**WRITTEN TESTIMONY OF**
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**JOBY AVIATION**

**BEFORE THE**
**HOUSE TRANSPORTATION AND INFRASTRUCTURE COMMITTEE**
**SUBCOMMITTEE ON AVIATION**

**HEARING ON AVIATION NOISE: MEASURE PROGRESS IN ADDRESSING COMMUNITY CONCERNS**

**March 17, 2022**

Chairman Larsen, Ranking Member Graves, and Members of the Subcommittee, thank you for the opportunity to be here today. My name is JoeBen Bevirt, and I am the Founder and CEO of Joby Aviation (Joby). It is my privilege to speak to you about topics that are a passion of mine — aviation noise, sustainability, and the work Joby is doing to create a clean, quiet, and accessible form of air travel.

**INTRODUCTION AND JOBY BACKGROUND**

I founded Joby in 2009 with the vision of saving a billion people an hour a day through sustainable flight. My passion for this began while growing up in the Redwoods of California. I remember walking home from school, where I experienced the beauty of the land around me, but, like any child, I dreamt of a faster way to get there. On these walks, I pictured myself flying in an aircraft that could takeoff vertically and blend into its surroundings, with a sound that mimicked wind rushing through the trees, and producing no emissions harmful to the environment. My dream was not possible back then, as the technologies necessary were not yet commercially viable. In 2009, this technology matured leading me to start Joby.

At the beginning of our journey, we were a team of passionate engineers working day and night at a workshop in the mountains above Santa Cruz, California. We experimented with new ways to design aircraft that could fly like airplanes, take off vertically and powered entirely by batteries and electric motors. This early work set out the path for electric vertical take-off and landing (eVTOL) aircraft.

As we set out to design our aircraft, we had a few key goals in mind. We wanted to build something more efficient and more economical than traditional aircraft thus allowing millions of people to experience routine air travel. We understood from day one that making flight a part of

everyday life required a revolutionary approach to acoustics, and this had to be considered in every aspect of the aircraft's design.

In 2009, this was an ambitious set of goals, as the Electric Aviation industry was still in its infancy. However, the federal government has long recognized and been committed to the research and development of electric flight. In 2012, we were fortunate to partner with the National Aeronautics and Space Agency (NASA) on several critical projects to help prove that electric flight was possible. One of the most successful, the LEAPTech project (see Figure 1), led to NASA green-lighting its first-ever electric X-plane project — the X-57 Maxwell — which we helped design and build elements of its propulsion system. This work was critical in showing the world that electric propulsion was ready for flight.


Figure 1
*Figure 1 shows the NASA LEAPTech Project which showcased Joby electric aviation powerplant components*

Meanwhile, we kept designing and testing our own motors, battery systems, and prototype aircraft. In 2015, we felt confident we had designed an aircraft that accomplished our goals, and we began flying subscale versions of it. The early tests showed enough promise that we proceeded to build a full-scale demonstrator that began flying in 2017.

After several hundred successful flight tests, our team was convinced we had the right aircraft to fulfill our vision, and we have since built two full-size pre-production prototypes and have been flying this platform since 2019. At the same time, we expanded our manufacturing facilities and — with the help of Toyota Motor Corporation, one of our leading investors and strategic partners — built our pilot manufacturing facilities in San Carlos, California, and Marina, California. We are currently building our first "production prototype" aircraft which we intend to fly later this year.

Simultaneously, in 2015, we began to engage with the Federal Aviation Administration (FAA), and in 2018, we formally applied to the FAA as a type certification applicant. We plan to bring to market a piloted electric airplane that seats four passengers, capable of flying 150 miles (plus FAA required 30 minute VFR reserve) on a single charge at speeds up to 200 miles per hour. I am pleased to say that we are currently on track to do this in 2024.

**USHERING IN A NEW ERA OF FLIGHT**

Our nation's history of aviation leadership is marked by innovation. From the first flight at Kitty Hawk to the dawn of the jet age, aviation has constantly reinvented what's possible, driven by the introduction of new propulsion methods. Today, we're witnessing the next propulsion revolution — the dawn of electric aviation. According to Morgan Stanley, just one segment of the the electric aviation industry known as Advanced Air Mobility (AAM) is

expected to be a $1 trillion industry by 2040[1] and is projected to add 280,000 jobs to the US economy by 2035.[2] Communities that decide to actively take advantage of this revolutionary technology will gain the societal and economic benefits that accompany this advanced form of transportation.

In this race for global aviation leadership, the FAA is leading the world. It is imperative that the United States not take this for granted and continue to take steps to ensure this leadership continues as Europe and China also seek to lead the emerging AAM industry. This leadership is possible due to the foresight of both Congress and the FAA nearly a decade ago, when they undertook the task of rewriting Part 23 and is furthered by the FAA's approach of using the flexibility of these and other existing regulations to their fullest extent.

On July 18, 2013, the U.S. House of Representatives unanimously approved the Part 23 rewrite, or the "Small Airplane Revitalization Act of 2013" (SARA). [3] The bill, which was signed into law by President Obama later that year, created a new way to certify airplanes that allowed for more flexibility in the design — provided that the aircraft still maintained the rigorous safety standards set by the FAA. The FAA's "Part 23 Rewrite" was created to modernize general aviation with an eye to the future by being durable enough to support and enable the design and certification of an entirely zero-operating emission aircraft like Joby's. It is a credit to the FAA's work and an example of the government maximizing safety while nurturing innovation.

Following the enactment of SARA, in 2020, the FAA decided eVTOL aircraft that fly on the wing and show airplane-like flight characteristics met the criteria to be considered a Part 23

[1] See, https://assets.verticalmag.com/wp-content/uploads/2021/05/Morgan-Stanley-URBAN_20210506_0000.pdf.
[2] See, https://www2.deloitte.com/us/en/insights/industry/aerospace-defense/advanced-air-mobility.html?id=us:2el:3pr:4diER6839:5awa:012621:&pkid=1007244#endnote-sup-6.
[3] See, https://www.congress.gov/113/plaws/publ53/PLAW-113publ53.pdf

21.17(A), normal category, airplane.[4] The FAA also created a range of special conditions to address items like electric propulsion and vertical performance of the airplane.

This determination also strengthens our global aviation leadership by enabling early eVTOL operations to use today's aviation system — including commercial pilots, air traffic control, and existing bilateral aviation safety agreements[5] — and therefore, no significant new regulations are needed to begin commercializing this technology. By choosing to leverage the new Part 23 for eVTOL aircraft, the FAA has remarkably enhanced manufacturers' ability to innovate and get quiet, sustainable flight to the masses — without compromising safety.

I firmly believe that Joby's aircraft and other companies working in our space are creating the start of a zero-emissions aviation future. Today, the aviation sector has proven to be one of the hardest to decarbonize. The industry is fully committed to creating a zero emissions future and have pledged zero operating emissions by 2050.[6] To meet this goal, companies are hard at work developing a path to in sector net zero emissions.

Electric, and eventually hydrogen, aircraft will power a suite of future aircraft that ultimately cover all potential use cases. Development of this technology will take time and the government must continue to heavily invest in order to decarbonize the industry, lead the world in the next era of aviation, and fully realize the potential benefits of clean aviation for society.

**NOISE AS A PRIORITY**

Electric aviation has the potential to truly improve our cities and communities — not just by eliminating emissions, but also creating faster, affordable new ways for people to move

[4] See, https://www.youtube.com/watch?v=WEOIe7qTejU&t=2778s
[5] See, https://www.faa.gov/newsroom/joint-faa-and-united-kingdom-caa-statement-evtol-aircraft
[6] See, https://www.aia-aerospace.org/news/net-zero-by-2050/ ; https://ibac.org/posts/ibac-commits-to-net-zero-carbon-emissions-by-2050 ; https://www.airlines.org/news/major-u-s-airlines-commit-to-net-zero-carbon-emissions-by-2050/

around increasingly congested areas. But these benefits can only be realized if industry can design planes quiet enough to blend into their surroundings. While replacing noisy combustion engines with electric motors helps to address the acoustics of vertical flight, achieving truly quiet flight requires careful design considerations throughout the aircraft.

At a high level, our airplane measures 65 A-weighted decibels (dBa) during take-off and landing from a distance of 100 meters, and 40 dBA in overflight. This is roughly 100x less acoustic energy than a traditional rotorcraft, and for comparison, about as loud as a normal conversation at its loudest point.[7] However, noise is inherently complex and it's important that when the aviation industry thinks about it, we consider both the measurable quantity of the noise as well as the quality of the sound. The Joby design addresses both in several ways.

First, we designed electric motors that create very high torque, which enables our propellers to spin powerfully at low revolutions per minute (RPM) while still generating substantial lift and thrust. As a result, the Joby aircraft has double the battery capacity of a Tesla Model 3 Long Range automobile, along with six times the torque density and three times the total propulsion power.[8] Next, we paired that motor with specially designed lightweight propeller blades optimized for low noise. The progression of our propeller design can be seen in figure 2. High torque motors, combined with a large, purpose designed, propeller capable of spinning at low RPMs has played a critical part in drastically reducing our total sound profile.

[7] See, Joby Dec. '21 Corporate Deck https://ir.jobyaviation.com/about-us/presentations
[8] See, Joby Aviation Analyst Day Deck https://ir.jobyaviation.com/about-us/presentations

Figure 2

*Figure 2 shows the range of propellor designs Joby tested to determine the optimal solution*

The amplitude, or loudness, of a sound is just one piece of the noise equation; sound quality is also critical to how noise is perceived. We focused extensively on both aspects of noise and designed our aircraft to avoid the "wop wop" of a traditional helicopter. We instead created a sound that closely resembles nature by limiting the impulsive sound coming off the aircraft.

Taken together, we believe our design approach resulted in an aircraft that is extremely quiet and more pleasing to the ear than today's aircraft. To validate this, it was critical for us to work with a respected third party and, for that reason, we were fortunate to partner once again with NASA as part of their Advanced Air Mobility National Campaign. Together, we conducted a series of test flights over two weeks in September 2021, using NASA's Mobile Acoustics Facility[9] to analyze the noise footprint of the Joby aircraft.

[9] See, https://www.nasa.gov/press-release/nasa-begins-air-taxi-flight-testing-with-joby

Since completing that testing, we have gained valuable insights into the noise signature of our aircraft, and figures 3 and 4 show some of the results. In sum, it showed that our aircraft met our acoustic design targets and emits a small noise signature compared to existing helicopters.

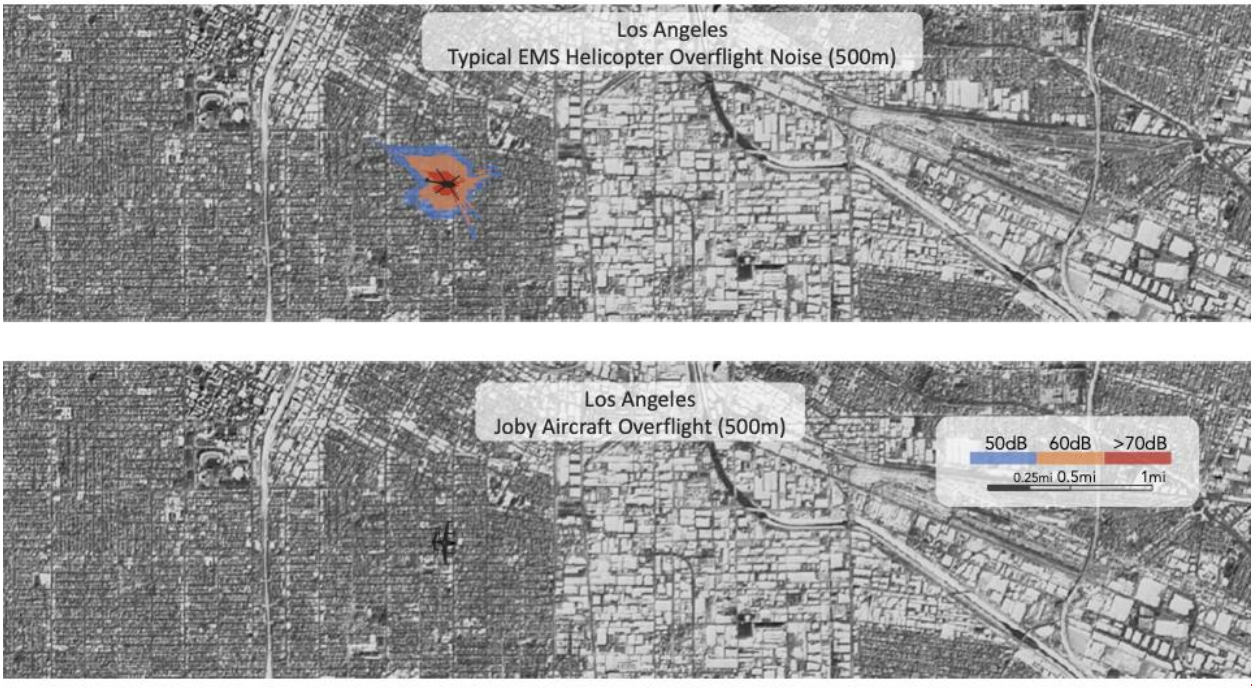


Figure 3

*Figure 3 compares the noise signature of a typical EMS Helicopter in Overflight at 500 meters with the noise signature of the Joby Aircraft in overflight at 500 meters*


Figure 4

*Figure 4 compares the noise signature of a traditional airliner as it is landing at LAX with the noise signature of the Joby Aircraft as it is landing at LAX.*

**COMMUNITY ENGAGEMENT IS VITAL TO THE FUTURE OF eVTOL**

Creating a fast, sustainable and quiet aircraft are essential steps, but we must also be good citizens and neighbors in the communities whom we plan to serve. As Los Angeles Mayor Eric Garcetti noted before this Committee in his April 2021 testimony: "Angelenos are no stranger to noise from aircraft, particularly from daily helicopter flights over urban neighborhoods and the broader noise issues faced by people who live near our various airports. OEMs, like Joby…are targeting noise levels less than 70 decibels at cruising altitude. This is comparable to the higher range of a normal conversation. Joby Aircraft, for example, has publicly made it known that its aircraft's acoustical characteristics are just as important as other performance characteristics. Communities demand quieter vehicles, and the industry is responding."[10]

[10] See, https://transportation.house.gov/imo/media/doc/Garcetti%20Testimony.pdf

Joby intends to not only design and build our aircraft, but to also serve as the commercial operator as well. We are on track to receive our Part 135 certification from the FAA later this year.[11]

Historically, most people have been unable to use air transportation for short, routine trips given costs and other factors. The objective of AAM is to create a new democratized, accessible form of air travel. My long-term goal is for the cost of a Joby flight to be lower than the cost of personal car ownership, but I recognize that will take some time. This new form of accessible, sustainable air travel will create a new paradigm in aviation where millions of people can afford to travel on our service daily or weekly.

In the early days of our service, we plan on operating out of today's existing aviation infrastructure. The United States leads the world with 5,080 airports and many more heliports located throughout the country.[12] Built in the aftermath of World War II, these airports triggered massive economic growth as they connected the U.S. in ways that had never been possible. Today, many of these airports are underutilized.

Congress, and specifically this Subcommittee, has devoted substantial time and resources to foster air services among underserved communities with underutilized airports around the country. We intend to revitalize many of these airports by providing a new sustainable service.

Due to the substantially reduced noise profile of our aircraft, along with its enhanced affordability, we believe there will be interest in and opportunities to permit new infrastructure closer to where people live and work, commonly referred to as "Vertiports" or "Skyports." Industry is actively working with the FAA to define this new class of infrastructure, but they are largely envisioned as similar in size to a heliport with electric charging and water available. In

[11] See, https://www.jobyaviation.com/news/joby-nears-completion-part-135-air-carrier-certification/
[12] See, https://www.statista.com/statistics/183496/number-of-airports-in-the-united-states-since-1990/

the future, I believe that we could consider incorporating noise standards into how we permit infrastructure. Quiet aviation is coming, and cities should be able to work with industry to make it a part of their transportation networks – but only with the promise that it won't be disruptive to their citizens.

This future will only be possible if industry engages early and often with local communities and can deliver a service that is both broadly affordable and a welcome addition to everyday life. We are already working with numerous cities to design a service that meets their specific needs and requirements. I believe more local communities will want to construct Vertiports to integrate quiet, accessible aircraft into their transportation networks.

To help cities begin to plan for Advanced Air Mobility, Joby and others in the industry have been pleased to support H.R. 6270, the Advanced Aviation Infrastructure Modernization Act sponsored by Chairman Larsen, Ranking Member Graves, and Representative Titus.[13] This legislation would enable one year planning studies for cities to study how Advanced Air Mobility will integrate into their specific community. To paraphrase something that Chair Larsen and I have talked about before, "the most important person may soon become the local city planner". I firmly believe that this piece of legislation is critical to give that local planner the resources necessary to understand how Advanced Air Mobility will benefit their local community.

**CONCLUSION**

The electric age of aviation is the most exciting time for the aviation industry since the dawn of the jet age, and the coming decades will be defined by quiet, sustainable, and accessible

[13] See, https://www.congress.gov/bill/117th-congress/house-bill/6270?q=%7B%22search%22%3A%5B%22H.R.+6270%22%2C%22H.R.%22%2C%226270%22%5D%7D&s=1&r=2

flight. We appreciate that both Congress and the FAA are doing their part to ensure that the United States continues to lead the world in the future of sustainable flight. Joby is committed to doing our best to ensure that we are providing them a service that is affordable, accessible, sustainable, and quiet.

Thank you again for the opportunity to be here today, and I look forward to your questions.