-ion battery technology. **Evation** has also conducted test flights but has suspended all activities due to financial issues.

Start-ups in the **Failed** sector have been already liquidated. Interestingly, both candidates in this field, **Lilium** and **Pantuo**, relied on a unique propulsion system based on electrically powered fans.

The potential of the **German AAM market** was examined in a study conducted by the Roland Berger Consulting in 2024 [4]. The results of this study are rather cautious:

- According to this study, AAM will be economically viable only **in premium niche markets** during the initial years, rather than in mass-transport.
- It highlights that investment in the AAM ecosystem has dropped significantly — from 6.8 billion € in 2021, to about 1.2 billion € in 2023.
- A concrete example: a 12 km air-taxi flight from Hamburg station to the Airbus Finkenwerder campus is estimated to cost between **175 and 350 €** for one passenger, versus much lower cost by surface transport.

In our view, one completely **underestimated** application of AAM is flight operations in connection with **tourism**. The global travel and tourism sector's total economic contribution (GDP) for 2024 is estimated at a record **11.1 trillion $**[1] by the World Travel & Tourism Council [5]. This figure represents 10% of the world's economy.

According to a customer survey conducted by Booking.com, **83%** of travelers worldwide recognize the importance of **sustainable travel** and express a firm intention to book more sustainably in the coming year.

This is where AAM aviation comes into the play. Helicopter flights nowadays offered in scenic areas could be substituted and extended by eVTOL flights. But there is much more potential:

- Whale watching flights could be carried out much faster with eVTOLs than with boats.
- African safaris from the air would be possible with less noise than with conventional aircraft.
- Cruise ships could be equipped with eVTOLs, and sightseeing flights could be offered as an additional tourist attraction.
- Leisure events such as festivals could offer additional comfortable travel packages.

In other words, we believe that the **full potential** of AAM in the tourism sector has not yet been recognized and still offers plenty of opportunities for future investors.

1.2.2 AAM for private aviation

Private aviation refers to the sector of civil flying that does not involve scheduled commercial passenger services. It typically encompasses the use of private or chartered aircraft, for personal, business, or recreational purposes.

Of course, there are also AAM start-ups that deal with private aviation, which, in our view, is not very well known in the public.

[1] The 11.1 trillion $ value is a comprehensive measure that includes all economic activity derived from travel: direct consumer spending on services like hotels, flights, and restaurants, as well as indirect effects from the supply chain and employee wages.

Type	Multicopter					Wing-based eVTOL			
Start-up	Jetson Aero 	Ryse Aero 	LIFT 	Bellwether 	Alef Aero 	Pivotal 	Air 	Skyfly 	Aska Fly 
URL	jetson.com/	ryseaerotech.com/	www.liftaircraft.com/	www.bellwether-industries.com	alef.aero	pivotal.aero	https://www.airev.aero/	skyflytech.com	www.askafly.com
Country	USA/Sweden	USA	USA	UK	USA	USA	Israel	USA	USA
#Seats	1	1	1	3	2	1	2	2	2
Target market	Leisure	Farmers	Tourism (rental)	Leisure	Leisure	Leisure	Leisure/ Business	Leisure/ Business	Leisure
SOP	2025	2026?	2023	2028	2025	2024	2026	2026	2026
Price	128,000 $	150,000 $	$349 per flight		299.999 $	190,000 $	150,000 $	180,000 $	789.000 $
Flying Prototype?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes (fixed)
Ultra-light vehicle?	Yes	Yes	Yes	No	No	Yes	No	No	No
Other	Already sold!	Farmers as target market	Hourly rental at tourist hot spots	Encapsulated rotors, eye-catching design	Flying car, 3,400 pre-orders		2,200 pre-orders	40 pre-orders	Flying car

Table 1 – AAM Start-ups addressing private aviation

To highlight the importance of the AAM private aviation sector, we have listed all the major start-ups involved here in Table 1[2], including some information about the company and the aircraft developed.

In the US market, the classification of **ultralight aircraft (ULV)** plays an important role, as these aircraft do not require a pilot's license or certification. However, this type of aircraft is limited to single-seater vehicles with an empty weight of less than 115 kg and a speed of less than 102 km/h. As shown in Table 1, four of the nine start-ups are developing aircraft that are compatible with the ULV specification.

As all companies in Table 1 are introduced in more detail in the following chapters, we just highlight some interesting aspects here:

- **Jetson Aero** and **Pivotal** are the first start-ups already selling AAM aircraft.
- **Ryse Aero** is targeting US farmers, with its aircraft intended to complement horses and trucks as work tools on large ranches.
- **Lift Aircraft** leases its aircraft for short flights to tourist hot spots. Customers receive brief training based on VR technology.
- **Alef Aero** and **Ask Fly** work on the old dream of the flying car: there devices shall be able to drive on roads and – in addition – to takeoff vertically and fly (see chapter 4)
- Israeli company **AIR** is developing a two-seater, wing-based eVTOL, for which it already has 2,200 pre-orders.

2. Start-ups for Multicopter eVTOLs

Multicopters are derived from toy drones. Their flight maneuvers are controlled exclusively by the speed of the vertical propellers, which makes their technology much simpler and more reliable than that of a helicopter.

[2] Volocopter recently announced its entry into the private aviation market with a small two-seater multicopter. We will update Table 1 accordingly for the presentation at AABC-Europe conference in 2026.

Of course, multicopters for passenger transport require a **fault-tolerant** propulsion system. The failure of one motor or one battery must not cause the aircraft to crash.

2.1 Multicopter start-ups for commercial aviation

Fig. 5 – Multicopter prototype and current model of Volocopter
(Source Volocopter)

There are **three** main multicopter start-ups addressing commercial aviation: **Volocopter** [6], **Ehang** [7] and **Skydrive** [8].

The German **Volocopter**, founded in 2011 in Bruchsal, is an early pioneer of the multicopter technology. On the left in Figure 5, the first flying prototype is shown built from parts originally designed for toy drones. Out of this prototype, the final **two-seated** multicopter named Volocity was developed, shown on the right of Figure 5.

The company achieved early manned electric multicopter flights and conducted successful test and demo flights in cities such as Singapore and New York. Volocopter had planned several show-flights for the 2024 Paris Olympics, however these had to be limited due to regulatory and safety concerns.

Facing serious financial issues and insolvency at the end of 2024, it was sold in 2025 to Diamond Aircraft Industries (Austria) and its Chinese parent company Wanfeng Auto Holding Group. Under the umbrella of the new parent companies and with a reduced workforce, one of the main goals remains to certify its first product, the Velocity, in accordance with EASA regulations.

In addition, Volocopter is developing a new type of lightweight multicopter aimed at the German market for ultralight aircraft for **private aviation** (see also 2.1).

Fig. 6 – Multicopter from Ehang and Skydrive
(Source Enhang and Skydrive)

The Chinese **Ehang** has also developed a **two-seat** multicopter shown on the left of Figure 6. Its technical concept is broadly like those of Volocopter. It differs, however, in its design, as the aircraft uses multiple propellers mounted on arms underneath rather than on top of the vehicle. This arrangement poses potential risks for passengers if they are still rotating.

Ehang has achieved significant regulatory milestones in China: its multicopter became the world's first passenger-carrying eVTOL to receive a full type and a production certification from the Civil Aviation Administration of China (CAAC). In Europe, the start-up has conducted demonstration flights in Spain.

The company is actively working on automated, pilot-less flight operations. Among its use-cases the tourism segment is explicitly targeted: sightseeing flights and urban aerial tours are cited as early commercial deployments.

The Japanese **Skydrive** develops the largest multicopter with the capacity of one pilot and two passengers. Supported by industrial partners, including **Suzuki**, Skydrive plans to begin production in Japan around 2026.

First test flights have been demonstrated at the world expo in Osaka in 2025, shown on the right in Figure 6.

2.1 Multicopter start-ups for private aviation

There are four main multicopter start-ups addressing private aviation: **Jetson Aero** [9], **Lift Aircraft** [10], **Ryse Aero** [11], and just recently also **Volocopter**.

The US start-up **Jetson Aero** has achieved a significant milestone in Advanced Air Mobility (AAM) by becoming one of the first companies to sell an AAM aircraft to a customer. Its model is a single seater multicopter sold for **98,000 $** that qualifies under the Ultralight Vehicle (ULV) registration in the US.

Fig. 7 – Flights of Jetson aircraft and Star Wars X34 Landspeeder
(Source Jetson Aero and Eden, Janine and Jim / Wikimedia Commons, CC BY 2.0, cropped)

Videos of the flying Jetson aircraft are particularly fascinating as shown on the left in Figure 7. They evoke the feeling of science fiction, strongly reminding them of Luke Skywalker's flight in the X-34 Landspeeder across the deserts of Tatooine in the first Star Wars movie from 1977; the X-34 is shown on the right in Figure 7.

Fig. 8 – Multicopter Lift Aircraft and booking menu of Lift´s homepage
(Source LIF Aircraft)

The US start-up **Lift Aircraft** is also developing a single seater multicopter also classified as ULV. The aircraft is already operational, as shown on the left in Figure 8.

The company's business model is not to sell the aircraft, but to operate flight centers where the public can book pay-per-flight flights without needing a pilot's license. Lift already offers bookings for flights in Austin, Texas, directly on its website, as shown on the right in Figure 8.

Ryes Aero is the third US start-up that develops multicopters for private aviation. What is interesting about this company is that it targets **US farmers** with large ranches by promoting its aircraft at agricultural trade fairs.

The multicopter is intended to be used as a work tool in rural areas, like horses and light trucks. Compared to the two companies mentioned before, Ryse Aero is lagging somewhat behind. Sales are not expected to start until 2026.

Following the sale of **Volocopter** to Diamond Aircraft Industries (Austria) in 2025 and the layoff of many employees, the German multicopter pioneer has realigned its business strategy.

Part of the new strategy is also to enter the private aviation market. Therefore, Volocopter is developing a lightweight two-seater multicopter named VoloXPro that falls under German certification regulations for ultralight aircraft, i.e., aircraft with a maximum takeoff weight of 600 kg. The start-up just recently published first manned prototype flight tests on social media (LinkedIn).

3. Start-ups for wing-based eVTOLs

The technology of wing-based eVTOLs is more complex than that of multicopters. **Vertical propellers** enable vertical takeoff and a vertical landing. **Horizontal propellers** provide propulsion and enable forward flight. During forward flight, **wings** generate lift forces.

Wing-based eVTOL has a significantly **longer range** than multicopters because the vertical propellers can be switched off during forward flights, thus saving energy. However, wing-based eVTOLs are more limited in their maneuverability than multicopters and can only fly backwards or sideways to a very limited extent. Of course, the propulsion system of wing-based eVTOL is designed with redundancy, i.e. the failure of one propeller during the flight should not lead to a crash of the aircraft.

3.1 Propeller configurations

Fig. 9 – Propeller configurations wing-based eVTOL
(Source Joby, Autoflight, Archer, AIR)

Wing-based eVTOLs differ with respect to their **propeller configuration**. Four types of propeller configurations (PC) have been designed so far, as illustrated in Figure 9:

- **PC1** – Propellers are **tiltable** from vertical to horizontal orientation. In vertical position propellers provide vertical takeoff, for forward flight propellers are tilted to horizontal position.
- **PC2** – Propellers are mounted in a **fixed** vertical or horizontal orientation. Vertical propellers are activated for takeoff; horizontal propellers provide propulsion for the forward flight.
  Vertical propellers are inactive during forward; horizontal propellers are often mounted in the back of the aircraft.
- **PC3** – Mixed approach: part of the propellers is **tiltable**, the remaining propellers are **fixed** in vertical position.
  Often, the tiltable propellers are mount at the front of the wing and the fixed vertical ones at the back of the wing.

- **PC4** – All propellers have a vertical orientation with a slight angle (approximately 10 degrees) in the direction of flight. The vertical propellers allow vertical takeoff; forward propulsion is made possible via different rotational speeds on the front and rear propellers.

The configurations PC1 – PC3 are used for commercial aviation eVTOLs, the configuration PC4 so far only for private aviation eVTOLs.

3.2 The transition maneuver

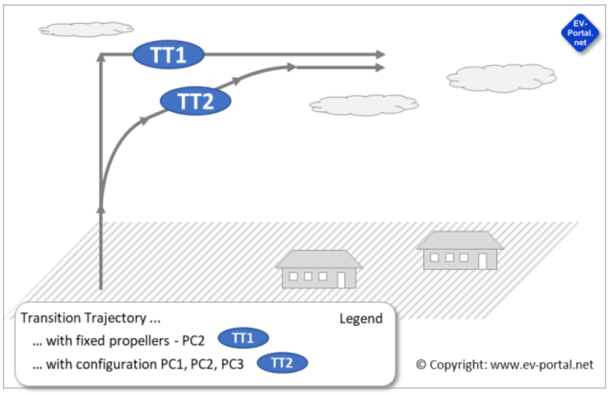

Fig. 10 – Transition trajectory depending on the propeller configuration

The transition maneuver is the most important flight maneuver for all eVTOL aircraft, it is essential for safe takeoff and landing.

The maneuver consists of 3 phases with two different transition trajectories possible, as illustrated in figure 10:

- In transition trajectory TT1, the aircraft climbs vertically, remains at a certain altitude, and changes flight direction at a sharp 90-degree angle to fly forward.
- In transition trajectory TT2, the aircraft climbs vertically and then flies in gentle arcs to transition into forward flight.

In general, wing-based eVTOL performs the transition maneuver with the TT2 trajectory.

However, the aircraft from the Chinese start-up **Autoflight** has already demonstrated that PC2-type eVTOLs can perform also the TT1 trajectory. This is possible, as the vertical and horizontal propellers can be controlled independent from each other.

For eVTOLs with all-tilting propellers, the control algorithm for the TT1 trajectory is more complex, as the tilting angle and the propeller speed must be controlled together.

For special applications such as emergency rescue, where slow horizontal flights at low speeds are required to find a good landing site near a traffic accident, eVTOLs with PC2 configuration offer the best conditions.

3.3 Start-ups for wing-based eVTOLs

While start-ups for commercial aviation focus on the PC1 - PC3 propeller configuration, the PC4 propeller configuration applies to private aviation.

3.3.1 Tilt propeller configuration PC1

There have been **four** main start-ups betting on all-tilt propeller configurations, namely **Joby Aviation** [12], **Lilium** [13], **Pantuo Aviation** [14], and **Supernal Aero** [15]. However, among these companies, only Joby and Supernal are still in operation.

Fig. 11 – All-tilt propeller eVTOLs from Joby and Supernal (animation)
(Source Joby and Supernal)

Founded already in 2009 in the US, **Joby Aviation** is a real pioneer in the eVTOL sector, utilizing an all tilt-propeller design (PC1). The aircraft carries a pilot and four passengers, offering a range of 240 km with a speed of up to 320 km/h. With this figure, Joby's eVTOL is one of the fastest aircraft in its sector. The high speed is a result of the all-tilt propeller configuration: all six propellers can provide forward thrust as shown on the left in Figure 11.

The company has significant strategic partners, notably **Toyota** for manufacturing and **Delta Air** Lines for commercial operations. Joby has achieved major milestones, including **piloted transition** from vertical to wing-borne flight and back. Joby is currently in the final stages of FAA certification, targeting full type certification in the 2025/2026 timeframe to launch commercial aviation.

The Korean **Supernal** is no classical start-up but a subsidiary of the **Hyundai Motor Group**. The company is developing a wing-based eVTOL for one pilot and four passengers, an animation is shown on the right in Figure 11. Target values are **190 km/h** with an initial range of **95 km**.

Supernal plans to launch commercial passenger services with its first eVTOL by 2028, with this schedule the company is behind Joby. However, flight testing with a full-scale technology demonstrator has already started.

Lilium, founded in 2015, was a German eVTOL start-up that developed the distinctive Lilium Jet. This aircraft featured an unconventional design with 30 electric ducted fans embedded in its wings and canard (front wing), intended to carry a pilot and six passengers. However, this complex technical concept faced criticism, notably from the German aviation magazine Aerokurier, which questioned the feasibility of the performance claims due to the ducted fans' high-power consumption during the hover phase.

Ultimately, Lilium ran out of funds and filed for insolvency, ceasing operations in February 2025. Following its collapse, rival **Archer Aviation** acquired the company's portfolio of around 300 advanced air mobility patents.

Pantuo Aviation is a Chinese eVTOL startup, founded in Shanghai. Like Lilium, its aircraft featured a sleek design with multiple ducted fans embedded in its wings. However, Pantuo's key technical difference was the design's use of entire tilting wings which were intended to tilt down for vertical flight. The company has provided no substantial updates or news since mid-2023, leaving the public status of the project uncertain.

3.3.2 Fixed propeller configuration PC2

There are **seven** main start-ups developing winged eVTOLs with fixed propeller configuration, making this configuration the most preferred one: **Airbus** [16], **Autoflight** [17], **Beta Technologies** [18], **ERC System** [19], **EVE Air Mobility** [20], **Horizon Aircraft** [21], and **Jaunt** [22].

Among these companies, China's **Autoflight** and the US's **Beta Technologies** are the most advanced. Both start-ups have already developed airworthy prototypes which successfully demonstrated the transition maneuver. Beta has already conducted manned flights, while Autoflight only conducted unmanned, automated flights to date.

Fig.12 – eVTOL from Autoflight and Beta Technologies
(Source Autoflight and Beta)

Autoflight's primary passenger eVTOL is the five-seat aircraft, which offers a range of over 250 kilometers and a cruise speed of 200 km/h.

As shown in Figure 12 on the left, the horizontal propellers are mounted at the rear as thrust propellers. The vertical propellers are switched off during forward flight. In this fixed position, the vertical propellers are aligned in the direction of flight to cause as little air resistance as possible, which is typical for an aircraft of PC2-type.

The company expects the type certification for the passenger version from the CAAC (Civil Aviation Administration of China) in **2026** and is simultaneously working towards EASA certification.

Autoflight was able to win **CATL** as a strategic investor. The start-up maintains dual headquarters in Shanghai, China, and in Augsburg, Germany, with the German location serving as the European R&D center for certification.

The US start-up **Beta Technologies** develops a generic AAM aircraft platform, which comes as a **CTOL** (Conventional Takeoff and Landing) and as **eVTOL** variant. The eVTOL model is shown on the right in Figure 12 with a push-propeller in the back like Autoflight.

It is designed to accommodate one pilot and up to five passengers or a corresponding cargo payload, with a demonstrated range for the eCTOL version of over
600 km.

A major milestone was achieved with the successful manned transition flight of the eVTOL prototype. The company is following a stepwise certification approach, targeting certification for its eCTOL model in 2025 and eVTOL in 2026.

Key partners and customers of Beta include the **U.S. Air Force**, **UPS Flight Forward**, and **GE Aerospace**.

As the other five companies are less advanced, we just summarize key aspects in the following overview:

- **Airbus**, the world's largest aircraft manufacturer, has **temporarily paused** the development of its CityAirbus eVTOL. The primary reason cited was the conviction that current battery technology lacks the necessary performance and maturity to achieve the required range.
- The German startup **ERC System** is developing its eVTOL for Emergency Medical Services (EMS) and patient transport. The commercial launch is scheduled for 2029, with a goal to manufacture units by 2032.
- The Brazilian **Eve Air Mobility** is a spin-off from **Embraer**, the third-largest aircraft manufacturer. Eve benefits from a domestic market in São Paulo having a large fleet of private helicopters. Commercial entry is targeted for 2026 or 2027.
- **Horizon Aircraft** is a Canadian developer of seven-seater eVTOL with a special "fan-in-wing" design. Propellers are integrated into the wing for take-off and landing; during forward flights, the openings for the propellers are closed to achieve good airflow characteristics. Certification is planned before 2030.
- The US-Canadian **Jaunt Air Mobility** is developing exotic eVTOL which looks like a helicopter. Its design features a single large main rotor for vertical flight, along with a fixed wing that has four small propellers for forward flight. Type certification is targeted for 2027.

3.3.3 Mixed propeller configuration PC3

There are **three** main start-ups developing wing-based eVTOL with mixed propeller configurations: **Archer Aviation** [23], **Vertical Aerspace** [24], and **Wisk Aero** [25].

Among these companies, **Archer Aviation** is most advanced. The U.S.-based eVTOL start-up was founded in 2018 in California, their aircraft is a piloted-plus-four-passenger aircraft. It is designed for short-haul urban routes with a range of about 100 km and a top speed of 240 km/h. The aircraft performed the unmanned transition flight in June 2024.

Fig.13 – eVTOLs from Archer and Vertical
(Source Archer and Vertical)

As shown in Figure 13 on the left, the eVTOL has a typical PC3 configuration. The tilt propellers mounted on the front of the wings are folded into a horizontal position for forward flight. The fixed vertical propellers, mounted on the back of the wing, are switched off and aligned in the direction of flight.

Archer has secured major strategic partners, including **United Airlines**, which has a significant aircraft order, and **Stellantis**, for high-volume manufacturing collaboration. Type certification is targeted for 2026. Archer is a key transportation partner for both the FIFA World Cup 2026 and the LA28 Olympic Games in the Los Angeles area, using these high-profile events to showcase its aircraft.

Vertical Aerospace is a UK-based competitor of Archer; the start-up was founded in 2016 in the British “aerospace capital” Bristol. Its aircraft is also a piloted, four-passenger eVTOL with a range of 160 km and a cruise speed of 240 km/h. Its basic design is very similar to that of Archer, as can be seen in Figure 13 on the right.

The company completed piloted flights with conventional takeoff and landing, the **piloted transition flight** is expected to be achieved by the end of 2025. Vertical is aiming for type certification in 2028. The company claims to have already secured a pre-order book of 1,500 units from global air carriers such as American Airlines and Japan Airlines.

The US start-up **Wisk Aero** differs from its competitors as it is aiming for **automated flights**. The company is owned by **Boeing**; its aircraft is a four-passenger eVTOL with no pilot onboard. Wisk argues that this is the key to achieving the highest safety standards in aviation by eliminating the possibility of human error. Wisk Aero is pursuing type certification for its aircraft by 2030, recognizing that the certification of unpiloted eVTOLs represents a significant and complex regulatory challenge.

3.3.4 Propeller configuration PC4

There are **three** start-ups developing wing-based eVTOLs for private aviation: **Pivotal** [26], **Air** [27], and **Skyfly** [28].

Fig.14 – Aircraft from Pivotal and Air
(Source Autoflight)

Pivotal is a US startup selling its single-seat wing-based eVTOL for 190,000 $ since 2024, thus being a pioneer in AAM business. Pilots will receive intense training from the company but will not need pilot licenses, as the aircraft is classified as ULV shown on the left in Figure 14.

The Israeli **Air** and the UK-based **Skyfly** both develop a two seated wing-based eVTOL. Both companies want launch sales in 2026 for leisure and business.

Air claims to have already 2,400 pre-orders for its model shown in the right in Figure 14.

4. Flying cars

The concept of the flying car has been a persistent and powerful American dream since the dawn of aviation, embodying the nation's cultural value of personal freedom and mobility. Early prototypes frequently captured the public imagination but ultimately failed to achieve commercial success due to issues with complexity, safety, and cost.

Today, this dream is making a serious comeback, driven by breakthroughs in battery technology, electric drive systems, eVTOL technology, and entrepreneurs who are willing to do what was previously impossible.

Two US start-ups, **Alef Aeronautics** [29] and **Aska Fly** [30], are developing flying cars based on the original vision of vehicles being able to drive on public roads and to fly in the air. Both companies follow different technological approaches.

Fig. 15 – Alef´s flying car on the road (photo) and in the air (animation)
(Source Alef Aeronautics)

Alef is developing a two-seated car based on the **multicopter** concept, shown on the left of Figure 15. It features a unique design for forward flights. The entire car body turns the sides of the car into a biplane-like wing structure, while the passenger cabin remains stable and upright, as shown on the left animation of Figure 14.

The company received a special FAA airworthiness certification, which allows for limited test flights for research and exhibition purposes. Delivery of pre-ordered vehicles is targeted for 2026, which seems to be quite optimistic from our point of view; the anticipated price is 300,000 $.

Fig. 16 – Aska´s flying car on the road and at flight test
(Source Aska Fly)

The **Aska** flying car uses a **wing-based eVTOL** concept, as shown in Figure 16. The aircraft uses retractable tandem wings that fold inward in driving mode. In flight mode, the wings are extended. Aska also has a special FAA airworthiness certificate. ASKA is aiming for type certification around 2026/2027 and is selling its flying car for $789,000.

The Chinese car manufacturer **Xpeng** [31] and the US start-up **Doroni Aerospace** [32] have developed their own interpretation of flying cars.

Fig. 17 – XPeng´s modular flying car system
(Source Xpeng AeroHT)

XPeng AeroHT, the air mobility division of the Chinese automaker XPeng, is focused on developing a modular concept, as shown in Figure 17.

The ground module, which is a large electric vehicle, and a detachable air module stored in the rear. The air module is a multicopter which can be recharged by the ground module. XPeng intends to begin mass production and deliveries starting in 2026.

Fig. 18 – Doroni´s flying car
(Source Doroni Aerospace)

Doroni Aerospace is developing a two-seated eVTOL designed to fit inside a standard two-car US garage, as shown in Figure 18. Thus, the aircraft can drive on private roads, but not on public streets. It features a ducted fan propulsion system and a tandem wing configuration with the enclosed fans reducing noise and protecting the blades. Deliveries are expected to begin in 2025/2026.

5. Start-ups for aircraft with conventional takeoff and landing properties

Although advanced air mobility is often associated with eVTOLs, the ability to take off and land vertically is not a prerequisite for an AAM aircraft. The main requirement according to NASA's AAA definition is the sustainability of air transport, which requires an electric propulsion system.

Several start-ups for aircraft with electric conventional takeoff-and-landing (**eCTOL**) properties have been found. Interestingly, the rise of eVTOLs has led to a new type of electric aircraft that requires only a very short runway. This type is called **eSTOL**, which stands for “electric, short takeoff and landing.” Aircraft of this type combines the advantage of eVTOL with its limited need for ground equipment with low energy consumption for takeoff**.**

To limit the scope of this paper, we just cover start-ups for commercial aviation here.

5.1 Start-ups for eSTOL

Fig. 19 – Electra´s eSTOL during takeoff and its hybrid propulsion system (animation)
(Source Electra Aero)

The US start-up **Electra** [33] is to our knowledge the only AAM company betting on an **eSTOL** aircraft. Founded just a few years ago in 2020, Electra develops a plane which can take off and land on a runway of less than 50 m length. The left picture of Figure 19 illustrates the conventional takeoff in an urban environment in an animation.

Its hybrid propulsion system employs eight propellers over the wing, shown in the right picture of Figure 19. The cabin is designed to carry nine passengers plus a pilot, offering a cruise speed of 320 km/h and a range of up to 2000 km.

The company's roadmap involves a full-scale prototype flight test in 2027, aiming for FAA Part 23 certification by late 2029 and entry into commercial service shortly, thereafter, backed by over 2,200 pre-orders.

5.2 Start-ups for eCTOL

There have been three main start-ups developing new eCTOL aircraft with closer timelines, which are **Eviation Aircraft** [34], **Heart Aerospace** [35], and **Vaerdion** [36].

Start-ups and companies planning to retrofit existing aircraft with electric propulsion systems or companies offering components for eCTOLs are not covered here, as this would go beyond the scope of this paper.

Eviation Aircraft had been leading the pack, with its full-scale prototype completing its demonstration flight back in September 2022. However, the US-based company has temporarily suspended its development work and laid off most of its employees as of February 2025.

The company is seeking new long-term strategic partnerships and funding to continue the program. Its aircraft, a nine-passenger eCTOL, successfully completed its first test flight in September 2022 and had received hundreds LOIs from customers such as **DHL** and **Air New Zealand**. The company said the temporary pause was a necessary step to explore strategic options and secure the resources needed to bring the aircraft to market.

Heart Aerospace is a Swedish American company developing a hybrid-electric regional airliner designed for 30 passengers. The aircraft utilizes four electric motors for propulsion, supported by a turbogenerator that can run on Sustainable Aviation Fuel (SAF) to extend its range.

Target figures are a battery-electric range of 200 km and an extended hybrid range of up to 800 km with 25 passengers. The company aims to achieve type certification by 2028 or 2029, with over 250 firm orders already secured from major carriers like **Air Canada** and **United Airlines**.

Vaeridion is a German, founded in 2021 by former Airbus and ZF engineers. The company is developing an aircraft designed for short-haul regional flights. Key features of their concept include a glider-inspired design for ultra-efficient aerodynamics and the integration of high-voltage batteries directly into the wings to save weight and maximize range.

The 9-passenger (plus up to two pilots) aircraft aim to offer a range of up to 400 km, positioning it as a sustainable and affordable alternative for connecting underserved regions. In Germany, for example, there are 24 commercial airports with 55 scheduled flights. If you include the smaller, regional airports, there are 209 airports with up to 2789 connections.

Vaeridion is targeting EASA CS-23 certification before 2030.

6. Energy storage strategies of AAM start-ups

Start-ups for AAM aircraft are generally quite reluctant to disclose technical details such as the lithium-ion cell types used, and the battery technology employed. In the following we summarize the information available w.r.t. energy storage technologies applied by AAM start-ups.

Regarding **cell types** and **suppliers**, here is the public available collected:

- **Archer** and **Vertical** use **cylindrical NMC** cells from Taiwanese manufacturer **Molicel** [37]; the company is a well-known supplier to Formula 1 racing cars.
- **Joby** has announced that it will rely on **pouch-format NMC 811** cells from the **automotive supply chain** rather than fully customized cells for aviation. No specific supplier was named, but from a geopolitical perspective, we suspect it is a Korean cell manufacturer.
- **Autoflight** corporates with **CATL**, so is obvious that the Chinese eVTOL start-up purchases its cells and batteries from the largest cell manufacturer in the world. However, cell type and cell chemistry are not known to the public.
- **Ehang** recently announced its collaboration with **Gotion** [38]; they are purchasing cylindrical cells in the 46-format (46 mm diameter). Cells with this format are also used by Tesla and BMW.
- The German eCTOL startup **Vaeridion** was compelled to change its battery cell supplier after its original partner, **Customcells**, faced insolvency due to payment issues from its largest customer, Lilium. Vaeridion now secured **Molicel** as its cell provider.

On the battery module and pack level, some AAM start-ups prefer an in-house development for the battery module and the pack. This holds for **Archer**, **Beta, Ehang**, and **Vaeridion** for example.

Other AAM start-ups outsourced the battery pack development:

- **Heart Aerospace** and **Eve** have contracted **BAE Systems** [39] for pack development.

- **Skydrive** and **Supernal** cooperate with **EP System** [40], a specialist in electric aerospace propulsion systems.

Neither battery pack manufacturer has disclosed its cell supplier so far.

The thermal management system (**TMS**) for battery packs also involves a mix of make-or-buy strategies:

- **Joby** developed the TMS itself; it consists of active liquid cooling with coolant plates between cells and sealed modules for thermal-runaway containment.
- **Archer** relies on a **Honeywell** TMS [41] to maintain safe operating temperatures.
- **Vertical** also relies on an in-house development for battery cooling.
- **Eve Air** contracted **Intergalactic** [42], a US specialist for aerospace TMS.

Beta adopts a distinct thermal management strategy for its eVTOL and eCTOL aircraft by **avoiding active battery** cooling **during flight**.

Instead of carrying heavy, complex cooling systems, Beta relies on pre-chilling the batteries with an external liquid cooling before takeoff. This ground TMS is integrated into the charging station, which is a proprietary Beta design. This approach significantly reduces aircraft weight and minimizes aerodynamic drag, thereby maximizing the aircraft's efficiency and range.

Regarding Beta´s battery system there is even more information available:

- Beta equips its AAM aircraft with **five** identical battery modules, each rated at about **45 kWh gross capacity**.
- The modules are designed to operate in parallel for **redundancy/safety** and **scalability**.
- Each module weighs roughly 255 kg, has a maximum voltage of around **832 V**, and incorporates advanced safety features like thermal-runaway containment and liquid-cooling capability.
- Depending on mission requirements, the aircraft can operate with two to five packs installed.

At full configuration, the gross capacity of Beta's AAM aircraft is **225 kWh**, which is only about one-third of the gross capacity of the **621 kWh** of Daimler Truck's long-haul truck.

7. Summary and Outlook

Our paper presents an extensive and vendor-independent overview of global start-ups developing aircraft for the emerging field of Advanced Air Mobility (AAM). Driven by rapid advances in battery technology, especially lithium-ion energy density, a new class of electric aircraft—eVTOLs (electric Vertical Takeoff and Landing)—has emerged, enabling sustainable short-range air transport with low noise, zero local emissions, and reduced operating costs. The study categorizes AAM aircraft by design (multicopter, wing-based eVTOL, and eCTOL/eSTOL) and by business model (commercial vs. private aviation).

Within commercial AAM, companies such as **Joby**, **Archer**, and **EHang** have reached advanced development stages, with **Joby** and **Beta Technologies** achieving piloted transition flights and **EHang** obtaining full type certification in China. In contrast, start-ups like **Lilium** and **Volocopter** faced insolvency or acquisitions, underlining the sector's volatility.

In private aviation, ultralight multicopter developers such as **Jetson**, **Lift**, and **Ryse** are pioneering early customer adoption through simplified certification and experiential business models.

The future of AAM will depend heavily on certification progress, public acceptance, and infrastructure readiness, particularly vertiports and airspace management systems. The **US** and **China** are expected to maintain **leadership** in deployment due to favorable regulatory ecosystems and government backing, whereas Europe must accelerate harmonization and funding to retain competitiveness.

In the medium term, AAM will likely penetrate high-value, niche markets—premium urban air mobility, tourism, and emergency services—before achieving mass-market economics. Continuous advances in energy storage, lightweight materials, and autonomous flight control will further reduce costs and enhance safety.

Looking ahead, AAM has the potential to transform regional mobility and reshape the aviation landscape, positioning electric flight as a cornerstone of sustainable transportation for the coming decades.

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