The eVTOL Air Taxi Startup Handbook

Air mobility optimism mounts, but industry faces challenges

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Key takeaways

- We forecast the global air taxi passenger mobility market to grow from a burgeoning $1.5 billion in revenue in 2025 to $150.9 billion in revenue in 2035. Electric vertical take-off and landing (eVTOL) aircraft have major operating cost advantages over helicopters and could make passenger air mobility affordable to the masses.
- Passenger air mobility startups raised $3.8 billion from financial (VC, PE, and SPAC) and strategic (aerospace, automotive, and tech) investors in the first quarter of 2021.
- Timeline expectations may be inflated as investors underestimate the complexity and capital cost of certification, as well as the technological, regulatory, and infrastructure-related hurdles required for mass adoption. Labor and supply shortages could further weigh on the space.
- Well-capitalized startups with established manufacturing partners are poised for success, while a shakeout may be in the cards for many of the 100+ startups developing technology in the space.
- We see opportunity for early-stage VC investors to back “picks and shovels” enablement technologies, such as mobility services, autonomous autopilot, and engineering analysis tools.

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Air mobility startup market map

eVTOL passenger aircraft

JOBY AVIATION, ARCHER, LILIUM, VOLOCOPTER, EHANG 184, KITTYHAWK, Aurora Flight Sciences, KAREM AIRCRAFT, INC., DUFOUR AEROSPACE, XTI AIRCRAFT, TALYN, ZEVA, JAUNT AIR MOBILITY, EVA, OPENER, ASX AIRSPACE EXPERIENCE TECHNOLOGIES, flyt hop, The ePlane Company, ALAKA'I TECHNOLOGIES, AtlasAero, BETA, Horizon Aircraft, Jump Aero, MAGLEV AERO, Overair, SKYWORKS, tetra tetra aviation corp., URBAN AERONAUTICS, VERTICAL, VOYZON AEROSPACE, wisk, AUTOFLIGHT

eCTOL aircraft

EVIATION, BYE AEROSPACE, pyka, ZUNUM Aero, AMPAIRE, Wright, hypoint, SONICBLUE AEROSPACE, Heart Aerospace, faradair

Electric propulsion & motors

PIPISTREL, ep ELECTRIC POWER SYSTEMS, ZEROAVIA, H55, LAUNCHPOINT ELECTRIC PROPULSION SOLUTIONS, GPL, MAGICALL, magniX

Roadable aircraft

SKYDRIVE, AEROMOBIL, TERRAFUGIA

Autonomous autopilot & airspace management

DAEDALEAN APPLIED INTELLIGENCE, Skyryse, XWING, ALTITUDE ANGEL, SKYGRID, NEAR EARTH AUTONOMY

Air mobility startup market map

Drones

zipline, Skydio, 3DR, DJI, DroneDeploy, PrecisionHawk, Airobotics, Skycatch, Drone Racing League, Saildrone, Makeblock, Clobotics, AirMap, Volansi, Dedrone, kespry, Yuneec, SkySpecs, Delair, Fortem Technologies, FlyPro Just Move, D-Fend Solutions, Iris Automation, Wingcopter, Elroy Air, Flirtey, JOUAV, Impossible, Flytrex, Cloudline

Battery technology

northvolt, QuantumScape, microvast, SILA Nanotechnologies, SVOLT 蜂巢能源, FREYR, Литех, ENOVIX, Livent, VARTA, ROMEO Power Technology, ENEVATE, Sion Power, GROUP14, SolidPower, CUBERG, ULTIUM CELLS

Supersonic aircraft

BOOM, RAMGEN Power Systems, AERION Supersonic, AMPAIRE, EXOSONIC, SPIKE Aerospace

Air mobility services

WHEELS UP, VistaJet, BLADE, VICTOR, Reliable Robotics, Hybrid Air Vehicles, JetSuite, APIN 国飞就上爱持机, WIJET Partenaire de Airfrance, OpenJet, PrivateFly, Jet Set Go, FlightBridge, EVOLUX, JetInsight, FLYT, avinode, FlexJet

Introduction

The passenger air mobility industry—which comprises electric vertical take-off and landing (eVTOL) aircraft manufacturers, their enablement technologies, and air taxi service providers—has the potential to significantly disrupt the landscape of urban mobility. Air taxis could dramatically lower the cost of long-distance urban transportation while reducing emissions and traffic congestion within cities. Although the industry faces significant technological and regulatory hurdles, we believe nontraditional investors such as manufacturers and corporates with vested interests in shaping the evolution of the transportation industry will continue to fund R&D in the space, helping drive a new wave of innovation and reshaping the aviation industry.

While the flurry of SPAC-driven public market debuts in air mobility has created a peak of investor expectations, we believe mass eVTOL deployments in the early-to-mid 2020s are unlikely given large technological, regulatory, and infrastructure-related hurdles. Nonetheless, there are clear, long-term commercial use cases for passenger air mobility, and we are relatively positive on the long-term business prospects for well-capitalized leaders in the space such as Joby Aviation, Archer Aviation, and Volocopter; as well as enablement technologies from providers including Daedalean, Reliable Robotics, and PHM Technology.

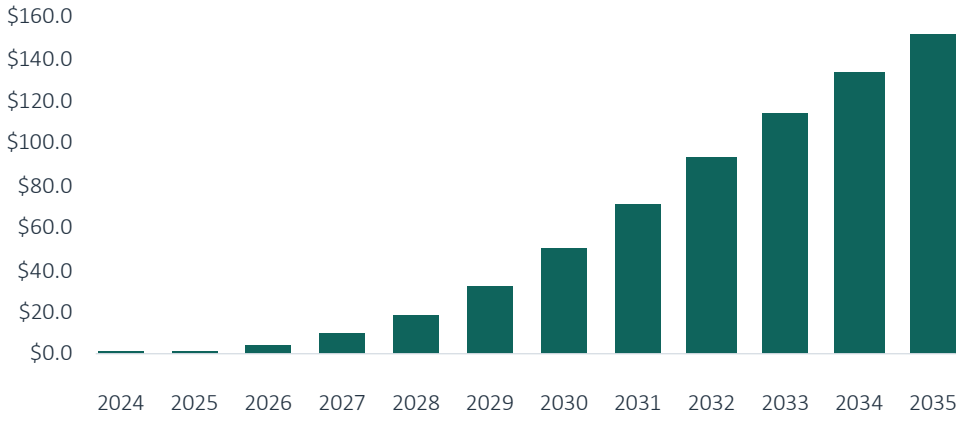
Large market size opportunity

We forecast the global air taxi passenger mobility market to grow from $1.5 billion in revenue in 2025 to $150.9 billion in revenue in 2035. This is equivalent to approximately 19.4% of expected global airline revenue in 2021.[1] Initially, we expect eVTOL rollouts in the early-to-mid 2020s to concentrate in high-income cities in mild climates, such as Dallas and Miami, as this will help maximize utilization at a premium price point. However, as aircraft volumes scale and battery and autonomous technologies improve, we expect maintenance and operations costs to decline substantially. This should help reduce the price of air taxi transportation to under $5 per seat-mile, expanding the market for passenger air mobility.

While most major corporates and startups in the space have announced deployment targets in the early to mid-2020s, we believe this is an aggressive estimate given technological and regulatory barriers. Achieving certification will be a major challenge for most startups in the space. We believe the energy density of batteries will need to improve significantly, and eVTOL manufacturers will face stiff competition from high-volume automakers in securing high-performance battery supply. A shortage of certified pilots is likely to constrain operations growth. Autonomous technology will also need to advance significantly to pass stringent flight control tests. Infrastructure represents yet another barrier to adoption as vertiports, charging infrastructure, and air traffic management services will need to be developed to support this burgeoning ecosystem.

1: “Global Airlines,” IBISWorld, Shawn McGrath, June 2020.

Air taxi passenger mobility market size ($B)



Source: PitchBook | **Geography:** Global

Despite these hurdles, we are optimistic about the industry over the long-term as eVTOL aircraft provide major advantages relative to helicopters, such as reduced noise levels. eVTOL aircraft could reduce noise levels by as much as 20dB compared to helicopters, and independent multi-rotor systems could tailor perceived noise to be less objectionable.[2] For example, a survey following a Volocopter demonstration showed spectators thought the aircraft was quieter than they expected.[3] Quieter aircraft should lead to increased routes opening closer to residential areas and increased frequency of flights, significantly expanding the market for air mobility beyond existing helicopter services. Additionally, eVTOL aircraft do not produce emissions, a factor that could speed adoption as governments seek ways to offset carbon emissions from conventional transportation solutions.

Electric air taxis also have several potential cost advantages that should speed adoption once scale is attainable. The cost of flying by helicopter is high—approximately $9 per mile—generally limiting the addressable market to high-income commuters or business executives. Air taxis will likely have relatively lower operating and maintenance costs, helping reduce per-mile costs for passengers. The inherent redundancies of most air taxi designs may also lower maintenance costs. Helicopters have a single point of failure—the main rotor—which necessitates recurrent and thorough inspection and increases the chances of catastrophic loss. Most air taxis in development have multiple motors and redundancies, which can improve safety and reduce maintenance requirements as well as maintenance-induced incidents. Additionally, battery or hybrid powertrains of air taxis should lead to significant fuel cost savings. Finally, we anticipate autonomous technology will reduce the need for certified pilots, which would bring down the cost of operation significantly. Uber Elevate, the urban air mobility division of Uber (which has since been acquired by Joby Aviation), focused on piloted air taxi flights to reach profitability,

2: "Noise Critical Issue for eVTOL Acceptance," Aviation International News, Mark Huber, January 2020.
3: "One Key to Public Acceptance of Air Taxis? Education," eVTOL.com, December 6, 2019.

but forecast that 2030+ air mobility operations would decrease cost per passenger mile to that of existing ground ridehailing operations (approximately $2.50 per mile). Air taxi startup Lilium has claimed that the cost of a trip from Manhattan to JFK Airport could be $70, or approximately $4.40 per mile. Joby Aviation estimates the operating cost of its aircraft will be $3.80 per mile for a 25-mile trip, significantly below the cost of a $9-per-mile helicopter trip.

Considerations for passenger air mobility investors

Although we are optimistic about the long-term prospects of the industry, we believe the 100+ startups developing passenger eVTOL aircraft face unprecedented execution risks that may be underestimated by the market. Risks include the difficulty and capital cost of obtaining developer and manufacturer certifications, gaining access to high-performance battery supply, manufacturing precision components and aircraft at scale, developing autonomous technology, establishing necessary infrastructure, and profitably operating mobility services with high utilizations.

Different vehicle configurations: Many of the leading eVTOL startups are developing radically different vehicle configurations, reflecting diverging expectations for market demand. *Electric VTOL News* has classified these configurations into several categories, including vectored thrust, wingless (multicopter), lift + cruise, and electric rotorcraft.[4] Vectored thrust—which uses thrusters that lift the aircraft then rotate to cruise—is the approach taken by leaders such as Joby Aviation, Archer, Lilium, Overair, and XTI, thanks to its efficiency benefits that expand range. These providers believe the bulk of demand will come from piloted medium range trips of 25–60 miles. Meanwhile, wingless multicopter technology—which involves fixed thrusters—is relatively conventional, enabling faster development, but is power-hungry, constraining range. Multicopter aircraft offered by EHang and Volocopter are well suited for autonomous short-range trips within cities. Drone-enabled cargo delivery is a key adjacent market for these providers.

High utilization key to success: High utilization will be required for passenger air mobility providers to generate profitable returns, and this dynamic could favor smaller aircraft providers servicing fewer passengers per trip. Joby Aviation forecasts annual net revenue of $2.2 million per plane to generate a 45% contribution margin in 2026, but this assumption is based on 7 hours spent in flight per day and a load factor of 2.3 passengers per trip. For comparison, helicopter operators tend to average just 1–2 flight-hours per day, depending on application.[5] Such high utilization could be difficult to achieve at a premium price point. This dynamic is reflected in existing mobility services such as ridehailing. Whereas the average passenger occupancy of ridehailing vehicles is 1.4, the average passenger occupancy of UberBlack—a premium ridehailing service in the

4: "eVTOL Aircraft Directory," Electric VTOL News, 2021.
5: "Honeywell Sees Helicopter Sales Growth Ahead," Aviation International News, James Ynbrandt, March 2013.
6: "Impacts of Ridesourcing on VMT, Parking Demand, Transportation Equity, and Travel Behavior," Mountain-Plains Consortium, Alejandro Henao, Wesley E. Marshall, and Bruce Janson, March 2019.

US—is just 1.0.[6] In addition, wealthier cities tend to have lower passenger occupancy rates compared to less wealthy cities where pooling is more common. As we expect the first rollouts of passenger air mobility to occur in wealthy cities at a relatively premium price point, lower demand could favor providers such as Wisk, Volocopter, and EHang, which are focused on using smaller aircraft to serve one or two passengers. On the other hand, if demand for mobility services outstrips supply, providers using larger aircraft with a higher ratio of passengers to pilots could be better positioned.

Certification hurdles dramatically underestimated by the market: In addition to the steep capital requirements for researching, developing, and manufacturing, aviation companies must achieve certification with regulatory authorities such as the Federal Aviation Administration (FAA) and the European Union Aviation Safety Agency (EASA). In the US, aircraft manufacturers must achieve two major certifications: a type certificate (TC) indicating an aircraft design has been deemed safe and airworthy and a production certificate authorizing the manufacturing of duplicate products under an FAA-approved design.

Obtaining these certifications is orders of magnitude more costly and complicated than achieving approvals for on-road vehicles. For example, EASA requires small VTOL aircraft to match commercial airlines at a one-in-a-billion chance of catastrophic vehicle failure. Hitting these high safety thresholds could be a significant barrier for the dozens of startups developing eVTOL technology.

We estimate the cost of certifying new light electric aircraft could exceed $1 billion, including design work and setting up production facilities. Of the 100+ startups developing eVTOL technology, only Joby Aviation, Lilium, and Archer have raised enough to cross this threshold (as of March 2021). As this ecosystem develops, we believe dozens of smaller startups in the space will ultimately be forced to shutter their projects due to the high cost of certification.

As autonomous systems are introduced, increasing the complexity of the overall system, this cost could significantly increase. The certification process is further complicated by the lack of pathways for certification of non-deterministic AI systems in commercial aerospace.

Another key consideration will be achieving manufacturing certification, which ensures that every vehicle meets crucial safety thresholds. In our view, eVTOL companies could save significantly on costs as they achieve mass production by leveraging the high-volume manufacturing experience of the automotive industry. We believe startups partnered with manufacturers—such as Joby Aviation partnering with Toyota, Archer Aviation partnering with Stellates, and Kitty Hawk/Wisk partnering with Boeing—are best positioned for mass production as these established producers have a long track record of high-volume manufacturing that fits safety and performance thresholds. That said, compared to aerospace manufacturers, automobile companies could face a learning curve in

dealing with enhanced aviation requirements, as evidenced by Mitsubishi's woes with its SpaceJet airliner project, which was recently suspended after failing to achieve certification despite billions of dollars in investment.

Complexity of eVTOL requires process rethink: Given the safety benefits of predictive-model-based analysis, we believe future airworthiness rules could mandate model-based system engineering tools. Engineering aircraft systems is a highly complex undertaking that entails expensive and extensive testing processes. There are many variables to consider, including long lead times, unpredictable weather, and unpredictable systems interactions. Deriving insights and critical information involves the integration of millions of data points. Model-based systems engineering (MBSE) could provide a solution to these challenges by moving previously siloed workflows and data to centralized model-based platforms for systems engineering. MBSE solutions provided by companies such as Siemens and PHM Technology enable companies to accelerate product development for complex projects while reducing unexpected costs, as well as more cohesively integrate design, analysis, validation, and verification during the product development lifecycle. Startups that have made progress adopting these engineering systems may have an edge over competitors.

Additional financing likely needed: Although recent financing rounds may be enough to propel major air taxi startups such as Joby Aviation through certification, we believe even well-capitalized eVTOL startups will need to raise additional rounds to get their service offerings scaled. Similar to how ridesharing services Uber and Lyft initially ran at a loss with VC money subsidizing fares to attract riders, we believe hundreds of millions in capital will initially be required to offset initial losses from air taxi services. However, whereas most rideshare companies achieved scale while relying on private funding sources, the fact that so many air mobility startups are now publicly traded and still without revenue adds a new layer of complexity to the financial picture. As companies transition from a certification focus to an operational focus, the ensuing land grab is likely to require heavily subsidized offerings to drive adoption, and it is uncertain how much potential share dilution public shareholders will be willing to stomach.

Startups face substantial competition from incumbents: With inherent advantages in R&D, regulation, and manufacturing, established aerospace, automobile, and industrial companies are likely to emerge as formidable competitors in passenger air mobility. Boeing is developing an autonomous, multi-rotor eVTOL air taxi for urban commuting with a range of up to 50 miles (the project has faced setbacks due to COVID-19). It has also partnered with Porsche to explore future premium eVTOL vehicles. Airbus is developing a new eVTOL dubbed CityAirbus, which uses a simplified multicopter design similar to Volocopter. Lockheed Martin and Northrop Grumman are investing in eVTOL research and development. Bell Textron is developing a hybrid electric eVTOL aircraft dubbed "Nexus," as well as a cargo drone. AerOS is Bell Lab's digital infrastructure platform that seeks to provide flight booking services, eVTOL fleet management, airspace management, battery analytics, and demand forecasting. Hyundai has

established an urban air mobility division and is investing $1.5 billion in air taxi technology through 2025. The automaker has announced partnerships with Hyundai Construction for vertiports, KT for communications infrastructure and services, and Incheon International Airport for additional infrastructure.

Battery supply chains will become more competitive: eVTOL manufacturers could face substantial competition from carmakers in securing battery supply, delaying widespread product distribution. Given the high performance and safety requirements of certain eVTOL vehicle configurations, we believe the electric aviation industry will require high-performance batteries that use technologies such as solid-state polymers, lithium-sulfur, lithium-metal, or silicon anodes. However, carmakers are likely to dominate the market for high-performance batteries as EV manufacturing ramps up over the next decade and battery suppliers seek to cater to this larger—and likely more reliable—market opportunity. Battery suppliers may also shun the air-taxi industry given the relatively high-stakes risk of a faulty battery winding up in an air-taxi as compared to a car.

Pilot labor shortage: A shortage of pilots could constrain scaling of air taxi operations. Given the lack of pathways for certification of non-deterministic AI systems in commercial aerospace, the air mobility industry is likely to rely on pilots for some time. However, certified pilots are currently in short supply, and the problem is getting worse. Boeing forecasts that impending retirements of tens of thousands of pilots will result in a shortage of 61,000 helicopter pilots globally by 2038.[7] The existing 15,000 certified helicopter pilots in the US may not be enough to service widespread air mobility routes. As such, air mobility providers must incentivize pilots to join their services, a dynamic that could negatively affect industry margins. Vectored thrust eVTOL vehicle configurations relying on traditional airplane pilots could be better insulated from this trend, although we note that the airline industry is currently also experiencing a pilot shortage. Lowering requirements for flight training using autopilot technologies such as Skyryse and Xwing could help solve this problem.

Second movers benefit from industry knowledge and maturing ecosystem: Joby Aviation and Wisk are largely viewed as pioneers in the industry and have made significant investments in designing and engineering customer components including electric motors, flight software, and lithium-ion batteries. However, later air-mobility entrants are joining a more mature market, where external supply chains are more developed and parts suppliers have more industry sophistication, allowing them to source components with fewer up-front design and engineering outlays. For example, Archer has established supply contracts with manufacturing partners including Stellantis (Fiat Chrysler and Peugeot) for support on composite materials, NVH (noise, vibration, and harshness) design, and battery suppliers. Leveraging high-volume manufacturing partners will likely be key to helping the company achieve its goal of mass production by 2026. A similar pattern emerged in micromobility, where first movers Bird and Lime helped blaze new ground, attracting billions in venture capital,

7: "Pilot and Technician Outlook 2020–2039," Boeing, June 2020.

scaling rapidly, and creating a new product segment. However, these first movers struggled under operations-heavy business models that attempted to do too much, whereas leaner second-mover startups such as Tier and Voi were able to avoid these mistakes and capitalize on the market their predecessors had helped establish.

Consolidation phase likely to heat up as investors turn toward supply chain and enablement technologies: With more than 100 startups currently developing eVTOL aircraft—and not all of them likely to overcome extensive manufacturing and certification challenges—we expect significant consolidation could be in the cards. For example, in February, eVTOL developer Horizon Aircraft was acquired by Astro Aerospace for an undisclosed amount. Startup Terrafugia recently shuttered its US-based operations after facing major technical challenges associated with making a roadworthy flying car. At this stage of the investment cycle, we are most confident in later stage, well-capitalized startups such as Joby Aviation and Volocopter, and believe early-stage startups will face a more uphill battle in raising capital. We expect early-stage VC investors are likely to deploy capital toward enablement technologies to support this burgeoning ecosystem rather than new aircraft developers.

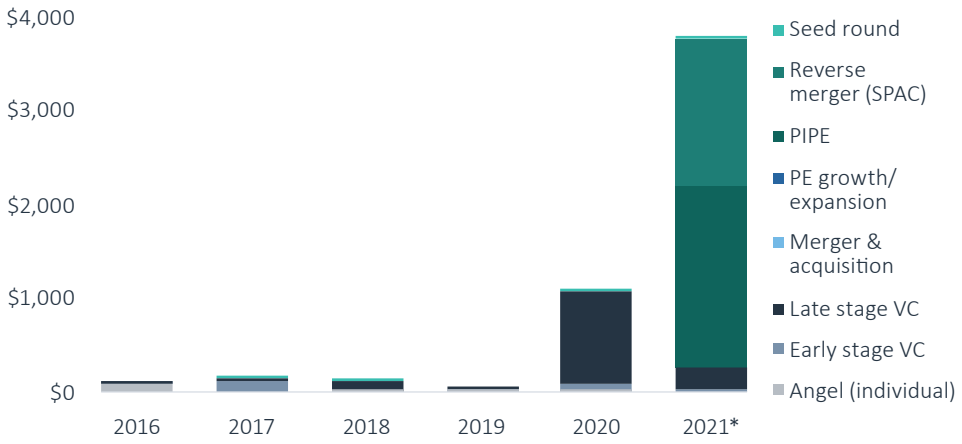
Autonomous ridehailing reduces cost advantage of air taxis, but not time advantage: Proponents of passenger air mobility often point to the high cost of ridehailing in urban areas—which can exceed $2.50 per mile—as the primary market for passenger air mobility. However, advancements in autonomous driving/robotaxis are likely to reduce the cost of ridehailing significantly to potentially below $1 per mile (and as low as $0.60 per mile) by the mid-to-late 2020s, reducing the comparative affordability of passenger air mobility. This potential threat from autonomous vehicles is offset by the fact that driverless vehicles are unlikely to solve the problem of congestion in cities (in fact the opposite could be true), meaning air-taxis may still have an edge in time savings if not in cost.

Parallels with autonomous driving industry: We see parallels between air mobility and autonomous driving, and think the market may be underestimating the capital intensity and execution risk of commercializing passenger air mobility. Both sectors are developing disruptive transportation technologies that are capital intensive, requiring billions of dollars in investment to develop, certify, manufacture, and scale services. Additionally, both sectors initially set aggressive timeline expectations for the deployment and commercialization of their technology. We believe passenger air mobility could be following the same hype cycle that led investors in 2015-2017 to anticipate widespread adoption of autonomous vehicles by 2020. The air mobility industry also has much shared knowledge as many of the same engineers will operate in both spaces. Financing trends are also similar, as both the autonomous car and air mobility spaces tend to attract the same venture investors, while the recent SPAC trend has been prominent across both industries. In our view, the significant complexities and hurdles of commercializing air mobility may warrant a reset in timeline expectations, as occurred with the autonomous driving industry.

Investment in startups on the rise

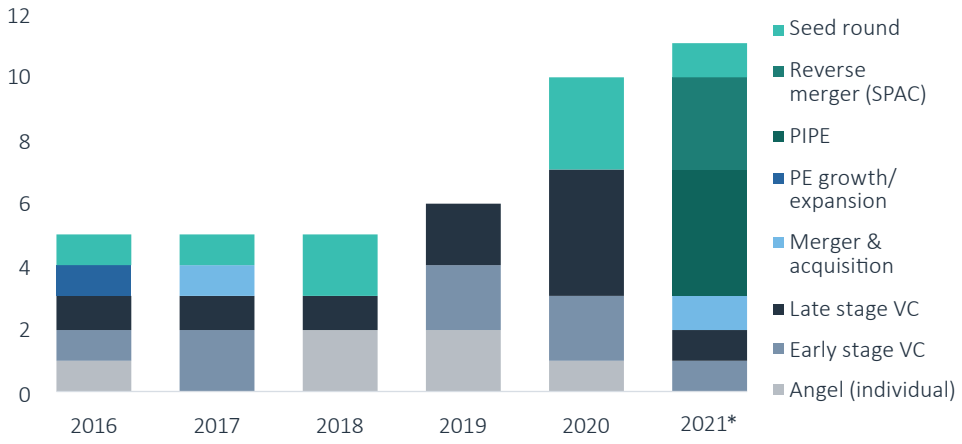
In the first quarter of 2021, investors poured a staggering $3.8 billion into eVTOL air taxi startups such as Joby Aviation, Archer, and Lilium, largely through SPAC mergers and concurrent PIPE deals. Investment in Q1 2021 marks more than triple the $1.1 billion invested in all of 2020, which mostly consisted of late-stage VC deals. Investment dollars are on the upturn but are being increasingly concentrated into late-stage leaders in the space. Given frothy valuations, we believe most discount opportunities reside among early-stage picks-and-shovels providers. While median late-stage mobility startup valuations increased 87.5% YoY in 2020—rising in tandem with public EV companies—early-stage mobility startup valuations were down 31.6%, suggesting discounts are available.

Investment in eVTOL passenger air taxis ($M)



Source: PitchBook | **Geography:** Global
*As of March 31, 2021

Investment in eVTOL passenger air taxis (#)



Source: PitchBook | **Geography:** Global
*As of March 31, 2021

Top investors in passenger air mobility

Investor name	Investment count
Intel Capital	4
Atomico	4
Baillie Gifford	4
LeBox Capital	3
PreAngel	3
JetBlue Technology Ventures	3
Levitate Capital	3
b-to-v Partners	3
Capricorn Investment Group	3
ZhenFund	3
LGT Group	3
Tencent Holdings	3
Team Europe Management	2
Lukasz Gadowski	2
AME Cloud Ventures	2

Investor name	Investment count
8VC	2
Sky Dayton	2
Avala Capital	2
Trucks Venture Capital	2
Daimler	2
DB Schenker	2
Paul Sciarra	2
Eniac Ventures	2
SPARX Group Company	2
Geely Technology Group	2
GGV Capital	2
Toyota AI Ventures	2
Lightrock	2
BlackRock	2

Source: PitchBook | **Geography:** Global
*As of March 22, 2021

The air mobility space has attracted a diverse set of investors. Major investors include technology companies such as Intel, Tencent, Qualcomm, and Google, which may see an opportunity to supply software, automation, and cloud computing capabilities. Strategic transportation investors include aerospace companies such as Boeing and Airbus; airlines such as JetBlue and United; and automakers and suppliers such as Toyota, Stellantis, Daimler, Geely, and Continental. Venture capital firms such as Andreessen Horowitz, Lightspeed Venture Partners, and Lux Capital Management are also active in the industry.

The US government is taking an active role in supporting the eVTOL air taxi industry. In March 2021, the United States House and Senate introduced bipartisan legislation calling on the US Secretary of Transportation to establish federal support for the development of aerial mobility infrastructure. The US military has also been active in the industry, which may in part stem from competition with China, which dominates the consumer drone market. According to PitchBook data, the United States Department of Defense has provided funding for at least six urban air mobility startups over the past three years. Additionally, the United States Air Force has taken an active role in supporting commercial investment in eVTOL aircraft through its Agility Prime initiative, which provides engineering, certification, and testing assistance. eVTOL aircraft could provide performance advantages in military environments, potentially offering a high-margin end market for providers. Joby Aviation has received a military airworthiness approval from the Agility Prime program. Beta Technologies has also made progress toward military airworthiness approval for its eVTOL aircraft.

In recent months, SPACs have emerged as a popular fundraising model, and air mobility companies have been taking full advantage. Thus far, Blade Urban Air Mobility, Archer Aviation, Joby Aviation, and Lilium have completed mergers with SPACs or announced plans to do so, while Volocopter has been linked to a SPAC. Relative to traditional IPOs, SPAC listings tend to receive less scrutiny and have become popular in the mobility space, where startups are characterized by money-losing, cash-burning, highly capital-intensive business models—many of which are pre-revenue. While high-risk companies such as these would likely struggle to find buyers in a traditional IPO, a SPAC merger provides a means to raise money via a public vehicle that is already listed on an exchange. SPACs function like a traditional acquisition, where the company being acquired primarily negotiates with just one party (i.e., the SPAC) rather than attracting many investors during a pre-IPO road show. This allows the company to share its vision more easily and provide long-term financial projections as opposed to the rigorous financial reporting required for an IPO. Pre-definitive agreement SPACs linked to the aerospace space currently include Zanite Acquisition (NASDAQ: ZNTE) and New Vista Acquisition (NASDAQ: NVSA).

Top eVTOL passenger air taxi startups by total capital raised

Company name	Total raised ($M)	Country
Joby Aviation	$2,328.30	US
Lilium**	$1,221.50	Germany
Archer Aviation	$1,155.70	US
Volocopter	$376.56	Germany
EHang (NAS: EH)	$132.00	China
Kitty Hawk	$75.00	US
Aurora Flight Sciences	$51.88	US

Source: PitchBook | **Geography:** Global
*As of March 22, 2021
**As of March 31, 2021

Highlighted startup manufacturers

Joby Aviation

Joby Aviation is a US-based developer of eVTOL aircraft and passenger air mobility services. The company has spent more than a decade developing its eVTOL aircraft with more than 1,000 test flights logged to date. The Joby aircraft is based on a quadcopter design and is expected to have a 150-mile range and a top speed of 200 miles per hour, allowing for long-range, intercity transportation. The company is widely regarded as a leader in the eVTOL air taxi space. Joby expects to achieve FAA Type Certification by the end of 2023 and launch its commercial service in initial markets in 2024. The company forecasts it will generate $2.1 billion in revenue in 2026 and EBITDA margins of 40%. Joby Aviation's strength lies in composite airframe design and fabrication, and the company has signed a long-term supply agreement with Toray Advanced Composites for high-strength, lightweight carbon fiber composite materials for its aircraft. Additionally, the company counts Toyota as an investor and manufacturing partner, which could provide significant benefits as the company enters mass production.

Similar to other competitors in the space, Joby plans to operate its own passenger mobility service—a move heralded in December 2020 when Uber announced the sale of its internal urban air mobility service, Elevate, to Joby Aviation. Concurrently, Uber will invest $75.0 million in the company. We believe this deal is very positive for Joby, as it insulates the company from new competitors entering the market through the Uber Elevate program and provides it with demand data on traffic, which will be crucial for launching its mobility service and planning initial routes and infrastructure deployments. Among the multitude of startups entering the space, we think Joby Aviation is in the best position to bring electric air taxis to the masses. The company, which is the best-capitalized independent air mobility company, owns Elevate; has a strong base of investors and partners including Toyota, Uber, JetBlue, and Intel; boasts an impressive proprietary technology with a market-leading portfolio of patents; and commands a leading position with regard to certification and clearing crucial initial regulatory hurdles.

Joby has entered a definite agreement to merge with SPAC Reinvent Technology Partners (NASDAQ: RTP) for $690.0 million, putting the company's pre-money valuation at an estimated $5.91 billion (a 1.27x step-up from its Series C). Concurrently, the company will receive $835.0 million of development capital from The Baupost Group, Fidelity Management & Research, BlackRock, and Baillie Gifford through a private placement. Previously, Joby Aviation raised a $590.0 Series C from Toyota Motor, Intel Capital, and other investors in January 2020.

Archer Aviation

ARCHER

Archer Aviation is a US-based eVTOL aircraft developer founded in 2018. The company's aircraft is expected to have a 60-mile range and a top speed of 150 miles per hour, while only producing 45 dB in noise while flying overhead. Although the company is relatively new, we believe it benefits from several "second-mover" advantages. Firstly, the company has assembled strong engineering talent from leading companies such as Airbus, Joby, Piper, and Wisk. Additionally, unlike first movers in the space such as Joby, which have been forced to vertically integrate and produce components themselves due to a lack of supply in the market, Archer has capitalized on the increased acceptance of eVTOL in the market to establish supply contracts with manufacturing partners such as Stellantis (Fiat Chrysler and Peugeot) for support on composite materials, NVH design, and establishing its battery supply chain. Leveraging the high-volume manufacturing experience of the automotive industry could help the company save significantly on costs as it expects to achieve mass production in 2026. The company has also secured a conditional order from United Airlines for $1.0 billion (plus an optional additional $500.0 million) in aircraft starting in 2024. The company expects to achieve a Type Certificate from the FAA in 2024. In our view, the main challenge facing Archer will be timeline expectations and whether it can launch its product fast enough to compete with first-to-market competitors such as Joby. Although the company is a newer entrant to the passenger air mobility space, we view Archer as a formidable competitor thanks to the strength of its engineering team, its focus on increased redundancy, and its strategy of integrating its supply chain with established partners.

Archer Aviation reached a definitive agreement to merge with Atlas Crest Investment (NYSE: ACIC) for $500.0 million, putting the company's post-money valuation at $3.8 billion. Concurrently, the company will receive $600.0 million of development capital from United Airlines Holdings alongside nine other investors through a private placement as of February 10, 2021. Previously, the company raised $30.0 million of Series A venture funding from Troy Capital Partners, Gaingels Syndicate, Crosscut Ventures, and Tamarack 4 on July 2020, putting the company's pre-money valuation at $70.0 million. Notably, the company counts Cathie Woods' Ark Invest as an investor, as the Ark Autonomous ETF currently holds approximately 1.4 million shares of Atlas Crest Investment Corp.

Wisk Aero (Kitty Hawk)

KITTYHAWK

Wisk is a US-based eVTOL developer, formed out of a joint venture between Kitty Hawk and Boeing. The primary focus of Wisk is Cora, a pilotless, 2-seat eVTOL aircraft currently undergoing flight testing in New Zealand, where it has completed more than 1,500 test flights. The Cora aircraft utilizes 12 independent rotors for vertical lift, operates using three independent flight computers, and is equipped with a parachute for

emergency landings. Wisk estimates the aircraft's initial range at 25 miles with a top speed of approximately 100 mph. Unlike others in the space that are focusing on both piloted and autonomous applications, Wisk is investing heavily in autonomous technology and envisions full autonomy as being key to the success of urban air mobility applications. Wisk has established a partnership with NASA to focus on the safe integration of autonomous aircraft systems. So far, Cora has obtained an experimental airworthiness certificate from the FAA and the New Zealand Civil Aviation Authority (CAA).

Volocopter

Volocopter is a Germany-based developer of eVTOL aircraft and passenger air mobility services. Unlike many of its competitors that are focusing on 4-or-5 seat applications, Volocopter's primary aircraft, the VoloCity, seats just two individuals—a pilot and a passenger—and is tailored for intra-city transportation. The VoloCity is also based on a multirotor design, which is simpler and could reduce certification time and expense but limits the range of the vehicle due to higher power consumption. Given that the average passenger occupancy of individual transportation services in wealthy countries is close to one, Volocopter's solution—which is optimized for just one or two passengers—could favor the company as competitors struggle to fill empty seats. On the other hand, if ridership is high, the company could be burdened with relatively higher running costs associated with labor and energy consumption. The VoloCity has significantly lower noise requirements (65dB) than others and touts battery-swap technology that would minimize ground handling time. We believe Volocopter is months away from achieving certification from EASA.

The company has created VoloIQ—an air taxi operating system developed with German airline Lufthansa—enabling Volocopter to exchange crucial flight data with cities. Volocopter has also established a partnership with rideshare app Grab to provide air taxi rides in Singapore and Jakarta. Finally, we believe a major differentiator for Volocopter is its focus on cargo services. The company is developing an aircraft specifically meant for carrying goods—similar to a very large drone—and has established a partnership with German logistics company DB Schenker. Given the company's progress toward certifications and focus on a more conventional design, we believe Volocopter will be the first European passenger air mobility startup to commercialize.

The company raised $241.8 million in Series D from Intel Capital, Daimler, and Geely Technology Group on March 3, 2021. DB Schenker, Continental, Tokyo Century, Klocke Holding, Avala Capital, Team Europe Management, b-to-v Partners, Blackrock Innovation Capital Group, Atlantia, and Jericho Capital Asset Management also participated in the round. The funds are expected to be used for certification and initial launch of commercial routes. Volocopter last received a post-money valuation of $623.2 million in February 2020.

Lilium

Lilium is a Germany-based developer of eVTOL aircraft and mobility services. With more than 600 employees, Lilium is the largest eVTOL developer by employee count, drawing experienced engineers from the automobile and aerospace industries. Lilium's aircraft, the Lilium Jet, seats seven people and is powered by 36 swiveling ducted fans, and is expected to offer a 155-mile range and a cruise speed of 175 mph. In addition to manufacturing aircraft, Lilium expects to launch its own regional air mobility service in 2024. Although the company's technology shows promise, it has yet to be validated by significant testing, let alone certification. Notably, its ducted fan approach requires significant power draw, especially during takeoff and landing, which could be beyond performance limitations of current-generation batteries. As such, Lilium could require next-generation battery architectures—which will take several years to become widely available—to begin significant testing and make progress in the multi-year certification process. Additionally, we think Lilium needs to secure a major automobile or aerospace partner to successfully manufacture at scale.

Lilium is one of the best capitalized eVTOL companies, having raised a total of $1.2 billion. In June 2020, the company raised $275.0 million of Series C venture funding in a deal led by Tencent Holdings, putting the company's post-money valuation at $1.0 billion. Additional investors include Atomico, Freigeist, LGT Group, Armada Investment, and Baillie Gifford. In March 2021, Lilium announced its merger with a $380.0 million SPAC, Qell Acquisition (NASDAQ: QELL), at a pro-forma equity valuation of $2.4 billion. Concurrently, the company will receive $450.0 million from a PIPE offering with participation from BlackRock, Tencent, Ferrovial, LG, Palantir, Atomico, FII Institute, and PIMCO.

EHang

EHang (NASDAQ: EH) is a China-based developer of drones and eVTOL aircraft. The company's two-seat eVTOL aircraft, the 216, uses a multicopter design (similar to Volocopter), has a maximum speed of 81 mph, and a range of up to 22 miles. The Ehang 216 has completed over 2,000 passenger test flights, and during the COVID-19 pandemic, the aircraft was used by government officials to transport medical supplies to local hospitals. Since EHang debuted on public markets in late 2019, the company's stock price has soared more than 250% thanks to strong investor enthusiasm over its product and the air mobility space. However, a report released by short seller Wolfpack Research disputed many of the company's claims, including the extent of its operations and progression toward airworthiness and certification requirements. Although EHang's management addressed many of the report's claims, questions remain about EHang's ability to achieve certification in the US and Europe.

That said, China is a huge potential market for next-generation mobility technologies—for example, China is currently the world's largest market for on-road electric vehicles, thanks to aggressive government subsidies funding corporates and encouraging user adoption. We expect the Chinese government to provide similar support for the burgeoning air mobility industry and think EHang could be a beneficiary. While EHang could struggle to gain certification outside of China, we think the company is well positioned to capitalize on the massive, emerging Chinese market for electric air mobility. EHang could be insulated from international competition by restrictions on foreign automated vehicles, as evidenced by China banning Tesla vehicles from military facilities over concerns about spying.

EHang received $40.0 million of development capital from Carmignac Risk Managers in January 2021 through a private placement. Previously, the company raised $40.0 million in its initial public offering on the NASDAQ stock exchange under the ticker symbol of EH in December 2019. As of March 2021, the company holds a market capitalization of approximately $2.5 billion.

Vertical Aerospace

VERTICAL

Vertical Aerospace is a UK-based developer and manufacturer of eVTOL aircraft. The company's piloted air taxi, the VA-X4, is expected to carry up to four passengers up to 120 miles at cruise speeds of more than 200 mph. In October 2019, Vertical Aerospace acquired MGI, an engineering consultancy focused on high performance Formula 1 and Formula E vehicles. In March 2021, Vertical Aerospace announced a supply agreement with Rolls-Royce for electric propulsion systems for the VA-X4 aircraft, as well as an agreement with Honeywell for avionics. The company has drawn engineers from Airbus, Boeing, Rolls-Royce, and Jaguar Land Rover, and has established partnerships with aviation companies Rolls-Royce, Honeywell, Atkins, and Tecnam. As part of the Rolls-Royce partnership, more than 150 Rolls-Royce engineers will work on the VA-X4 aircraft. Vertical Aerospace expects to achieve certification in 2024 and plans to commercialize intercity air taxi services thereafter.

Jaunt Air Mobility

JAUNT AIR MOBILITY

Jaunt Air Mobility is a US-based manufacturer of eVTOLs. Unlike many other companies in the space, Jaunt utilizes a single large rotor (similar to helicopters) for takeoff and landing. The company's technology is based on reduced rotor operating speed aircraft (ROSA) technology, in which

the main rotor is used for takeoff and landing purposes but then turns at a lower speed to reduce noise and increase efficiency. ROSA has been used in more than 250 hours of demonstration flights. The company expects to begin the certification process in 2022 with production beginning in 2025. Jaunt Air Mobility raised $1.3 million of angel funding in the form of convertible debt financing from undisclosed investors in September 2020.

Overair

Overair, a spinoff of Karem Aircraft, is a US-based developer of eVTOL aircraft. The company's aircraft, the Butterfly, is a quad-tiltrotor 5-seat aircraft with a range of 100 miles and a top speed of 200 mph. The Butterfly is optimized for the tradeoffs between hover and cruise efficiency. Lightweight composites, improved aerodynamics, and unique, individually controlled blades enable improved safety and reduced power draw compared to competitors. Korean conglomerate Hanwha Systems (KRX: 272210) acquired a 30% stake in the business for $25 million in January 2020.

Beta Technologies

Beta Technologies is a US-based developer of eVTOL aircraft and modular charging systems. The company primarily plans to monetize through cargo delivery and military applications, replacing helicopters and light aircraft. The company's aircraft, the Alia-250, has a range of 250 miles and a cruising speed of up to 170 mph. UPS plans to purchase up to 150 eVTOL aircraft from Beta Technologies, replacing part of its conventional aircraft fleet. UPS will also utilize Beta's charging stations for fast charging of eVTOL and electric delivery vans. Beta Technologies has made progress toward military airworthiness approval, with potential applications in search and rescue, evacuation, disaster relief, and logistics. Beta Technologies raised $143.2 million of venture funding from undisclosed investors in March 2021. Although Beta Technologies is primarily focused on logistics, we see passenger air mobility as a potential adjacent market for the company.

8: "HFACs Analysis of Military and Civilian Aviation Accidents: A North America Comparison," ISASI, Scott A. Shappell and Douglas A. Wiegmann, 2004.
9: "The Batteries Behind the Electric Aircraft Revolution," Aviation Today, Brian Garrett-Glaser, September 8, 2020.

Enablement technologies

While clearly aircraft manufacturers are poised to play an important role in the development of the passenger air mobility ecosystem, we believe startup manufacturers will face an uphill battle developing technology and achieving certification, and ultimately competing with established aerospace companies. Given the steep capital requirements required for these projects to scale, we believe VCs should deploy their capital toward earlier stage enablement technologies that will be necessary to support the development of the space. These include engineering analysis tools, autonomous autopilot software, traffic management solutions, perception sensors, infrastructure builders, and next-generation battery technology providers.

Autonomous autopilot technologies will be key to bringing the cost of air mobility below $3/mile. Additionally, autonomous autopilot will help reduce human error, which is responsible for 70-80% of aviation accidents.[8] Initially, we expect autonomous autopilot to assist human pilots with collision avoidance, navigation, and vertical takeoff-and-landing. Gradually, the barriers for flight time could be reduced, expanding the market for eVTOL pilots. Longer term, pilots could be displaced entirely, further improving utilization and the unit economics of passenger air mobility.

We believe improvements in battery technology will be key to making electric urban air mobility viable, driven by the adoption of next-generation battery technologies, such as lithium-sulfur, silicon anodes, and solid state. Although some startups are electrifying fixed wing aircraft and developing eVTOL aircraft using conventional lithium-ion batteries—which put out approximately 250 watt-hours per kilogram (Wh/kg), aircraft with larger passenger loads will likely require energy densities to exceed 400 Wh/kg.[9] This will require a significant step-up in energy density from the incremental improvements seen in conventional lithium-ion batteries over the past five years. In our view, high-volume production of next-generation battery technologies is likely to occur in the mid-2020s, bringing the energy density of high-performance batteries over the crucial 400 Wh/kg threshold.

Highlighted enablement-technologies companies

PHM Technology

PHM Technology
Decisions better made

PHM Technology has developed digital risk-twin-enabling, model-based systems engineering (MBSE) analysis and decision-making support tools for complex, mission-critical systems with automotive, aviation, and military applications. Whereas many other AI companies focus on correlations, PHM uses a causation-based approach to AI for predictive maintenance, a significant discriminator for eVTOL, UAV, aerospace, and advanced manufacturing applications. In our view, MBSE could enable eVTOL companies to accelerate product development for complex projects while

reducing unexpected costs, and more cohesively integrate design, analysis, validation, and verification during the product development lifecycle. Additionally, as aircraft designs are refreshed and improved incrementally, MBSE will be crucial to avoid starting from scratch. PHM's tools can also be leveraged to minimize cost of ownership by improving aircraft reliability, thereby increasing utilization and reducing costly downtime. PHM's customers include Lockheed Martin, Northrop Grumman, and NASA, and the company counts Siemens as an investor and partner.

Skyryse

Skyryse is a US-based developer of a flight automation system powering conventional helicopters, airplanes, and eVTOL aircraft. The system, called FlightOS, allows operators to control aircraft using just a video game-like touchscreen tablet. By using on-board computers and external sensors such as radar, the system keeps aircraft within their limits and can take over in emergency scenarios. Skyryse expects FlightOS to receive a supplemental type certification for certain airframes in the coming months. Skyryse's system could enable pilots with fewer hours of flight time to become eligible to operate eVTOL air taxis, which would significantly expand the labor supply—a crucial measure for widespread adoption.

In May 2020, Skyryse raised $2.5 million of convertible debt funding from undisclosed investors. Previously, the company raised $20.0 million of Series A1 venture funding in a deal led by Cantos Ventures in December 2019, putting the company's post-money valuation at $113.0 million. Stanford Venture Capital Holdings, Industry Ventures, Fontinalis Partners, Eclipse Ventures, Trucks Venture Capital, Venrock, and Bill Ford also participated in the round.

Daedalean

Daedalean is a Switzerland-based startup developing a vision-based autonomous autopilot system. Unlike other startups developing autonomous transportation for ground-based vehicles, Daedalean shies away from the most cutting-edge forms of artificial intelligence, as non-deterministic "black boxes" could face scrutiny from regulators during the certification process. Instead, Daedalean's technology is based on convolutional neural networks, which enable predictable, repeatable responses to certain inputs. Daedalean's technology is platform agnostic and can be applied to commercial air transport, general aviation, unmanned aerial vehicles, and urban air mobility. The company is working with aerospace giant Honeywell as well as eVTOL air taxi startup Volocopter. Honeywell is also an investor in the company, as well as Carthona Capital and Redalpine Venture Partners. Daedalean was last valued at $13.8 million in May 2018 and is in the process of raising $25.0 million of venture funding from undisclosed investors.

Reliable Robotics

Reliable Robotics is a US-based developer of autonomous flight technology. The company is made up of veterans from SpaceX and Tesla and is primarily focused on automating fixed wing cargo planes. Focusing on the transport of goods could enable the company to validate and commercialize its technology more quickly than automating the transport of people. In the fall of 2020, Reliable Robotics announced a partnership with Giumarra Companies, an international fresh produce network, to autonomously deliver produce within 24 hours of harvest, reducing the time and touch points between farms and end-consumers.

In September 2020, Reliable Robotics raised $25.9 million of Series B venture funding in a deal led by Eclipse Ventures, putting the company's post-money valuation at $125.9 million. Lightspeed Venture Partners and Teamworthy Ventures also participated in the round. Previously, the company raised $8.3 million from Lightspeed Venture Partners at a $42.3 million post-money valuation in September 2017.

XWing

XWing is a US-based developer of autonomous flight technology. The company, which is made up of executives from Stripe, Girhub, Terrafugia, Lockheed Margin, and Aurora Flight Sciences, has developed a software stack enabling existing small passenger and cargo planes to fly autonomously. So far, the company has performed several test flights in a Cessna 208B Grand Caravan. The company has established a partnership with NASA to develop unmanned flight integration in US airspace and is working with helicopter maker Bell on automating helicopters. In November 2020, XWing raised $14.0 million of Series A venture funding in a deal led by R7 Partners, putting the company's pre-money valuation at $35.0 million (a 2.75x step-up). Eniac Ventures, Alven Capital Partners, Jeff Hammerbacher, Marek Olszewski, Rene Reinsberg, Thomas Annicq, Taher Savliwala, Dawoon Kang, and Thales Group also participated in the round.

TakeFlight Interactive

TakeFlight is a developer of a flight simulation training program. The company's software helps train potential general, commercial, and military pilots with online lessons incorporating verbal instructions, real-time

feedback, and grading of pilot performance using objective scoring based on FAA Airman Certification Standards (ACS). The company sells its software online and currently boasts a userbase of over 1,500. In our view, TakeFlight could help alleviate the labor shortage faced by the air mobility industry. Boeing forecasts that impending retirements of tens of thousands of pilots will result in a shortage of 61,000 helicopter pilots globally by 2038. Many qualified instructors are being captured by the aviation industry due to the ongoing pilot shortage, further shrinking the pipeline of future pilots. TakeFlight helps solve this issue by making pilot training more accessible to a wider audience. Expanding the market for future pilots could be crucial to making widespread passenger air mobility a reality. In August 2019, Takeflight Interactive raised $155,000 of convertible debt financing from undisclosed investors.

SkyGrid

SKYGRID | A Boeing, SparkCognition Company.

SkyGrid is a US-based developer of a software platform to ensure the safe, secure integration of autonomous cargo and passenger air vehicles in the global airspace. The company provides a platform with blockchain integration, AI-enabled dynamic traffic route identification, cybersecurity capabilities, and a certified maps database ensuring safe integration of autonomous air vehicles. SkyGrid was formed out of a joint venture between Boeing (NYSE: BA) and SparkCognition in November 2018.

We believe new air traffic control (ATC) systems will be required for UAM to scale in cities. A study conducted in Melbourne by Embraer and Airservices Australia found that just four air mobility operations were enough to overwhelm existing city air traffic control systems.[10] As passenger air mobility scales, cities globally will need to establish procedures to effectively manage an increasingly dynamic airspace filled with diverse aircraft with varying flight characteristics and automation. Companies such as SkyGrid could be key to facilitating the safe adoption of autonomous air mobility.

AEye

AEye is a US-based developer of lidar (light detection and ranging) technology for on-road autonomous driving. The company touts industry-leading performance thanks to its extreme configurability. AEye's micro-optical mechanical-based lidar system is software-definable, enabling perception engineers to configure scanning for each use-case. The system allows users to define and utilize multiple scan patterns within a frame and zone in high-resolution regions of interest. Bore-sighting cameras with agile

10: "Urban Air Traffic Management Concept of Operations," Airservices Australia and Embraer Business Innovation Center, 2020.

lidar enable 2D computer vision algorithms to extract true color and additional perceptual data from 3D point clouds. Additionally, AEye's business model benefits from the unique software definition of its product. The company's ability to focus on the most relevant information in real time permits fewer sensors per vehicle, reducing the total cost for potential buyers. In addition, the same system can be used for multiple use-cases, allowing automakers to source the same system for multiple vehicle form factors. Finally, outsourcing manufacturing helps AEye maintain a leaner business model relative to competitors. AEye has partnered with automotive supplier Continental AG to validate, manufacture, and provide a sales channel for its lidar.

We believe AEye could be well positioned to sell its lidar solutions into the air mobility ecosystem. Notably, three of AEye's strategic investors—Continental AG, Intel, and Airbus—have made investments in air mobility. Continental is an investor in Volocopter, Intel Capital has invested in Joby Aviation, and Airbus is heavily involved in the space. AEye could leverage these partnerships to gain exposure in the burgeoning air mobility space. In our view, lidar could provide important sensing capabilities for safety-critical vertical takeoff and landing. The long-range capabilities of AEye's product (which can detect objects out to 1000 meters) could be well suited for aviation use-cases. Additionally, AEye's focus on configurability could be well suited to the dynamic needs of autonomous vertical takeoff and landing.

In February 2021, AEye announced a reverse merger with CF Finance Acquisition Corp. III (NASDAQ: CFAC), valuing the company at $2.0 billion. Concurrently, the company announced that it will receive $225.0 million of development capital from Intel Capital, Hella Ventures, Subaru, GM Ventures, and Taiwania Capital through a private placement. Previously, AEye raised $29.8 million of Series B venture funding in the form of convertible debt from Continental, Horizon 3 Venture Capital, and other undisclosed investors in December 2020.

Metawave

METAWAVE

Metawave is a US-based developer of beam-steering radar for on-road autonomous driving. The company's radar uses advanced digital signal processing technology to detect and classify vehicles beyond 350 meters and delivers high performance during adverse weather conditions such as fog and rain. Advanced radar solutions could be integral for future air mobility applications, especially in enabling autonomous takeoff and landing. In January 2021, the US Air Force selected Metawave to provide next-generation radar for eVTOL aircraft. Metawave has raised a total of $48.0 million as of May 2020 and was last valued at a post-money valuation of $200.0 million in November 2019.

Blade Urban Air Mobility

Blade Urban Air Mobility operates a private air travel service for commuters through a mobile app. The company's platform reduces consumers' cost of air travel on private aircraft by maximizing passenger capacity. The company purchases aircraft time by the hour from operators, covering flight-associated costs, and leases terminal space from heliports and airports. Blade Urban Air Mobility's financial structure provides some degree of downside protection for investors. The company does not own its own fleet, functioning instead as an asset-light software intermediary. Additionally, the company's cost structure is largely variable with fixed hourly rates paid to operators covering pilot, fuel, maintenance, and additional costs. In our view, service providers such as Blade will be key to facilitating adoption of air mobility services. Blade Urban Air Mobility is well-positioned to see increased growth and expanded margins driven by eVTOL aircraft adoption, which the company expects to help propel its revenue to $875.0 million in 2026.

In December 2020, Blade Urban Air Mobility reached a definitive agreement to complete a reverse merger with Experience Investment (NASDAQ: EXPC) for $275.0 million, putting the company's post-money valuation at $825.0 million. Concurrently, the company received $125.0 million of development capital from KSL Capital Partners, Hedosophia, and HG Vora Capital Management through a private placement.

Skyports

Skyports is a UK-based startup that secures, designs, builds, owns, and operates vertiports for passenger and cargo urban air mobility. The company acquires sites, designs and builds vertiports, and runs airside and landside vertiport operations. Notably, the company has established a partnership with German air taxi company Volocopter, in which Skyports will build modular vertiports—called VoloPorts—where Volocopter's aircraft can take off, land, and charge. The VoloPorts are expected to be built on rooftops, train stations, parking lots, and other urban locations. Skyports also operates a drone delivery business and has partnered with the NHS in Scotland to transport COVID-19 test samples and medical materials via its drones, reducing travel time from 36 hours to 15 minutes in some cases. In our view, vertiport infrastructure will be key to the adoption of air mobility, as eVTOL aircraft will require dedicated vertiports enabling landing, takeoff, and servicing. Companies such as Skyports could be key enablers of this shift.

In December 2019, Skyports raised a $7.7 million Series A led by Deutsche Bahn Digital Ventures, Aéroports de Paris, and Irelandia Aviation. Levitate

Capital also participated in the round. The funds are expected to be used to acquire sites for passenger and cargo vertiports in cities such as Singapore and Los Angeles, to further develop the company's drone delivery business, and to commercialize its delivery services.

LaunchPoint Electric Propulsion Solutions

LaunchPoint is a US-based developer of electric propulsion and motor control systems for manned and unmanned electric and hybrid-electric aerial vehicles. Spun off from tech incubator LaunchPoint Technologies, the company has been developing its technology since 2009. LaunchPoint's rotors leverage an axial flush design to self-cool, removing the need for liquid cooling and reducing the weight of the system. Initially, LaunchPoint plans to offer its motors and control software to drone companies, but longer term the company sees passenger air mobility as an important market and is developing larger motors to power eVTOL air taxis. LaunchPoint raised $2.08 million of seed funding from undisclosed investors in February 2021.

Sion Power

Sion Power is US-based developer of rechargeable lithium-metal battery technology with applications for eVTOL aircraft and unmanned aerial vehicles (UAV). Based in Tuscon, Arizona, the company employs nearly 100 people and holds nearly 500 patents. While the company initially focused on lithium-sulfur, it encountered challenges with the number of viable charge cycles and low discharge rates that caused slow charging speeds. Since 2015, Sion Power has focused on developing its Licerion technology, which pairs Sion's proprietary metal anode with conventional lithium-ion cathodes. Through this method, Sion's battery produces 400 Wh/kg, surpassing a crucial threshold to enable electric aviation. The company has established partnerships with Airbus (in which its sulfur batteries powered Airbus' Zephyr 7 solar-electric unmanned plane) and LG Chem. Sion Power is currently fundraising to raise capital to scale up its production. In December 2011, Sion Power raised $50.0 million of venture funding in a deal led by BASF Venture Capital. Topspin Venture also participated in the round.

OXIS Energy

OXIS Energy is a UK-based developer of lithium-sulfur battery technology, which combines a lithium metal anode with a sulfur-based cathode.

Compared to conventional lithium-ion batteries, OXIS Energy's approach reduces weight by approximately half while improving energy density, safety (particularly against penetration), cycle life, and cost effectiveness (lower sulfur raw material costs). The company claims it has achieved energy density of 450 Wh/kg at the cell level and argues lithium-sulfur could provide theoretical specific energy in excess of 2,700 Wh/kg.
The company is targeting electric aviation as a key end market and has partnered with Bye Aerospace, a US-based fixed wing light electric airplane company. In January 2020, OXIS Energy raised $9.0 million of venture funding from Development Bank of Wales and other undisclosed investors, putting the company's post-money valuation at $64.2 million. The company counts aerospace company Safran as an investor, along with Samsung.

Cuberg

Cuberg is a US-based developer of lithium-metal batteries that provide improved energy density, safety, and performance at a lower price point compared to traditional li-ion batteries. The company's technology is based on combining non-flammable electrolytes and a lightweight lithium metal anode. Cuberg's battery technology has received independent validation from the US Department of Energy showing an increase in specific energy of 369 Wh/kg, up to 80% relative to li-ion cells.[11] The startup's customers include Boeing, Beta Technologies, Ampaire, and VoltAero. In March 2021, Cuberg was acquired by Swedish battery manufacturer (and VW partner) Northvolt for an undisclosed amount. Previously, the startup had raised more than $3.4 million from investors such as Boeing HorizonX, the US Army, and the US Department of Energy.

Enevate

Enevate is a US-based developer of advanced silicon-film lithium-ion battery technology for automotive OEM and electric vehicle battery makers. The company's technology enables five-minute extreme fast charging with high energy density, low temperature operation for cold climates, low cost, and safety advantages over conventional lithium-ion batteries. Unlike solid-state battery technology, Enevate's technology relies on existing manufacturing processes and will likely see faster revenue generation. The company is currently designing for 2024-2025 model electric cars and smaller electric vehicles such as electric motorcycles and e-mopeds. Enevate—which counts John Goodenough, a Nobel laureate for his work on lithium-ion batteries, as an advisory board member—has a 250+ patent portfolio and has secured partnerships with key OEMs and Tier-1 suppliers such as Nissan-Renault and LG Chem. Unlike some of its

11: "Cuberg Next-Gen Electric Aviation Battery Technology Receives U.S. Department of Energy Validation of Industry-Leading Performance," Cuberg, June 17, 2020.

competitors, Enevate does not supply materials—the company generates revenue from licensing its technology to battery companies and automotive OEMs. Although the company is currently focused on the automotive market, electric air mobility could grow to become an important end-market over the long term. In February 2021, Enevate raised an $81.0 million Series E led by Fidelity Management & Research, with participation by Infinite Potential Group and Mission Ventures. The funds are expected to be used to expand the company's pre-production line.

HyPoint

HyPoint is a US-based developer of lightweight hydrogen fuel cell propulsion technology for both fixed wing and eVTOL aircraft. The company's technology utilizes compressed air (like a car turbocharger) for cooling and oxygen supply, enabling it to be three times as light as liquid-cooled systems. HyPoint's fuel cells have an energy density of 960 Wh/kg, generating three times the performance and four times the lifespan of existing hydrogen fuel cell systems. Lightweight hydrogen fuel cell technology could provide an avenue for eVTOL aircraft to achieve performance and range targets difficult to achieve with conventional lithium-ion batteries.

In October 2020, HyPoint raised $1.1 million of Series 1 venture funding in a deal led by Dmitry Mikhailov. 808 Ventures, Asymmetry Ventures, Jordan Levy, Vladimir Belkovich, Alexander Katalov, and Murat Abdrakhmanov also participated in the round. The company is expected to use the funding to expand operations, develop research and development capabilities, and increase production capacity.

Electric Power Systems

Electric Power Systems is a US-based provider of electric propulsion technology, lightweight lithium-ion batteries, and charging infrastructure for electric VTOL and fixed-wing aircraft. Spun out of Phillips Aerospace, EPS has drawn experienced talent from the aerospace industry. The company's technology is tailor-made for aerospace applications, with innovations in thermal management and package optimization enabling reduced weight and improved safety. EPS provides the energy storage and battery management systems for the upcoming Bell Nexus eVTOL aircraft. The company is also working with Bye Aerospace, Embraer, and NASA.

In September 2019, Electric Power Systems raised an undisclosed amount of Series A venture funding from Boeing HorizonX and Safran Corporate Ventures. The funds are expected to be used to develop an automated

industrial base to produce aviation-grade energy storage systems at scale. Previously, the company raised $15 million in venture funding from undisclosed investors in July 2019.

Pipistrel

Pipistrel is a Slovenia-based developer and manufacturer of light aircraft, battery packs, and electrical components. The company has been developing electric flight technology for over two decades. Pipistrel was the first successfully certify an electric aircraft—the Electro—which is used in Europe for pilot training due to its low noise and operating costs. Pipistrel is developing a VTOL cargo drone with a payload capacity of 660 pounds and expected range of 185 miles. In addition, the company is a leading provider of electrification technology for the aviation industry. Pipistrel provides retrofit electric propulsion systems as well as a plug and play system to OEM manufacturers and end users. According to PitchBook data, Pipistrel generated $36.5 million in revenue in 2020, up 49.2% YoY.

MagniX

MagniX is a US-based developer of electric propulsion systems for aerospace applications. MagniX retrofits small commuter aircraft with electric propulsion systems and provides its technology to OEM manufacturers. Vancouver-based Harbour Air is converting its seaplane fleet to electric using MagniX's propulsion systems. Eviation, a leading electric plane company, uses MagniX motors to power its aircraft. Longer term, MagniX could provide propulsion technology for electric rotorcraft and VTOL applications. The company was acquired by The Clermont Group (which also owns Eviation) through an LBO on an undisclosed date. Previously, MagniX received $2.5 million of grant funding from the Australian government in March 2017.