Air Taxis, Starting to Takeoff?

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June 2022

1. Introduction

A bit over three years ago, I wrote the post linked below on flying EVs. Although there are some flying EVs (as there were then), these have hardly become mainstream, but the title version for this paper appear to (very slowly) taking off, and the amount of funds being pumped into them by major firms are taking off, big-time.

Flying Cathodes and Anodes Everywhere: *As I started researching this paper I quickly determined that there is a surprising range of flying EVs that transport humans (as opposed to unmanned aerial vehicles (UAVs)) that are starting to enter various markets, and that is what this paper is about.*

https://www.energycentral.com/c/ec/flying-cathodes-and-anodes-everywhere

2. Evolution

I was reading a March Issue of IEEE Spectrum, and I came across two articles on the title of this paper. This triggered a memory that I had written a similar article a number of years ago. I pulled the file up, and in that article in the section on air taxis I wrote: *A few of these designs are near production (most notably E-Hang, Volocopter and Kitty Hawk), and the first commercial use of these will probably be in Asia (China, Singapore) and New Zealand within the next few years. Do I believe these will really happen in the next few years? You better believe it. Many very smart individuals and very large corporations are betting on these in a big way.*

The bad news is that none of the above three companies have certified a design for general use in the U.S., but the good news is that all three are still alive and working on their designs. Furthermore there is one (other) company that has partially achieved U.S Certification of their air taxi design.

Below we will look at how the above three firms are doing, and also the one firm that appears to be nearing lift-off, and then, in the following section, repeat some insights from the IEEE Spectrum Articles.

2.1. E-Hang

I was surprised to find that E-Hang still has not achieved certification, even in its home market (China). *Electric, vertical takeoff and landing (eVTOL) developer EHang said it's planning to win type certification in China of its 216-S two-seat, autonomous air taxi by the middle of 2022.*[1]

The China-based company wants to begin commercial passenger service shortly after certification. "We aim to be the first firm to launch commercial operational service in the

[1] Thom Patterson, Flying, "EHang Expects Chinese Certification of Autonomous Air Taxi by Mid-2022," March 30, 2022, https://www.flyingmag.com/ehang-expects-chinese-certification-of-autonomous-air-taxi-by-mid-2022/?msclkid=88476749ce5111ecb0b792a786820282

world, probably in the second half of the year," said Edward Xu, EHang's chief strategy officer.

The eVTOL aircraft boasts a top speed of 80 mph, a payload capacity of 485 lbs, and a range of 22 miles, according to EHang's website.

2.2. Volocopter

This company still has a long path to certifying their design (air frame) anywhere. Their final design just made its first flight in December of last year. *The German startup, which is one of the pioneers in urban air mobility, just shared a video of the fully electric "VoloCity" air taxi successfully completing its first flight...*[2]

The culmination of 11 years of development, countless iterations and more than 1,500 test flights, the final, full-size prototype successfully performed its maiden voyage in Bruchsal, Germany. The flight, which actually took place last December, marks a major milestone for the company…

2.3. Kitty Hawk

Kitty Hawk is, well, strange. This isn't surprising considering who their main supporter is.

Eleven years after Google co-founder Larry Page bankrolled one of the first efforts to develop an electric flying car, rivals appear to be accelerating past his company Kitty Hawk in the race to lift your daily commute into the sky...[3]

But there may be no first mover advantage in the uncharted skies of urban air mobility and Kitty Hawk CEO Sebastian Thrun has an ambitious plan to leapfrog the pack that he revealed to Forbes that hinges on convincing safety regulators to allow it to fly passengers without a pilot onboard—something that most other air taxi developers hope to do eventually but which they think is a tall order in the near term. Page and Thrun, a former Stanford roboticist who founded Google's self-driving car program, have committed to a strategy in which Kitty Hawk will build a larger version of Heaviside, the prototype electric vertical takeoff and landing (eVTOL) aircraft it's been working on since 2017, that will seat two passengers, up from one at present, and that will operate autonomously for the most part while being overseen by a pilot on the ground who will handle multiple aircraft at a time. The remote pilot will communicate with air traffic controllers and deal with situations that Heaviside's artificial intelligence brains can't.

Thrun is a prominent evangelist for how Silicon Valley tech can improve the world, says Kitty Hawk expects to win safety approval for its new air taxi by 2024 from the U.S. Federal Aviation Administration. "It's a riskier path than going for a piloted aircraft but we believe the payout is 100X of what any piloted aircraft could be in terms of its business opportunity," he says.

In 2019, the Kitty Hawk Cora autonomous personal air vehicle prototype was split off into a joint venture between Wisk Aero LLC and Boeing, becoming Cora by Wisk. In

[2] Rachel Cormack, Robb Report via Yahoo Entertainment, "Volocopter's All-Electric Flying Taxi Just Completed Its Maiden Flight," April 14, 2022, https://www.yahoo.com/entertainment/watch-volocopter-electric-flying-taxi-210000359.html

[3] Jeremy Bogaisky, Forbes, "Billionaire Larry Page's Kitty Hawk Is Making An All-In Bet On Robot Air Taxis.," June 11, 2021, https://www.forbes.com/sites/jeremybogaisky/2021/06/11/larry-page-kitty-hawk-air-taxi-sebastian-thrun/?msclkid=01cee94cce6611ecbb643b856bc92a70&sh=4ba358bb738c

December 2019, the Cora team was rebranded and spun off as a separate company called Wisk Aero. Wisk is doing pretty well (see section 3.2).

2.4. Joby Aviation

The title company is the firm that I feel has the best chance of starting to ship air taxis in the U.S., in volume, before any other firm. These air taxis have more impressive capabilities than most of Joby's competitors. And they have been quietly working on this design for over a decade.

History:

2009: Day and night, a small team of seven engineers worked out of "The Barn," our workshop in the mountains above Santa Cruz. We explored the frontiers of technologies like electric motors, flight software, and lithium-ion batteries — engineering almost every component from the ground up.[4]

Beginning in 2012, Joby was selected to collaborate with NASA on several groundbreaking electric flight projects, including the X-57 and LEAPTech.

2015: After many years of subscale testing and analysis, we arrived at our current configuration and flew a subscale technology demonstrator for the first time.

Our first full-scale demonstrator took to the skies in 2017.

2019: As well as becoming a strategic investor in Joby, Toyota deployed dozens of engineers to work shoulder-to-shoulder with our team, lending their expertise on factory layout, manufacturing process development and high-volume production.

2020: Joby became the first eVTOL company to receive airworthiness approval from the U.S Air Force in December 2020. Flying our aircraft on-base and having access to government testing facilities provides an opportunity to develop our operational capabilities in advance of commercial launch.

2020: We deepened our partnership with Uber, agreeing to integrate our aerial ridesharing service into the Uber app, and vice versa, across all U.S. launch markets.

[4] Joby Aviation, Our Story, https://www.jobyaviation.com/about/

Uber increased their investment in Joby and we acquired the Elevate division, bringing their software tools and commercial launch expertise in house.

During 2021 Joby listed on the New York Stock Exchange (NYSE:JOBY), our pre-production prototype flew more than 5,300 miles, including a flight of 154.6 miles on a single charge.

We also built a second pre-production prototype, completed our first FAA production conformity inspection and officially began our journey to become the first certified eVTOL airline.

2022: In the years ahead, we'll be focusing on three key goals: certifying our aircraft, scaling our manufacturing, and preparing for commercial operations in 2024.

Capabilities:

Note that the Joby design is extremely efficient. It allows a combination of vertical take-off and landing, high capacity (4 passengers plus a pilot), high speed (200 mph) and long range (150 miles).

"The aircraft made only a partially perceptible sound that, in this editor's view, would almost certainly be undetectable against the everyday noise background of an urban environment."

Guy Norris – Aviation Week

A Part 135 Air Carrier Certificate is required for Joby to operate its revolutionary electric vertical take-off and landing (eVTOL) aircraft as an air taxi service in cities and communities around the United States. Alongside a Type Certificate and Production

Certificate, this is one of three regulatory approvals critical to the planned launch of Joby's all-electric aerial ridesharing service in 2024.[5]

After filing an initial application for a Part 135 Air Carrier Certificate in June 2021, Joby completed the second stage in August, which includes submission of a complete package of manuals. The third and fourth stages involve FAA review and approval of manuals and FAA observation of the Company performing operations to ensure full regulatory compliance.

Last week (March 2022), Joby entered the fourth stage of the process, with FAA representatives beginning to observe Joby's initial cadre of pilot instructors as they demonstrate mastery of training and operational procedures using the Company's prepared manuals and training program.

The fifth phase is FAA final approval and issuance of the Part 135 certificate. Joby expects to complete the Part 135 certification process later this year.

Additional Comments: Joby has the highest funding of any publically traded company (approximately $2 Billion), and they have a very impressive board of directors (link below).

https://ir.jobyaviation.com/corporate-governance/board-of-directors

3. Other Air Taxi Insights

…Today, some 250 companies are working toward what they hope will be a revolution in urban transportation. Some, such as Wisk and Kittyhawk and Joby, are flying a small fleet of prototype aircraft; others have nothing more than a design concept. If the vision becomes reality, hundreds of eVTOLs will swarm over the skies of a big city during a typical rush hour, whisking small numbers of passengers at per-kilometer costs no greater than those of driving a car. This vision, which goes by the name urban air mobility or advanced air mobility, will require backers to overcome entire categories of obstacles, including certification, technology development, and the operational considerations of safely flying large numbers of aircraft in a small airspace.[6]

Even tech development, considered the most straightforward of the challenges, has a way to go. Joby, one of the most advanced of the startups, provided a stark reminder of this fact when it was disclosed on 16 February that one of its unpiloted prototypes crashed during a test flight in a remote part of California. Few details were available, but reporting by FutureFlight suggested the aircraft was flying test routes at altitudes up to 1,200 feet and at speeds as high as 240 knots.

The IEEE Spectrum article referenced below has a table of Air Taxi developers drawn from a "Reality Index" developed by SMG Consulting. In addition to the firms I covered in the prior section, I have identified two others, drawn from this table, that I feel might have a chance of entering this market with a viable product.

[5] Joby Aviation Press Release, "Joby Nears Completion of Part 135 Air Carrier Certification," March 15, 2022, https://www.jobyaviation.com/news/joby-nears-completion-part-135-air-carrier-certification/

[6] Glenn Zorpette, Evan Ackerman, IEEE Spectrum, "EVTOL Companies Are Worth Billions—Who Are the Key Players?" Feb 22, 2022, https://spectrum.ieee.org/evtol-air-taxi-industry

3.1. Beta Technologies

Beta's air taxi candidate is the Alia-250c. This craft has five props – four lifting props, two each on the longitudinal booms (that appear to be stowed during normal flight), and a single propulsion pusher-prop.

Capabilities: Range: 288 miles, Capacity: 6 passengers including pilot, Speed: 170 MPH.

Beta seems to have a reasonable Board of Directors (link below).

https://www.beta.team/team/

There was little other real information on Beta's web site, so I got the following from Wikipedia.

History:

BETA Technologies was incorporated in 2017 in Burlington, Vermont by Kyle Clark, an experienced pilot, engineer and entrepreneur.[7]

The company identified its first customer as United Therapeutics, which under founder and CEO Martine Rothblatt was looking for efficient transportation methods for man-made organs intended for human transplant. United Therapeutics awarded BETA a $48 million contract.

On May 23, 2018, the company made the first tethered flight of its original 4,000 lb Ava XC eight motor, eight propeller battery-operated proof of concept aircraft.

The company came out of stealth in January 2019. That year, the Ava XC became the world's heaviest eVTOL aircraft to fly.

In February 2020, the company began participating in the United States Air Force Agility Prime program that seeks to advance electric air mobility. In May, the Air Force Life Cycle Management Center announced that the company, along with Joby Aviation,

[7] Wikipedia article on Beta Technologies, https://en.wikipedia.org/wiki/Beta_Technologies?msclkid=2188cf4fceed11ec853c8e489f28db25

would progress to the third phase of the program.] In June, the company unveiled its second aircraft prototype, ALIA-250.

In March 2021, the ALIA-250 made a test flight from Plattsburgh, New York, across Lake Champlain to Burlington, Vermont. In April, United Parcel Service (UPS) entered into a contract for ten ALIA-250 aircraft to be supplied in 2024, which included the option for UPS to acquire up to 150 more aircraft. UPS announced it planned to have them travel directly to and from UPS facilities, rather than use airports. In April, Blade Urban Air Mobility ordered 20 ALIA aircraft, becoming BETA's first passenger service company. In May, the U.S. Air Force's Public Affairs office announced that BETA Technologies was granted the Air Force's first airworthiness certificate as a part of the AFWERX Agility Prime program, allowing the military to begin using the company's aircraft for test flights. Also in May, the company announced it was building a 270,000 square-foot manufacturing facility at the Burlington International Airport, with a planned production capacity of 400 EV aircraft per year. In July, the company completed a 205 mile crewed flight of its aircraft, its longest flight up to that point.

The company announced on January 31, 2022 that it had won a U.S. Army contract to support flight testing of its Alia electric vertical takeoff and landing aircraft. The partnership eventually aims to help the Army test specific military cargo and logistics missions for eVTOLs, while allowing Beta to accelerate development for both military and civil applications. Initially, Army engineers and Beta's team plan to evaluate how Alia might best be applied to specific missions by measuring its range, altitude, endurance, and payload limits.

Finances:

Reportedly secured in March 2021, BETA Technologies raised $143 million in venture funding from undisclosed sources. Announced on May 18, 2021, BETA raised $368 million in Series A financing, with Fidelity Management & Research leading the round alongside investors Redbird Capital and Amazon's Climate Pledge Fund.

Author's Comment: Beta seems to be reasonably capitalized, and also has a reasonable product. It is somewhat larger than Joby's Air Taxi, has a simpler design, and otherwise has similar capabilities. Joby appears to at least a year ahead of Beta in certification. I'm guessing that there is enough room in this emerging market for both to survive. Note that in the above quote from Wikipedia, there are potentially two eVTOLs: *In February 2020… ALIA-250*, and *January 31, 2022…Alia electric vertical takeoff and landing aircraft.* It's possible both are the same craft or that the second is a different design, and may or may not be manned.

3.2. Wisk Aero

See the last paragraph in section 2.3. Wisk was spun out of Kitty Hawk.

Prior to the spin off: *In 2017, the Kitty Hawk Cora program received $1 million from the Defense Innovation Unit Experimental (DIUx), a Pentagon organization that focuses on implementing cutting-edge technology into the U.S. Military.*[8]

[8] Electric VTOL News, "Wisk Aero Cora (Generation 5)," https://evtol.news/kitty-hawk-cora/?msclkid=253850e1cef211eca7f9bd32ae06512e

Then Cora was first revealed on Mar. 12, 2018, after nearly eight years of secretive eVTOL developments by Zee Aero (originally founded in March 2010) and was backed by Larry Page (the co-founder of Google) in 2017, the company was absorbed by Kitty Hawk, another eVTOL company backed by Page.

In 2017, the Kitty Hawk Cora program received $1 million from the Defense Innovation Unit Experimental (DIUx), a Pentagon organization that focuses on implementing cutting-edge technology into the U.S. Military.

On March 12, 2018, Kitty Hawk announced that it had been flying a two-seat eVTOL aircraft named Cora in California and New Zealand, which was a derivative of the Zee Aero Z-P2. The company also announced:

Kitty Hawk established Zephyr Airworks in December 2016 "to be able to test and work with the New Zealand Government, New Zealand Maori people and Iwi, business partners and the community. We shipped our first air taxi to New Zealand in October 2017 and began testing shortly after that."

Zephyr Airworks is the operator of Kitty Hawk in New Zealand. New Zealand is recognized for its safety-focused regulatory environment and a strong history of excellence in airspace management.

For its initial flight testing, Cora was only permitted to test three times per week, and was limited to the airspace over Hollister, CA Airport. This is likely one of the reasons why Wisk has been making test flights in New Zealand, as they can fly the aircraft more often there. Now, in the USA, Cora is allowed to fly up to 5,000 ft, either flying itself or with non-paying passengers aboard. It was announced that as of January 2020, Cora has logged over 1,000 flights.

Cora is a two passenger autonomous eVTOL aircraft with 12 independent electric-powered lifting propellers mounted on its 36 ft (11 m) long wings for vertical takeoffs and landings and one three-bladed pusher propeller providing thrust for forward flight. It has tricycle wheeled stationary landing gear. It was confirmed in January 2020, that Wisk will only be making the Cora eVTOL as an autonomous aircraft, there will be no pilot.

More recently: *We recently had the opportunity to share our vision with Anderson Cooper on an episode of 60 Minutes. Watch the episode here.*[9]

…During the conversation, our CEO Gary Gysin, talked with Anderson about the development of our 6th generation aircraft and answered the question that we've been asked the most since revealing that we're working on a new aircraft: How many seats?

We're ready to confirm that our 6th generation aircraft will have 4 seats! This is a change from our current, 5th generation aircraft, Cora — and there's a reason why.

The larger seat configuration provides more space for passengers and baggage, while allowing us to ensure that we're creating a service that is accessible for those with disabilities. In addition to these benefits, our 6th generation aircraft's larger capacity opens the door to future use cases. Higher payloads and cabin volume will better support other applications and use cases long term.

[9] Wisk Blog, "Our 6th Generation Aircraft is Four Seats!" April 18, 2022, https://wisk.aero/news/blog/cbs-gen-6-four-seats/

Capabilities: Note that the following specs are compiled from news/blog reports, and I feel that Wisk is still in a prototype development stage. Range: 25 Miles, Passengers: 4, Speed: 100 MPH.

Autonomy: *By autonomy, we mean that our aircraft aviates, navigates, and communicates, on its own. It is fully autonomous and it flies itself, today. Since 2017, we've been flying without a pilot on board, nor a remote pilot on the ground. Unlike other unpiloted aircraft, there is not a traditional "stick and rudder" in our system.*

However, there are still humans in the loop via our ground station where all flights are monitored, but this role is more akin to air traffic controller rather than a traditional pilot.

We've designed our system in a way that, in the event of an off-nominal situation, a flight supervisor can intervene by sending a new command to the aircraft, which it will then execute on its own. This is how we conduct flight tests today.

However, we are not building a black box of AI to fly the aircraft. Our autonomous system is built on proven aviation systems, such as autopilots, precision nav, data links, that are augmented with sensors and our procedural-based decision-making software. Essentially, we are combining many well-understood, deterministic technologies into one system, which we intend to certify.

Safety: There is a single point of failure, the propulsion pusher prop. Based on looking at a video on the Wisk home page (link below) it appears that the lift props do have some single-axis rotation control, but this rotation is only along an axis perpendicular to the direction of travel, so (apparently) the lift props cannot provide thrust. If the pusher prop fails I would hope that the 12 lift props can safely land the Wisk Air Taxi.

https://wisk.aero/aircraft/

Also the above linked page states that the craft has an emergency parachute: *If a situation arises where we need to land without the use of lift fans, every aircraft is equipped with a parachute for safe landing.*

Final Author's Comment: The Wisk Cora has one major difference between it and the other air taxi platforms that I believe are contenders in the near future – a much shorter range: 25 miles vs. much more than 100 miles. This would mean much smaller battery energy storage, and thus much lighter weight. One would hope that this would also mean that it would be much less expensive. But could it still address the air taxi market, or at least a major part of it? I believe it could.

A typical flight segment might be from a roof-top landing area in a major city to a nearby major airport. In my area this might be from the San Francisco Financial District to SFO or OAK. This distance (as the Cora would fly) is in the range of 10-15 miles. Ditto San Jose and most of Silicon Valley to SJC or SFO (the latter destination is maybe 15 to 20 miles). Since I have transited most of the major metropolitan airports in the U.S., I believe you would see a similar story for these.

Then there is the autonomy. If this works out, not needing a pilot (in-craft or on the ground) would significantly reduce operating expenses. The Cora clearly will not be the first to certify, but it may come later with a more cost-effective solution for many markets.