

# eVTOL BASICS FOR INVESTORS

An introduction to navigating the new  
landscape of urban air mobility



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# eVTOL BASICS FOR INVESTORS

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## Introduction

### eVTOL Basics for Investors

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The first months of 2021 have been marked by an explosion of interest in the electric vertical take-off and landing (eVTOL) space. As leading eVTOL developers continue to announce plans to combine with special purpose acquisition companies (SPACs) at multi-billion-dollar valuations, retail investors have rushed to learn more about this potentially transformative industry and its most promising players.

That's not a simple task. The promise of urban air mobility (UAM) hinges on multiple novel technologies as well as regulatory, infrastructure, and public acceptance requirements, many of which have yet to be clearly defined. Most eVTOL developers have been fairly secretive about their activities, making it challenging for newcomers to the space to distinguish between aircraft with legitimate paths to market and projects that are unlikely to ever get off the ground.

This report was created to provide a concise yet thorough exposition of the eVTOL industry, its key opportunities, and risk factors. It draws on the input of multiple experts, as well as the author's extensive aviation background and four years of dedicated reporting on the sector.

The author has no positions in or business relationships with any of the companies mentioned in this report. Rather than endorsing specific eVTOL developers, the report is intended to provide a conceptual framework with which savvy investors can evaluate manufacturers' competing claims, now and in the future.

The eVTOL industry holds exceptional promise, but like other nascent technology sectors, it will create both winners and losers. The premise of this report is that more knowledgeable investors will be better positioned to pick the winners, and thus do more to advance the industry as a whole.







## Part I: The Five Ws

### What are eVTOLs?

Electric vertical take-off and landing aircraft are able to take off and land vertically, like a helicopter, without the need for a runway. Unlike conventional helicopters, which rely on internal combustion engines and mechanical transmissions to drive their large main rotors, eVTOL aircraft typically have multiple smaller propulsion units driven by electric motors.

These propulsion units can be placed almost anywhere on an aircraft, a concept called distributed electric propulsion (DEP) or “power-by-wire.” DEP enables tremendous design flexibility and unconventional configurations that were never possible before, which is reflected in the hundreds of eVTOL aircraft catalogued by the Vertical Flight Society (VFS) at [evtol.news/aircraft](https://www.vfsociety.com/aircraft).

VFS recognizes several broad categories of eVTOL designs. The simplest are wingless multicopter designs, which resemble oversized consumer drones. [Volocopter’s VoloCity](#) and [EHang’s EH216](#) are examples of eVTOL multicopters.

Lift-plus-cruise designs use one or more “thrusters” (typically propellers) for cruise flight and separate thrusters for vertical lift. An example of this is [Beta Technologies’ Alia](#), which uses four overhead propellers for vertical take-offs and landings and a

rear-mounted pusher propeller for forward flight. In cruise flight, lift is provided entirely by the wing and the overhead propellers stow in a fixed position for aerodynamic efficiency.

Vectored thrust designs are more complex. They use at least some of the same thrusters for both lift and cruise, which requires changing the orientation of the thrusters in flight. An example is [Joby Aviation’s winged S4](#), which incorporates six tilting propellers. The [Lilium Jet](#), which incorporates 36 electric ducted fans, is another vectored thrust design.

VFS also recognizes an electric rotorcraft category for electric helicopters and gyroplanes. These include both electrified versions of conventional helicopters, such as [Tier 1 Engineering’s modified Robinson R44](#), as well as new designs like the [Jaunt Air Mobility Journey](#).

Each design category has advantages and disadvantages. Multicopters are very simple, but without a wing for efficient forward flight, they are limited in speed and range. Lift-plus-cruise designs are also fairly simple and can easily accommodate a wing, but having separate sets of thrusters can add weight and drag, and pose challenges for optimizing both efficiency and noise. Vectored thrust designs can achieve high speeds and efficiencies, but are more complex to design and build.



Electric rotorcraft are potentially easier to certify because the certification criteria for conventional rotorcraft is already well established (including their ability to glide to the ground, or “autorotate,” in the event of a power failure). However, because they do not leverage DEP for efficiency and noise reduction, fewer companies are pursuing them as commercial products.

eVTOL aircraft may be fully electric or hybrid-electric. Most of today’s fully electric designs use lithium batteries, but there are also designs powered by hydrogen fuel cells, like the [Alaka’i Technologies Skai](#).

Hybrid-electric designs incorporate an internal combustion engine (ICE), either a gas turbine engine as in [Honeywell’s turbogenerator](#), or a reciprocating engine like the diesel engine used by [VerdeGo Aero](#). Depending on the design, the ICE may be used throughout the flight or only in cruise, with take-offs and landings being performed on battery power for lower noise levels. With their conventional engines, hybrid-electric aircraft can achieve much greater range and performance than is possible with today’s batteries alone. However, they are noisier and more polluting, and cannot achieve the reductions in complexity, weight, and operating costs fully electric aircraft are likely to enjoy.



## What is the difference between an eVTOL and a drone?

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Drones, or unmanned aircraft systems (UAS), are aircraft that operate without an onboard pilot; they may be flown by a human remotely or operate autonomously without direct human flight control inputs. The term “drone” was originally applied to military drones like the General Atomics MQ-1 Predator, but has recently come to also describe small consumer multicopters like those produced by DJI. That’s usually what people are thinking of when they describe eVTOL aircraft as “oversized drones” or “passenger drones.”

In the context of urban air mobility, “eVTOL” is typically used to refer to aircraft intended to carry human passengers or significant amounts of cargo. Most of these aircraft are being designed with high levels of autonomy, although they may be certified to fly only with a human pilot on board. The ability to conduct unpiloted flight testing is an advantage in the development process, as it allows companies to iterate through various designs and explore certain flight regimes without risking the life of a human test pilot. However, while most eVTOLs are functionally drones, they would not be described as such if they’re certified for conventionally piloted flight.



## Why eVTOLs?

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Broadly speaking, eVTOL aircraft have three key advantages over helicopters: they're potentially cheaper, quieter, and more environmentally friendly. These differentiators are what proponents believe will enable urban air mobility operations at a scale that simply hasn't been possible with helicopters, which are much more expensive, noisy, and polluting.

Helicopter engines and components are costly to build and maintain, in part because of their stringent certification requirements and low production volumes. Although eVTOL aircraft will have similarly strict standards for certification, electric motors are inherently simpler to manufacture than the gas turbines that power many comparably sized helicopters. eVTOLs will also have fewer critical parts than helicopters, which have many transmission and drivetrain components that require regular inspection and replacement.

Although aerospace-grade batteries will be far more expensive than automotive batteries, they should have some salvage value, and recharging a fully electric eVTOL will be much cheaper than filling a helicopter's fuel tank. In an [analysis presented](#)

[in 2019](#), Uber Elevate estimated that fully electric air taxis would have near-term operating costs of around \$700 per hour, at least 35 percent less than a comparably utilized single-engine helicopter. The cost per kilowatt-hour of batteries is also decreasing rapidly, with many potential breakthrough cell chemistries under development, as billions in

investment flood into R&D — largely due to the exploding market for ground electric vehicles.

When combined with ridesharing apps that allow passengers to book flights by the seat, eVTOL aircraft should be an affordable form of transportation for many more people than today's helicopters. Their low operating costs will also make them attractive for some other missions currently

being performed by helicopters, such as organ transport. However, because eVTOLs are generally not optimized for the high energy requirements of hovering flight, helicopters will remain preferable for missions that require sustained hovering or higher payloads.

With respect to noise, not only are helicopters quite noisy, many people find their noise signature especially irritating. That has led to organized

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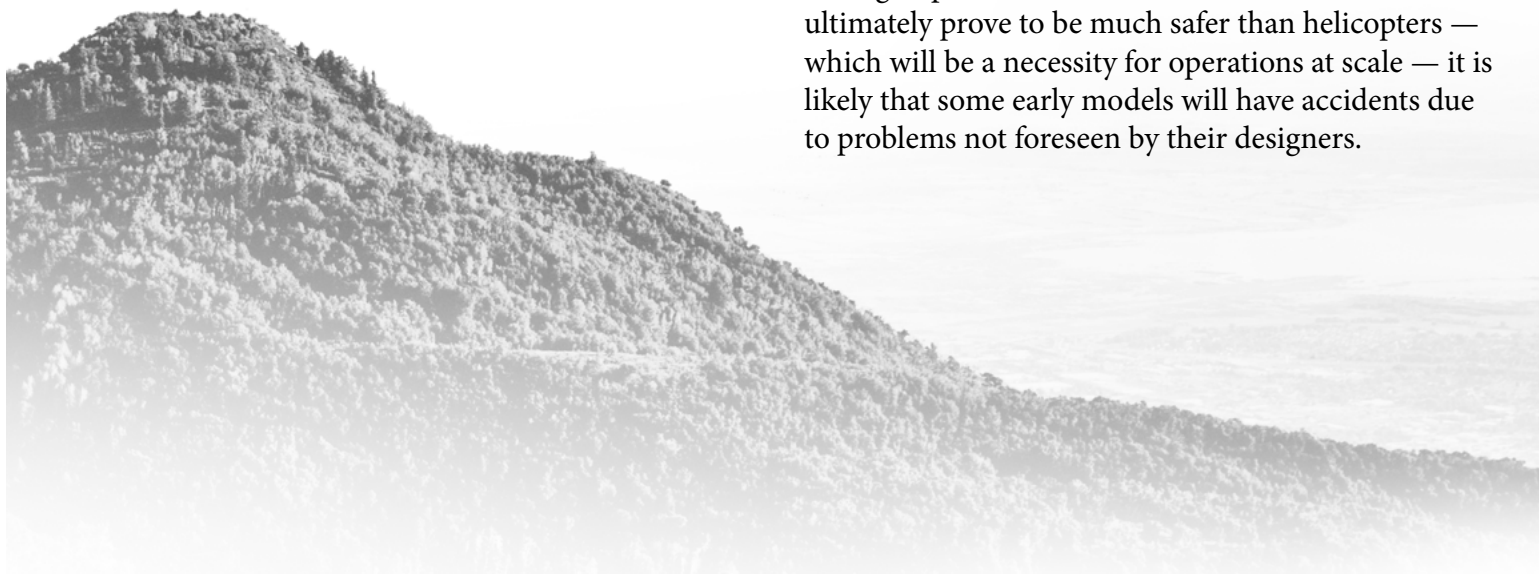


opposition to them in communities such as New York and Los Angeles where helicopters are prevalent — an obvious obstacle to their wider deployment. Fully electric VTOL aircraft do not have any of the noise associated with an internal combustion engine. Moreover, distributed electric propulsion designs can typically be optimized for noise to a much greater extent than can helicopters, changing not only the loudness but also the character of the sound.

Just because an eVTOL aircraft can be optimized for noise, however, does not mean that it has been, and it is reasonable to expect that eVTOL models will have widely varying noise signatures. To date, many eVTOL developers have avoided public demonstrations of their aircraft, and/or released footage of their flight testing without sound. Because noise will be so critical to public acceptance of eVTOL aircraft, investors should pay close attention to this point for any company targeting the UAM market in particular.

Sustainability is another factor likely to influence public acceptance. Compared to conventionally powered aircraft, eVTOLs that reduce or eliminate emissions have a better case for being integrated into future transportation systems. Communities that place a higher value on sustainability will likely evaluate those systems more holistically, considering the source of the electricity that powers eVTOL aircraft, how they integrate with other forms of transportation, and the full life cycle impact of batteries used.

Another argument in favor of eVTOLs relates to safety. Although not all eVTOLs will have the gliding or autorotative capabilities of conventional planes and helicopters, distributed electric propulsion enables them to be designed with fewer single points of failure. Proponents also believe that the high levels of automation in eVTOL aircraft can reduce and ultimately eliminate accidents related to human error, which are the primary cause of aviation accidents today. However, this claim has yet to be demonstrated through operational service. Even if eVTOL aircraft ultimately prove to be much safer than helicopters — which will be a necessity for operations at scale — it is likely that some early models will have accidents due to problems not foreseen by their designers.



## Talking terminology: Urban air mobility vs. advanced air mobility

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Most of the investor enthusiasm surrounding eVTOL aircraft is related to the enormous potential market size for urban air mobility — moving passengers around congested urban environments using electric air taxis. Various white papers have pegged that market in the billions or trillion of dollars, with Morgan Stanley, for example, [estimating it at \\$9 trillion by 2050](#).

Within this potential UAM market, various players see the opportunity differently, with some emphasizing latent demand for short, intra-city hops, and others more focused on longer trips between cities. Investors should be aware of distinct markets being targeted by various eVTOL developers and the resulting differences in aircraft and ecosystem design approach.

But UAM is only one possible use case for eVTOL aircraft, and an exceptionally challenging one from a safety, regulatory, and public acceptance perspective. Consequently, many eVTOL developers are exploring other possible applications for their aircraft.

Beta's launch customer is United Therapeutics, which plans to use its eVTOL aircraft to transport human organs for transplant. Beta also recently [announced a deal with UPS](#), which will use as many as 150 of the eVTOLs to move time-sensitive parcels in small and mid-size markets. Volocopter partnered with the German air medical provider ADAC Luftrettung to study the [potential for its eVTOL multicopters to transport physicians](#) to the scenes of emergencies. EHang has embraced both [medical applications](#) and [aerial tourism](#).

Because eVTOL aircraft are not limited to urban air mobility, NASA and others have adopted the more inclusive term “advanced air mobility” (AAM) to describe the use of aircraft incorporating high degrees of electrification and autonomy deployed in transformative and innovative ways. While much of NASA's AAM National Campaign remains focused on enabling UAM, the agency is also studying rural and cargo-carrying applications for this new generation of aircraft.







## Who are the eVTOL industry's key players?

As recently as six years ago, the eVTOL “industry” was a sub-niche constituting just a handful of visionary pioneers. Since then, the sector has steadily been gaining momentum, thanks in large part to the coordinating efforts of Uber Elevate, which attracted buzz and buy-in to the sector starting with the publication of its [Elevate white paper](#) in October 2016. Uber laid out a vision for urban air mobility that continues to shape the industry’s pursuit of that market, even following the acquisition of the Uber business unit by Joby Aviation in December 2020.

Today, the landscape of eVTOL developers includes pioneers such as Joby, Kitty Hawk, and Volocopter; other accomplished startups like Beta, Lilium, and Vertical Aerospace; and dozens of would-be developers that have not progressed beyond subscale models or, in many cases, just a concept on paper. Established aircraft manufacturers including Airbus, Bell, and Embraer continue to work on their own eVTOL concepts, while Boeing has entered the sector through a joint venture with Kitty Hawk called Wisk.

Major automotive manufacturers are also betting on urban air mobility. Hyundai has established its own UAM division, Toyota is a major investor in Joby, and Fiat Chrysler — now Stellantis, after a merger with Groupe PSA — has partnered with Archer. China’s

Geely Holding Group, whose brands include Volvo and Lotus, is both an investor in Volocopter and developing its own eVTOL design.

China also has notable eVTOL startups including Autoflight and, most prominently, EHang, which went public on the Nasdaq in December 2019 — the only major eVTOL startup thus far to pursue an initial public offering rather than a SPAC merger.

While many eVTOL makers are highly vertically integrated at this early stage of development, an increasing number of suppliers are being drawn to the sector. Honeywell, BAE Systems, and Garmin are some of the conventional aerospace suppliers that have announced agreements with eVTOL developers. Startups focused on enabling technologies are also working in the eVTOL space, for example Daedalean, a Swiss company that is developing autonomy systems based on computer vision.

One of the greatest challenges facing the eVTOL industry is that the regulations for certifying these novel aircraft do not yet exist, and neither do the airspace management paradigms to enable operations at scale. In recent decades, aviation regulators have been generally conservative and slow-acting. Enacting even basic rule changes can take years and



certifying new aircraft can take much longer. Much of the skepticism of the conventional aviation industry towards the UAM space can be traced to this history of regulators being slow to embrace new technology.

However, the eVTOL industry has already succeeded in persuading the Federal Aviation Administration (FAA) and European Union Aviation Safety Agency (EASA) to devote considerable resources toward developing the regulatory framework for eVTOL aircraft. NASA is also playing an active role in developing UAM concepts through its [Advanced Air Mobility National Campaign](#). And, in 2020, the U.S. Air Force threw its weight behind the industry with the launch of [Agility Prime](#), an initiative that is directing funding and in-kind resources to eVTOL developers and associated technology companies.

Outside of the United States, multiple countries have taken a keen interest in UAM. Singapore [hosted a demonstration](#) of a Volocopter eVTOL prototype and supporting “VoloPort” in October 2019. China has been permissive in allowing EHang to [carry passengers on demonstration flights](#) of its “autonomous aerial vehicles,” and New Zealand has partnered with Wisk on an [airspace integration trial](#) using the latter’s self-flying Cora eVTOL. Numerous nations, including China and the United States,

have begun work on a “national strategy” of sorts to coordinate government, military, and research efforts related to eVTOL technology, motivated both by the promise of economic benefits and the military potential of the sector.

Several trade associations have been playing key roles in the sector as well. The [Vertical Flight Society](#) was an early supporter of what it has dubbed the “Electric VTOL Revolution” and is the leading organizer of technical conferences on the subject. The [General Aviation Manufacturers Association](#) (GAMA) has also been a strong advocate for eVTOL aircraft and has taken a lead in developing technical standards for the industry, along with standards developing organizations including [SAE International](#), [ASTM International](#), and [EUROCAE](#).

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The more recently established [Community Air Mobility Initiative](#) (CAMI) aims to support local communities and decision-makers as they move toward adoption of UAM. Other trade associations taking an interest in eVTOLs include the [National Business Aviation Association](#) (NBAA) and [Helicopter Association International](#) (HAI).



## Are eVTOLs flying cars?

That depends on what you mean by flying car, but generally speaking, no.

Within the eVTOL industry, the term “flying car” is used narrowly to refer to roadable vehicles that can also fly. A few companies are developing true flying cars, and many of these are conventionally powered by fossil fuels. Designing a vehicle that can meet both highway and aviation safety standards is challenging, and the resulting product is typically sub-optimal as both a car and an aircraft. As a form of personal transportation, the flying car is also limited to the small market of people who are qualified to pilot aircraft under today’s aviation regulations.

When eVTOLs are described in popular media as flying cars, that’s typically in reference to their proposed functionality as an everyday form of

transportation. But that’s not a perfect analogy, either. Cars today give their owners a high degree of flexibility to go anywhere on their own schedule, but we’re still far from having the autonomy, landing infrastructure, and airspace management capabilities needed to allow everyone to fly themselves.

Most UAM proponents today envision eVTOL aircraft being deployed in a ridesharing model by approved operators, not private owners. For the foreseeable future, they’ll also need to operate from fixed airports or “vertiports” — they won’t be able to land just anywhere in a city. The term “air taxi” has become common to describe this combination of vehicle and operating model. However, air taxi also has an established regulatory meaning pertaining to on-demand flights in suitably certified small planes and helicopters, not just eVTOLs.



## When and where can we expect to see eVTOLs?

When eVTOL aircraft will actually take to the skies for commercial operations is a hotly contested question. Volocopter says it expects to see its two-seat VoloCity multicopter certified by EASA [in time for commercial operations at the 2024 Paris Olympics](#). Joby and Archer, which are both developing more complex vectored thrust eVTOLs, likewise intend to

have FAA-certified aircraft in service by 2024. Blade Urban Air Mobility, a helicopter booking platform which announced its intention to go public via SPAC in December 2020, recently [announced a deal with Beta](#) that will see the first eVTOL aircraft delivered for its service also in 2024.





These are ambitious targets in the context of traditional aircraft certification programs. In addition to incorporating novel electric propulsion technology, eVTOL aircraft also incorporate fly-by-wire flight controls, in which control inputs are commanded electronically rather than through mechanical linkages. Fly-by-wire technology is common in military aircraft and large commercial airliners, but the first fly-by-wire commercial helicopter — the Bell 525 — is [still awaiting certification](#) after a 10-year development effort that included a fatal crash during flight testing. The Leonardo AW609, expected to be the world's first civil tiltrotor aircraft, first flew 18 years ago and [has yet to receive the FAA's stamp of approval](#) (although not all of the delays in that program have been technical in nature — it also underwent some transfers in ownership).

For the first wave of eVTOL developers to stay on schedule, their flight test programs will need to go smoothly, and regulators will need to move swiftly in adopting a regulatory framework for the aircraft and validating the results of the test campaigns. Although neither is impossible, no serious industry observer will be shocked if these schedules slip — particularly for aircraft that are more complicated and include more novel features, systems, or components.

Different regulatory approaches may determine where urban air mobility operations launch first.

For example, China, which has already allowed passenger-carrying demonstrations of EHang's EH216, may approve that aircraft for commercial operations well before the FAA or EASA certifies an eVTOL aircraft. While speedy certification by any regulator could give a manufacturer a near-term edge, a certification process that does not adequately identify and resolve potential safety issues could ultimately prove to be a liability.

Besides Singapore, a number of major cities have already endorsed the concept of urban air mobility, including Dallas, Los Angeles, and Miami in the United States, and Melbourne in Australia. However, the speed and extent to which UAM operations scale will depend on each city's procedures for consulting with stakeholders, and the community's receptiveness to UAM.

Further discussion of risks that could impact eVTOL developers' schedules can be found in the next part of this report.





## Part II: Five Kinds of Risk

What can go wrong when you're introducing a safety-sensitive technology with the explicit goal of transforming society? Pretty much everything. This section of the report discusses five broad categories of risks that could impact eVTOL developers' chances of success.

Investors with a solid understanding of the risks involved will be better prepared to evaluate how

each company plans to address them. Some eVTOL designs will naturally carry more technical and certification risks, and some markets will have more infrastructure, operational, and sociocultural risks. Although some eVTOL developers will be well positioned to rise to the challenges, others will simply lack the knowledge, talent, or resources to adequately meet them.)

### Technical Risks

It is hard to overstate the technical challenges involved in building a viable eVTOL aircraft. The aerodynamics of vertical lift are extremely complex, especially for any vehicle that will be transitioning between hovering and wing-borne flight. Propulsion, energy storage, flight controls, and autonomy all present their own daunting technical challenges in creating an aircraft that is safe and functional, let alone optimized for its mission.

It is true that recent advances in computer simulation and modeling have made the tools of aircraft design widely available, so it's no longer unreasonable to believe that an ambitious startup can design an aircraft to rival the creation of a much larger

company. However, software cannot substitute for expertise. Any viable eVTOL company will need a strong base of engineering talent or a plan for attracting it. (Notably, the Vertical Flight Society has identified available talent as a critical risk for the vertical flight industry, as there currently aren't enough engineers in the U.S. to meet all of the eVTOL and rotorcraft development programs.)

Investors should be wary of being oversold on the significance of subscale model testing. Thanks to the explosion of the military and consumer drone industries, the technology for building subscale models is readily available, as are engineering services firms that will build



models for a relatively affordable price. Subscale models are important tools for proving and iterating aerodynamic design concepts, but they do not on their own establish the viability of a design. Only full-scale models can demonstrate a company's ability to integrate the various elements of an eVTOL into a working aircraft.

While taking an eVTOL aircraft through a flight test campaign is a major accomplishment, it does not guarantee commercial success. Even if the aircraft is certifiable (see below) it must have the cost and performance characteristics to support a practical business case.

One reason why helicopters are so expensive is because they are produced in very low volumes — for some models, just one or two dozen per year. High-volume manufacturing will be key for dropping the unit cost of eVTOL aircraft, yet scaling up manufacturing presents its own technical challenges, particularly when it comes to the composite materials

that most eVTOL manufacturers are using for their strength and light weight.

Not only must eVTOL aircraft be affordable, they must be capable of performing their intended mission. Investors should be skeptical of any design that relies on nonexistent battery technology to

achieve its performance targets.

Even if batteries do advance to the necessary level, that development will likely benefit multiple eVTOL developers, including those with inherently more efficient designs.

Investors should be wary of companies' claims with regards to aircraft capability, flight test progress,

and timeline for entry-into-service. Video footage of aircraft performance should be viewed as a main source of substantiation for claims, and investors should be careful to compare what a video actually demonstrates with what a company claims it demonstrates.

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### Questions for investors to ask eVTOL companies:

- What experience and qualifications do your engineers have with respect to designing and building aircraft? What are the current gaps in your engineering staff, and how do you plan to fill them?
  - What simulation and real-world testing have you done to validate the design of your aircraft and its systems? What is your timeline for full-scale flight testing?
  - What assumptions does your design make about batteries? What technology advancements are necessary to achieve your intended performance targets?
  - How do you plan to manufacture your aircraft, and how do you expect manufacturing to scale? What supplier partnerships have you established?
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## Certification Risks

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Making an aircraft fly is one thing; gaining regulatory approval to fly it with paying passengers is another. Multiple eVTOL developers now have full-scale models that have performed hundreds of test and demonstration flights, but they still have a long way to go in proving to regulators that the aircraft are safe for commercial service.

Airplanes and helicopters have extensive, well-established regulations governing their certification. Although the certification process for these aircraft is typically lengthy and expensive, manufacturers at least have a clear idea of what to expect and can plan and budget accordingly. The certification program for a conventional aircraft can run to \$1 billion — for larger airliners, up to the tens of billions — which is another reason why volume manufacturing is so important for unit economics, as it spreads that cost across a large number of aircraft.

By contrast, the certification rules for eVTOL aircraft have yet to be established. The FAA is taking a case-by-case approach, using 14 Code of Federal

Regulations (CFR) Part 23 rules for small airplanes as the basis for each certification program, and adopting special conditions relevant to the eVTOL design as appropriate. EASA, by contrast, has issued a [special condition for small category VTOL aircraft](#) intended to create a uniform framework for eVTOL developers in advance of targeted rulemaking.

Each method has its advantages, but these divergent approaches could make harmonization between the major regulators more difficult. Today, the FAA and EASA have broadly similar certification rules for helicopters and airplanes; although each regulator goes through a process of “validating” type certificates issued by the other, manufacturers do not have to contend with widely varying sets of requirements. Similar harmonization will be necessary for eVTOL models to cost-effectively launch in both the U.S. and Europe, and in the many countries that base their own validations on either FAA or EASA type certificates.



In China, EHang has been developing its “autonomous aerial vehicles” under a regulatory framework for unmanned aircraft systems, although China recently announced [the creation of a dedicated type certification team](#) for the EHang EH216. It is not clear how China will choose to validate Western eVTOL designs that require human pilots or how Western regulators will approach validating eVTOL designs certificated in China.

It is also unlikely that the FAA and EASA will certify autonomous eVTOL aircraft for passenger-carrying

flight before conventionally piloted models. Not only are the agencies less prepared to evaluate the safety of fully autonomous aircraft, it is unclear how unpowered aircraft will integrate into the existing airspace system. Although the FAA, EASA, and other regulators and government agencies are actively exploring these questions, autonomous eVTOL aircraft are likely many years away from commercial passenger-carrying operations in the U.S. and Europe.

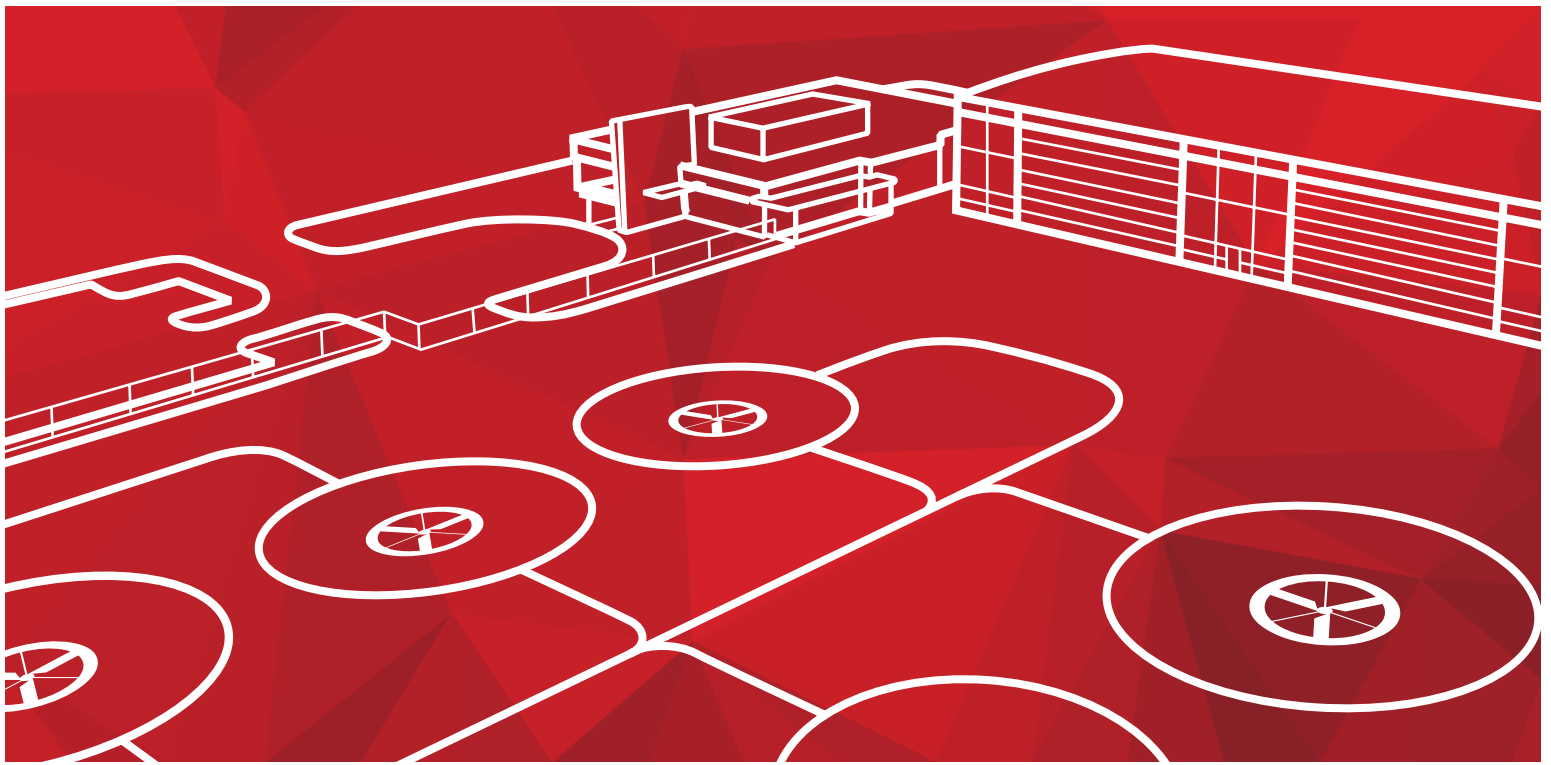


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### Questions for investors to ask eVTOL companies:

- How have you engaged with the relevant aviation authorities to date? Have you filed an application for type certification? Have you established a certification basis for your design?
- How does your design comply with the requirements of Part 23 and/or SC-VTOL? How does it diverge, and how do you plan to demonstrate an equivalent level of safety in these areas?
- Are you active in any of the committees or initiatives that are working to shape the regulations and standards for eVTOL aircraft?
- Do you have the resources necessary to complete an aircraft certification program? If not, how do you plan to acquire them?
- Do you have personnel who are experienced and knowledgeable about aircraft certification?
- If your aircraft is autonomous, how are you working to define a certification pathway for passenger-carrying operations? How do you plan to generate revenue or continue securing investment until your aircraft can be certified, potentially many years into the future?





## Infrastructure Risks

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Two types of infrastructure are needed for eVTOL aircraft to fulfill their potential: ground infrastructure and airspace management systems.

Piloted eVTOLs will be able to leverage existing aviation infrastructure at launch. Their human pilots will be able to integrate with today's voice-based air traffic control (ATC) system, and they should be able to fly into many established airports and heliports, although fully electric aircraft will need provisions for charging.

However, even modest scaling of UAM operations will demand considerable infrastructure investments. Cities will need well designed vertiports in convenient locations to enable popular UAM routes. UAM aircraft will also need specialized air traffic management services in fairly short order. A [simulation conducted by EmbraerX and Airservices Australia](#) found that existing airspace near Melbourne could become saturated with just four UAM operations present due to current procedure limitations.

A variety of actors have started to define infrastructure requirements for eVTOL aircraft. On the ground infrastructure side, most leading eVTOL companies have started to make plans for vertiports and charging stations. Beta Technologies is developing its own [modular, transportable charging platforms](#) using cargo containers. Volocopter has teamed up with Skyports to develop a "[VoloPort](#)" [concept](#) that was exhibited in Singapore, and Lillium has [partnered with the infrastructure operator Ferrovial](#) to build a network of vertiports across Florida.

At this early stage of development, it makes sense for eVTOL developers to pursue their own infrastructure projects. However, cities that adopt UAM will want a large say in where vertiports are located, how they operate, and what requirements they'll have to meet for charging and fire suppression. Given the enormous diversity of eVTOL designs at present, it is possible that some public vertiports will only be





able to accommodate certain types of aircraft. (It is also possible that communities will mount opposition to new vertiport projects, as discussed in the sociocultural risks section below). Inadequate ground infrastructure could preclude UAM operations from achieving scale and profitability.

On the airspace management side, both private companies and government agencies are actively exploring concepts for UAM traffic management. The FAA published its [first UAM Concept of Operations](#) (ConOps) in mid-2020, and NASA published a [ConOps for a more advanced stage of UAM](#) in early 2021. NASA will also be studying various approaches to airspace management through its Advanced Air Mobility National Campaign.

However, these concepts are still in their early stages and have yet to go through a full stakeholder

engagement process. Other users of the airspace have already expressed some concern in reaction to the idea of dedicated UAM corridors, for example, and any resistance could slow the progress of UAM. Moreover, each geographic market could take a different approach to airspace management.

In the long term, most UAM proponents expect that airspace management will become highly automated in order to achieve volume operations and, ultimately, enable operations by autonomous aircraft. This could take many years to achieve, though. Investors should be wary of revenue projections that assume a very high tempo of operations before the infrastructure is in place to enable it.



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### Questions for investors to ask eVTOL companies:

- What infrastructure will your aircraft require at launch? If this infrastructure does not already exist, how will it be created?
  - What are the charging requirements for your aircraft and how do you expect to meet them? If your aircraft is hybrid, how will you accommodate refueling needs in the areas you plan to operate?
  - Who are you engaging with on infrastructure in your target markets?
  - Are you involved with any of the initiatives to define the airspace management requirements for your operations?
  - How many hours do your aircraft need to fly per year to be profitable? What infrastructure will be required to enable this tempo?
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## Operational Risks

Today, most aircraft manufacturers are in the business of selling aircraft, not operating them. Boeing and Airbus sell jets to airlines; they don't operate airlines themselves. At this mature stage of the industry, it would be foolish (and potentially [anti-competitive](#)) for them to diversify.

However, eVTOL aircraft are in their infancy, and many eVTOL developers including Joby and now EHang see a compelling argument for also operating their own aircraft, or at least being closely involved with those operations. When these novel aircraft are certified, the manufacturers will have more familiarity with them than anyone else and, in the case of UAM, will have a vision for the passenger experience they want to ensure. Being involved with early operations will also allow eVTOL developers to quickly identify and address any latent design issues, ideally before they can damage the reputation of the aircraft.

But there are several reasons why manufacturing and operations have become separate lanes in the larger aviation industry. An eVTOL developer who attempts to do both will essentially be managing two distinct, complex business enterprises, each

demanding specialized expertise. Although they will have some synergies, taking on both will necessarily require additional human resources and capital — doubly so for companies that also plan to build and own the demand aggregation process, customer-facing booking system, and other necessary software elements of the ecosystem. (If they succeed, and the UAM industry grows as its proponents hope, such companies could eventually become subject to antitrust actions, as Boeing was in the 1930s.)

Those eVTOL developers that plan to operate their own aircraft should be able to articulate compelling reasons for doing so. Gaining authorization to conduct commercial flight operations is a separate regulatory process that can stretch into years, so companies should have a plan for achieving the necessary operating certificates, and employees with the qualifications required to serve as responsible personnel. Developers of

piloted aircraft should also have a plan for attracting and retaining the many pilots they'll need for their operations, which could become more challenging as the broader aviation industry rebounds from the Covid-19 pandemic.

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**Those eVTOL developers that plan to operate their own aircraft should be able to articulate compelling reasons for doing so.**

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Insurance is another factor to consider. Aviation insurance has recently become much more difficult and expensive to obtain for the types of on-demand operations that UAM companies will be conducting. It is not clear how underwriters will appraise the risks of new and unproven aircraft types, particularly if they are engaged in high-profile UAM operations.

eVTOL developers that choose not to operate their aircraft should be selective about their launch operators, particularly for UAM. Any accidents involving their aircraft could reflect poorly on their brand, even if the design of the aircraft is not at fault. Archer's [strategic partnership with United and Mesa Airlines](#) is an example of an eVTOL developer looking to an established and reputable outside party for operational expertise.

Although there is risk associated with operations, there is also opportunity. Today's on-demand air taxi operations — conducted under 14 CFR Part 135 in the United States — have a much poorer safety record than the Part 121 airlines, largely due to operational factors. Although most eVTOL companies expect that their aircraft will be flown under Part 135 rules or their international equivalents, introducing airline-type safety practices and culture from an early stage could help establish UAM as one of the safest forms of transportation.



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### Questions for investors to ask eVTOL companies:

- Do you plan to operate your own aircraft? If so, what advantages will outweigh the costs and risk associated with those operations?
  - If you plan to operate your own aircraft, have you already started the process of seeking an operator certificate? Who in your organization will be responsible for operations and what are their qualifications? What safety programs will you be implementing?
  - If you do not plan to operate your aircraft, what steps are you taking to ensure that they will be introduced to the market safely?
  - How do you envision your aircraft being maintained, and what preparations are you making for product support?
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## Sociocultural Risks

As discussed earlier, eVTOL aircraft have multiple possible use cases, many of which are not controversial. The transport of human organs or cargo, or military logistics missions, are unlikely to draw many objectors when helicopters are already serving these roles. The community acceptance risk for such operations is relatively low.

Not so for urban air mobility, which is the high-risk, high-reward use case drawing most of the investment in the sector. UAM operations will only deliver billions of dollars of revenue when they have scaled to the point of fundamentally altering a city's transportation landscape. Such a far-reaching transformation will impact many stakeholders, any of whom could act to accelerate or derail UAM progress in the community.

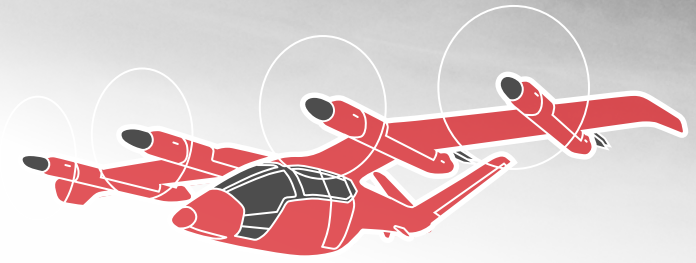
For UAM evangelists, it may be difficult to understand how anyone could object to clean, quiet eVTOL aircraft whisking passengers over congested roadways. In many communities, however, they'll be up against the negative associations created by helicopters — which are widely perceived as noisy, disruptive toys for the rich — as well as drones, seen by some as dystopian tools for privacy violations by companies or governments.

To secure the necessary permissions for UAM operations and infrastructure, proponents will need to persuade a broad range of stakeholders that eVTOL aircraft will benefit the community at large, not just the privileged few. Depending on the business models chosen, they may also need to make a case for why cities should invest in UAM infrastructure — or at least allow private sector investment — in addition to or in lieu of other transportation improvements.

Then, they'll need to convince people to actually ride on the aircraft. That shouldn't be too difficult, if eVTOL air taxis can deliver substantial time savings at a price competitive with ground transportation options such as Uber Black. But that's a big "if." Operators must ensure seamless multi-modal connections to realize meaningful time savings for passengers, especially on shorter trips. And if they can't drive costs down to a level that is compatible with what people are willing to pay for the service, then they'll never turn a profit — or they will remain a niche service for the wealthy, with the associated community pushback.



Meanwhile, there is also safety to consider. A high-profile accident like the helicopter crash that killed Kobe Bryant could shake the confidence not only of passengers, but also the communities they're flying over. Scaled UAM operations will only be possible if they can achieve very high levels of safety, as cities simply won't tolerate aircraft falling out of the sky on a regular basis. That said, it is possible that different geographic regions may have different standards for what constitutes an acceptable level of safety.



### Questions for investors to ask eVTOL companies:

- How do you intend to reach your target price point, and what requirements for scale are baked into that target?
- If you are pursuing UAM as an early use case, what strategies are you developing to secure community support for your operations?
- How will your offering benefit the cities in which you're operating? Why should they invest in UAM in addition to or instead of other transportation options?
- How will the noise of your aircraft compare to a helicopter? How do you intend to minimize disruption to local communities?
- How will you ensure a seamless transportation experience for your passengers?
- What studies have you conducted to validate the pricing for your offering? How will your revenue projections be impacted if you have to lower pricing or carry fewer passengers than estimated?
- How will you respond to a fatal accident involving your aircraft?





## Closing Thoughts

It is not an exaggeration to say that the present moment represents the dawn of a new era in aerospace. Advancements in electrification, autonomy, simulation, manufacturing, and more are enabling new aircraft designs that promise to create new markets and transform existing ones. But aviation is a challenging and capital-intensive industry with long horizons. Investors who buy into it expecting swift and certain returns will almost surely be disappointed.

For those investors with the resources and patience for long-term plays, eVTOL companies today present exciting opportunities to get in on the ground floor.

They also have the potential to make aviation more accessible and more sustainable — goals that for some people are just as important as the impact on their portfolios. For everyone else: proceed with caution, and expect volatility as the challenges inherent in developing, certifying, and deploying new aircraft play out across the industry. A road to large-scale UAM may exist, but there are likely to be some bumps along the way.





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## Thanks for reading eVTOL Basics for Investors



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