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The Next Normal

The future of air mobility: Electric aircraft and flying taxis

November 2021

Look! Up in the sky! Not a bird ... or a plane ... it's an eVTOL!

eVTOLs are electric vertical takeoff and landing aircraft—and thousands of them could be flying above cities by 2030. Hear McKinsey experts and industry pioneers describe what's coming in the world of “advanced air mobility” (AAM) and how it could affect passengers, pilots, and our planet.

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Advanced air mobility in 2030

In this video, three McKinsey experts on aerospace and mobility describe a future in which electric flying vehicles are a safe, affordable, and sustainable way to travel.



Benedikt Kloss

Over the coming decade (or soon after), electric aircraft could become a popular mode of transportation and a viable alternative to traditional taxis. For unpiloted passenger drones, however, gaining public acceptance may take longer. Hear the predictions of three McKinsey experts on the future of advanced air mobility.

The commuter experience of the future

Benedikt Kloss: Flying taxis are gonna happen. The question for me at the moment is *when* it's going to happen—not if.

Robin Riedel: We will have aircraft that are much smaller than today's aircraft, and they will be much more accessible. They're going to land in your neighborhoods. You might take a short car ride or a micromobility scooter ride to get to the vertiport, and you'll go through there just like you do at a taxi stand today. You'll get on an aircraft that will take you quite rapidly across the city or to the next city or anywhere within a 100- or 150-mile radius.



Robin Riedel

Kersten Heineke: And this all will be one seamless experience. I imagine it to be fully integrated into my mobility app: my e-scooter ride to the office in the morning, the trip to the airport, the flight, the trip from the airport into the city, and then, again, the scooter for the last mile. It may even be one integrated ticket. All of these new vehicles are going to be fully electric; they're going to be much cleaner and completely emission-free. Will advanced air mobility replace car ownership? I doubt it. I think it will be complementary.

Robin Riedel: Some of the timelines we see are very aggressive. I'm not quite as bullish as some of the public statements around how quickly we can ramp up the system, but in the medium to long term—ten years out—I'm actually quite bullish. I think this is a mode of transportation that will eventually become quite frequently used. It will be safe, it will save many of us time, it will be sustainable—so there's a bright future to look forward to.

Benedikt Kloss: I would say that flying above the street is much safer than driving with other people on the road.

Will air taxis be autonomous?

Robin Riedel: Technology-wise, we're getting there. I think the big hurdles we have to overcome are, on the one hand, public acceptance: Are we going to be happy flying in an aircraft without a pilot? If something goes wrong, who do we hold accountable? And how do we certify a system as "good enough"? Those are important questions that a number of working groups are working on, but that will slow us down in getting to fully autonomous aircraft. So, autonomous passenger flights I'm less bullish on; I think it'll take us into the next decade before we see those.

Benedikt Kloss: The evolution that could happen is this: first, the pilot is in the vehicle. Then you take the pilot out of the vehicle and the pilot is on the ground, but you have a one-on-one operation—one pilot for one vehicle, but remotely operated. And then, over time, this ratio goes down.

Kersten Heineke: As for full autonomy—as in, the vehicle is doing all the decision making, and there is no remote observation—I don't think this will ever happen. We don't have it today in conventional air mobility: all the planes are supervised. I think we'll see something similar in advanced air mobility.

A multibillion-dollar market

Benedikt Kloss: People are ready for flying taxis. Across geographies, more than 15 to 20 percent of survey respondents say they can definitely imagine switching from their current mode of mobility to a flying-taxi service in the future. Passengers are spending more than \$400 billion globally for taxi services every year. E-hailing is another \$100 billion on top of that. If you now imagine that flying taxis can capture some of this market share and become a real alternative to the taxi by 2030, the market opportunity is in the range of several billion US dollars.

Robin Riedel: I think we're going to see in the tens of billions of dollars in market size globally in the early 2030s. But I could see it scale up much faster if we hit all these "unlocks" right.

Kersten Heineke: By 2030, we will still see a sizable number of players out there: ten, 15, maybe even 20. Why? Because by 2030, the technology will still be ramping up. But, ultimately, I think there's space for five or so players globally.

A growth industry that's sustainable *and* inclusive

Kersten Heineke: We're talking about the democratization of helicopter flight and, ultimately, the democratization of private jets. That's something that many people would not be able to afford if it weren't for these advanced air mobility vehicles. Taking a private jet is something that probably less than 1 percent, or much less than 1 percent, of the population will ever do in their entire lifetime.

Robin Riedel: It's going to be so important that this is not a toy for the rich but something that is broadly providing value to people. There are many people in the world today who can't afford a plane ticket, but if we really get this industry to scale, this could be the same price as a taxi. I'm excited about the ability of advanced air mobility to be sustainable and inclusive, and I'm excited to see the ramping up of a brand-new industry.

Kersten Heineke is a partner in McKinsey's Frankfurt office, where **Benedikt Kloss** is an associate partner; **Robin Riedel** is a partner in the Bay Area office.

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November 2021 | Interview



Bonny Simi

Rideshares in the sky by 2024: Joby Aviation bets big on air taxis

Joby executive Bonny Simi sees a future in which aerial ridesharing is popular, traveling between rural and urban areas is quick and easy, and the pilot workforce is much more diverse.

“By 2030, Joby Aviation will be the world’s largest airline by departures.” The confidence with which Bonny Simi makes this prediction isn’t surprising when one considers her background: Simi, who is Joby’s head of air operations and people, was a longtime commercial pilot and a US Olympic bobsledder and luger. She was also the founding president of a corporate venture-capital fund. She doesn’t shy away from risk, she’s accustomed to doing things that others find scary, and she likes to go fast.

Joby, founded in 2009 by entrepreneur and engineer JoeBen Bevirt, has developed an electric vertical takeoff and landing (eVTOL) aircraft that seats five people—a pilot and four passengers—and can travel at speeds of up to 200 miles per hour. And it’s gotten the attention of investors and partners: Joby is one of a handful of eVTOL players that went public in 2021. It plans to launch its air-taxi service in 2024.

During a visit to Joby’s facilities in Northern California, McKinsey’s Robin Riedel—himself a certified commercial airline pilot—talked with Simi about Joby’s aircraft, the pilot workforce of the future, and the promise of advanced air mobility (AAM). Edited excerpts of their conversation follow.

Robin Riedel: Let’s look ahead to 2030. What do you imagine the passenger experience will be like in a Joby aircraft? What will people use eVTOL aircraft for?

Bonny Simi: Imagine waking up in the morning and thinking you could drive your car to work—but that might take an hour, an hour and a half. Instead, you just open up an app. A car picks you up and brings you to a heliport five minutes away. You ride in one of our aircraft. The flight takes ten minutes. At the other end, there’s a car waiting for you. The entire ride is seamless, convenient, and affordable.

Initially, aerial ridesharing will simply replace what people currently do. Perhaps it replaces a long commute on a train or ridesharing on the ground. But we believe adoption of aerial ridesharing will grow as people's lifestyles change. Maybe people will work from home most of the time but go into the office one day a week, and they'll use our aircraft. Perhaps two people in opposite ends of a city can come together very quickly for an in-person meeting instead of doing it over Zoom, and they'd take our aircraft. Over time, people will move out into the more rural areas, because aerial ridesharing will make it possible to have short daily commutes into the city. This technology just completely changes how you think about work.

It can also change how you think about vacations. Getting to an island will be much quicker and easier. Getting from one side of a city or region to another, even over physical barriers—like mountains—will be much easier.

Our focus currently is on passenger transportation. However, our aircraft could also be used in a whole variety of ways. Think about an area that might be devastated from a hurricane or other natural disaster, where the airports are no longer available and the roads are inaccessible. Our aircraft can move in and land pretty much anywhere in an emergency situation to help transport people and medical supplies. That could be one use case. Last-mile transportation of cargo could be another one. It's all about where the economics are going to be, and we believe initially that's in passenger transportation.

Robin Riedel: What geographic areas will likely be the early adopters of AAM? Will it be rural or urban areas? Will it be the Western world or emerging markets?

Bonny Simi: I think the early adopters will be in the large, dense urban centers where congestion is a real problem: Los Angeles, New York, Miami, Singapore, Tokyo, perhaps parts of Brazil. As cities become denser and the roads become more and more congested, trains and buses won't be able to support everyone's transportation needs. Over time, though, AAM will be able to connect large metropolitan areas: San Francisco to San Jose, or Santa Barbara to Los Angeles. You ultimately can connect Nagoya to Tokyo, for example. And eventually, AAM will be bringing people from the rural areas into cities.

What most people get wrong about air taxis

Robin Riedel: What are some of the major misconceptions people have about eVTOL aircraft?

Bonny Simi: One misconception is that these aircraft are noisy. But when we first bring people to see our aircraft fly, the very first thing they remark on is the sound—or the lack thereof. It sounds, even in a hover, like the leaves on a tree. You almost don't hear it.

It isn't just the volume; it's also the quality of sound. When you think of a vertical-lift aircraft, like a helicopter, you hear that "wop-wop." You don't hear that with this vehicle at all. And that's one reason why consumer adoption will be so dramatic.

Another misconception is that aerial ridesharing will be expensive. Joby's vision is to save a billion people an hour a day—so we are planning for mass adoption. If you want to go from one end of town to the other, or perhaps between two cities, the cost of aerial ridesharing will be the same as ground-based ridesharing. Initially, it'll be a little bit more expensive, but gradually, as more people take air taxis and the network effects kick in, we'll get the price point down.

Bonny Simi biography

Vital statistics

Born in 1962 in Mount Baldy, California
Married, with one adult daughter

Education

Holds master's degrees in engineering and business from Stanford University and in human resources from Regis University, as well as a bachelor's degree in communications from Stanford University

Career highlights

Joby Aviation

Head of air operations and people
Adviser, JetBlue Airways
(2020–present)

JetBlue Airways

President, JetBlue Technology Ventures
(2016–20)

Held a variety of executive roles overseeing talent, customer experience, and airport and people planning
(2007–15)

Airline pilot
(2003–07)

United Airlines

Airline pilot
(1990–2003)

NBC Sports Group

Expert commentator during the Olympic Games
(1994–2002)

United States Olympic Committee

Three-time Olympian and ten-time national champion in luge and bobsled
Served on board of directors and executive committee
Volunteered as a licensed international luge judge
(1984–2019)

Fast facts

Is a board director of Pebblebrook Hotel Trust and a former board director of Red Lion Hotels

A third misconception is that these aircraft are drones. That's not accurate: a drone is an aircraft that does not have a pilot in it. Our aircraft is piloted—it's very safe and it's easy to incorporate into the existing air-traffic system. Our business model is built to be profitable around a piloted aircraft. Long term, at scale, we think we'll eventually move toward autonomous aircraft. That will take some time, and we're not betting our business model on it. But we are exploring autonomy, because to be truly ubiquitous we'll need to have autonomous aircraft.

Building the pilot pipeline

Robin Riedel: Tell us more about the pilot experience. In a typical pilot training program, trainees have to learn about high-altitude aerodynamics, jet engines, and other things that don't apply to flying an eVTOL aircraft. How are you thinking about pilot training and building the pilot pipeline?

Bonny Simi: Our aircraft is very intuitive and easy to fly. You can take off and land like a regular airplane on a runway, or you can take off and land vertically—like, on top of a building. It transitions from vertical flight to horizontal flight seamlessly. But our pilots will still need to operate in the regular airspace with other aircraft, so they'll be subject to the same pilot regulations. We're training them to fly in a regular general aviation aircraft first. They'll then transition quickly to our eVTOL aircraft, build up their experience, and launch into commercial operations after they get their commercial license.

As you know, there's a pilot shortage, so we're thinking a lot about building a pilot pipeline. We've partnered with educational institutions. We want to open up access to pilot training to communities that have never even thought about flying as a career. We're determined to make the pilot workforce much more diverse. We see this as a big social enterprise as well, and I'm very excited about the directions in which our pilot academy is headed.

Robin Riedel: You brought up diversity. Our research has shown that, globally, less than 6 percent of airline pilots are female. How does Joby plan to address that?

Bonny Simi: When I started flying a few decades ago, the percentage of female pilots globally was in the single digits. Sadly, it's still the same. Part of the problem is access; another problem is that it's hard to raise a family when you're traveling constantly.

At Joby, our aircraft is easy to operate, so the cost for pilot training is very low—which means we'll be able to open up pilot academies to a diverse population. Also, our focus is on urban air mobility, which means our pilots will be home every night! It makes for a family-friendly operation. We imagine that the workforce of the future for our aircraft will be very diverse, both in gender and ethnicity. So it's not only environmentally sustainable but also socially sustainable.

'Electric is now'

Robin Riedel: What else needs to happen to make Joby's air-taxi service a reality?

Bonny Simi: As we think about building out the entire operation, it's not just building and certifying the aircraft. That's an important piece, and it's what most people are focused on, but we also have to build the infrastructure to run what will be the world's largest airline.

Part of the infrastructure, of course, is the charging infrastructure. We've designed the aircraft for a very quick charge. Our normal stage length—the distance that we'll fly the aircraft—will be about 25 to 50 miles. It takes just about the same amount of time to charge the aircraft as it does for people to get off and for a new set of passengers to get on—so, roughly five to seven minutes. For flights that are longer, like 150 miles, it could take up to 45 minutes to charge the aircraft. By the way, our aircraft completed a 150-mile flight in July 2021 on a single charge. As far as we know, that set the record for the longest eVTOL flight so far.

Robin Riedel: Do you think Joby aircraft will always be electric? Are electric aircraft the future of aviation?

Bonny Simi: A lot of people say the future of aviation is electric. I say, that's not the future—that's now. We're flying electric aircraft now. What comes next? We believe that hydrogen is next; perhaps first a hybrid of hydrogen and electric, and then ultimately pure hydrogen down the road.

If we think about long-haul travel, hydrogen is the long-term future. For urban air mobility—trips of up to 100 miles—I think electric is ideal. As you begin moving out to regional transportation, it might be a hybrid. And then even farther out than that, it might be pure hydrogen. We believe that in the aviation community broadly, hydrogen will be the standard by 2050.

Robin Riedel: What's your biggest and boldest prediction about where AAM can go?

Bonny Simi: At Joby, one of our values is "reimagining possible." So when I think of bold, audacious goals, one is that we will be the largest airline in the world by departures by 2030. Think about that: 1,000 aircraft operating dozens of takeoffs and landings every day. That will make us ubiquitous in the community. Our aircraft will just be a part of people's everyday life.

Robin Riedel: What's scarier to you—getting on an eVTOL aircraft for the first time or going down the luge track?

Bonny Simi: Luge and bobsled are not unlike piloting. I actually see a lot of parallels: it's very much about precision, safety is always paramount, you go fast. But for the riders, trust me: the Joby aircraft is a much smoother ride.

Comments and opinions expressed by interviewees are their own and do not represent or reflect the opinions, policies, or positions of McKinsey & Company or have its endorsement.

Bonny Simi is head of air operations and people at Joby Aviation. **Robin Riedel**, a partner in McKinsey's Bay Area office, conducted this interview.

[For more from Bonny Simi, see the videos accompanying this article on McKinsey.com.](#)

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November 2021 | Interview



Daniel Wiegand

‘Speeding up everyday travel’: Lilium prepares for takeoff

Daniel Wiegand, CEO of air-mobility company Lilium, believes that electric passenger aircraft will be commonplace by 2030.

He didn’t expect aircraft development to cost a billion dollars. When Daniel Wiegand and his team at German aviation company Lilium first set out to make electric flying vehicles a reality, he was “a bit naive” about the cost and scope of such an undertaking. Much has happened since Wiegand and three other graduates of the Technical University of Munich founded Lilium in 2015. Today, Lilium is one of more than 250 entities developing electric vertical takeoff and landing (eVTOL) aircraft.

The advanced air mobility (AAM) industry has been hot lately, attracting more than \$5.4 billion in investment in just the first nine months of 2021. Lilium became a publicly traded company in September. Wiegand says that the company plans to offer its first commercial flights to consumers in 2024; locations announced to date include Florida and parts of Germany and Brazil. Unlike many AAM players, which are focusing on urban air mobility—flying passengers and cargo to and from various areas within a city—Lilium is instead gearing up to offer a regional intercity service. Its website describes a world in which a future trip from San Francisco to Lake Tahoe takes under an hour by eVTOL aircraft, compared with almost four hours by car. Traveling from Zurich to St. Moritz, a two-and-a-half-hour drive, would take 29 minutes by air. Wiegand calls it “expanding the radius of life.”

Wiegand recently spoke with McKinsey’s Robin Riedel in Lilium’s hangar near Munich, where the company is constantly testing and refining the technology for its sleek, black-and-white seven-seater electric jet. Edited excerpts of their conversation follow.

Robin Riedel: Let’s start with the name of your company. Why is it called Lilium?

Daniel Wiegand: Otto Lilienthal is believed to be the inventor of aircraft in Germany. We took the Latin version of his second name, which means “lily.” He had a dream that, one day, instead of walking or using horse carriages, we would be flying through the air as our main means of travel. His dream fits pretty well with what we’re doing here at Lilium.

Robin Riedel: When do you think that dream will become a reality? Paint us a picture of what AAM will look like in the coming years and who will be using it.

Daniel Wiegand: I believe 2025 will be the launch phase of this industry, and by 2030 it will really be ramping up—that's when you will see exponential growth, and eVTOL aircraft will become a part of everyday life. I expect that there will be many applications of this new technology. On the ground today, there's everything from sports cars to trucks to buses. We will see something similar in the air: there will be eVTOL aircraft used on intercity shuttle routes, which is what Lilium is focused on right now. There will be sightseeing applications, taxi applications, cargo applications, and so on. We'll see many different products and business models.

Robin Riedel: Will AAM reduce private car ownership?

Daniel Wiegand: Maybe a little. I think what it will truly change is the perception of time and distance. Imagine how different our lives would be today if we only had bicycles. We would have to live very close to our workplace, close to our friends, close to where we want to shop, et cetera. For short trips like these, a bicycle is roughly five times slower than a car.

An eVTOL is five times faster than a car. So think about how that would change things: we'll see different pricing of real estate, for example. We'll be able to live in the countryside and work in the city. What we like to say at Lilium is, this is a different radius of life. Essentially, the radius of our life expands with the speed at which we can travel—especially the speed at which we can do everyday travel.

The passenger experience

Robin Riedel: What will it feel like to ride on a Lilium Jet in five or ten years? Will it be just like flying in an airplane?

Daniel Wiegand: It will be safe, fast, and convenient. We're looking at the aircraft not only as a product—we want to get the whole experience right, from the check-in process to actually getting on and off the aircraft. That means we, along with our infrastructure partners, like Ferrovial [the Spanish transportation infrastructure company], are working hard to make the entire journey seamless, from the first mile to the last.

The Lilium Jet has a spacious cabin. Our jet technology has a very low vibration, so it will be a comfortable ride, with low noise emissions. We want to deliver an experience that corresponds to what customers expect in the 21st century.

It's also important to us that all of this is connected within a network—so we're not only looking at the Lilium flight itself but also at embedding these flights into a bigger transportation network that covers an entire country. That means being connected to ground transportation—taxis, car services, trains—and all the way up to the big airlines, to which Lilium flights would act as feeder flights.

One thing I'd like to clear up is that Lilium won't be an air-taxi service—at least not in the first ten years or so. Instead, we will be providing scheduled shuttle services from one city center to another. The business model is comparable to a high-speed train that connects two cities.

Robin Riedel: You said the aircraft will have "low noise emissions." Noise is obviously a big concern for consumers—not just passengers but anyone who lives or works near takeoff and landing points. How has Lilium been able to solve the noise problem?

Daniel Wiegand biography

Vital statistics

Born in 1985 in Tübingen, Germany

Education

Holds a master's degree in aerospace engineering from Technical University of Munich

Career highlights

Lilium
(2015–present)
Cofounder and CEO

Fast facts

Named one of *MIT Technology Review*'s "Innovators Under 35" in 2017
Won European youth science competition "Jugend forscht" in 2004
Started flying gliders at age 14

Daniel Wiegand: We use ducted electric vectored thrust [DEVT] technology. Our jets have ducted fan engines powered by electric motors. Acoustic liners around the fans capture and dissipate much of the noise. Our tests show that the perceived noise level of the jet, when it's in its initial hover phase, is about the same as a dishwasher from 100 meters away. And when it's cruising, you will barely hear it at all.

We believe low noise emissions is one of the key enablers for the entire eVTOL sector. Low noise is crucial to community acceptance and to accessing the spots in urban environments where we want to take off and land. Helicopters have been able to do vertical takeoff and landing for a very long time, but they are very noisy and costly. The eVTOL industry won't be truly successful unless it solves those two fundamental issues.

Affordability and autonomy

Robin Riedel: So DEVT is your solution to the noise issue. What about the affordability issue? When will most people be able to afford a Lilium flight?

Daniel Wiegand: Initially, we're expecting that the price will be around \$2.25 per passenger mile. Over the medium or long term—with higher-capacity autonomous aircraft and lower-cost infrastructure—the price will be comparable to high-speed trains or other ground-based transportation.

From the start, it's been Lilium's mission to create a high-speed transportation system that is affordable for everyone. All our decisions have been made with this goal in mind. The early adopters will most likely be businesspeople, partly because price points will be higher in the early phases. But we think that eVTOL aircraft will eventually become a standard means of transportation for our whole society. In the 2030-to-2045 time frame, using an eVTOL aircraft will be as normal as driving a car is today.

Robin Riedel: Where exactly will all these eVTOL aircraft take off and land?

Daniel Wiegand: We've designed an infrastructure—and an aircraft—that meets current regulations while also allowing a very high-throughput eVTOL service. We're determined to achieve high throughput because that was the feedback from our partners and customers. They said, "We don't want just 20 people coming in per day. We want hundreds, maybe thousands, per hour."

The infrastructure looks quite simple: each “vertiport” has at least one helicopter pad and multiple gates—typically six to ten—where passengers can board while the aircraft is charging. All these places are connected via a central taxiway. There will typically be some kind of lounge where passengers can check in to their flight on their phones and get some food and beverages. But we envision people flowing through this infrastructure quickly—not spending a lot of time there like we do today in airports.

This can be one of the big advantages of the eVTOL industry: making the airport experience very different from what we know today. We’re all annoyed at how much time we spend on the ground and how little time we spend in the air. With eVTOLs, we can have small, distributed, efficient vertiports. It will take two or three minutes—not an hour or more—to get from a car into an airplane.

By 2030, there will probably be a lot of infrastructure created in a very distributed way, from private garages and vertiports in small villages to hotel rooftops and downtown vertiports in big cities. Beyond 2030, Lilium could potentially shift from providing shuttle services only for larger groups of people to also providing on-demand services for individuals, where you can maybe take a two-seater airplane from a vertiport next to your house to a village somewhere. Again, with autonomous aircraft and low-cost infrastructure, we could get to the price points and throughput that will make sense for an on-demand air-taxi business model.

Robin Riedel: So the price will drop when the vehicles become autonomous—but Lilium flights will be piloted at first, right? How do you expect that to evolve?

Daniel Wiegand: Yes, Lilium will initially have pilots on board. Each of our pilots will hold a commercial pilot license and get the full training of an airline pilot, plus an additional “type rating,” or certification, for the specifics of the Lilium Jet.

Over time, we’ll develop autonomous technologies. People often ask, “What will happen to the pilots training on these aircraft today?” We think we’ll need them for a very long time. The pilot will be on the ground, acting as a supervisor of five, ten, 20, or 30 autonomous aircraft flying at the same time. So we’re envisioning a gradual shift from a fully piloted service to a more or less autonomous service. As we shift to autonomy, the number of aircraft that one pilot can operate will simply increase.

Making aviation more sustainable

Robin Riedel: What about sustainability? Is it good for the environment to have so many Lilium jets in the air?

Daniel Wiegand: Sustainability is part of our core mission. From day one, we made our aircraft all electric and battery powered. We didn’t even go for any hydrogen options, because hydrogen consumes roughly three times more primary energy to make the same trip.

The eVTOL sector is also serving as a catalyst for the entire aviation industry to become more environmentally friendly. Lilium aircraft are jets—just like the airplanes flying in the air today—so the technologies and processes we’re using aren’t just for eVTOL aircraft. They can also be used for “normal” electric jets. The regulation to certify batteries for our aircraft, for example, can be used to certify batteries for other electric jets. So, in this way, eVTOL is helping to bring sustainability into the wider aviation community.

Leadership lessons

Robin Riedel: You cofounded Lilium before you turned 30. What are some of the biggest leadership lessons you've learned as a young founder and CEO—and one who has been building not only a new company but a whole new industry?

Daniel Wiegand: One lesson that's probably independent of this industry—it's a lesson for founders—is that whenever something goes great in the company, it's linked to your people. And whenever something isn't going so well, it's also linked to either your people or the structure in which you put them. It's all about the people.

There have been challenges along the way, of course. One of the challenges we faced was that we were initially a bit naive about the scope and cost of developing something like this. I think our first estimate was for a smaller sports aircraft in the \$50 million to \$100 million range. But now that we're designing against the same safety standards as an airline, we've discovered that the development cost will be \$1 billion or more.

With this recognition comes the need for more fundraising, which means you need to spend much more laser-focused time on making sure that you have a compelling business case. Otherwise, the whole thing will just fall apart.

Thankfully, at Lilium, we started early. More than four years ago, we began looking systematically into the business case—the costs, what customers expect from such a service, and so on. One thing we found, for example, was that an air-mobility service needs to reduce passengers' travel time by at least half an hour. Otherwise, they won't think it's worth the trouble to switch from a car to an aircraft and back to a car; they'll just take the longer car trip.

Robin Riedel: It's an exciting time in AAM, and there are now so many companies hoping to compete in this space. How do you think the AAM ecosystem will evolve? Is there room for everyone?

Daniel Wiegand: We think there's room for at least five to ten players—both big companies and independent companies—because the demand in the medium and long term is going to be so high that one company alone would never be able to meet it. We're excited that there's a whole sector growing up around us, because when there's an ecosystem, investors are more comfortable with investing. Your partners are more comfortable because they know that if you fail, someone else can take your place. And there is more infrastructure being built, more supply-chain developments happening, more politicians pushing for state funding. If we were the only company in the entire sector, most of these things would not happen, and we would have a very hard time making progress. So we welcome the competition.

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Daniel Wiegand is a cofounder and the CEO of Lilium. **Robin Riedel**, a partner in McKinsey's Bay Area office, conducted this interview.

[For more from Daniel Wiegand, see the videos accompanying this article on McKinsey.com.](#)

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November 2021 | Interview



Florian Reuter

Will VoloCity transform urban transportation?

Electric air taxis such as VoloCity, made by Germany's Volocopter, are poised to revolutionize not just city travel but also the global mobility industry, says CEO Florian Reuter.

Both the bicycle and the automobile are said to have been invented in Southern Germany, near the city of Bruchsal. Soon, another transportation game changer could emerge from that part of the world. So says Florian Reuter, CEO of Bruchsal-based aircraft manufacturer Volocopter. His company is building multirotor electric vertical takeoff and landing (eVTOL) aircraft, which it plans to offer for commercial use in 2024.

Volocopter is working on three types of eVTOL vehicles: the VoloCity, a two-seater urban air taxi; the VoloConnect, for traveling between cities and suburbs; and the VoloDrone, for transporting cargo. VoloIQ, the company's digital platform, is designed to connect all of these services and allow consumers to book flights easily. Volocopter is one of several eVTOL companies that have recently gotten considerable traction in the investor community; the company has raised more than \$350 million in equity and has formed partnerships to bring its services to a number of cities, including Los Angeles and Paris.

Reuter recently discussed his views on the future of air mobility with McKinsey's Kersten Heineke. The following are edited excerpts of their conversation, which took place at a hangar in—where else?—Southern Germany.

Kersten Heineke: If Volocopter sticks to its announced timeline, just three years from now your aircraft will be flying above metropolitan areas, carrying people and products. How do you envision advanced air mobility [AAM] changing over the next decade? What will people be able to do in 2030 that they can't do today?

Florian Reuter: I envision that by 2030, there will be a wide range of AAM options, for both passengers and goods. As a consumer, I will be able to simply tap my smartphone and it will show me all the different options. And I can choose the one that best meets my specific needs at that time—whether my priority is the lowest price or the shortest trip or something else. The options will have to be 100 percent sustainable, there's no doubt about that.

I think urban air mobility—for example, air-taxi applications within cities—will start a profound transformation in the air-mobility sector overall. Specifically, the digitization and the electrification in urban applications will spread to other, longer-range missions until eventually we develop the means to fly, with 100 percent sustainability, from continent to continent. In 30 years, AAM will be as ubiquitous as any other transportation mode.

I can say that with confidence because this technology isn't just promising—we've actually already shown that it works. We've had public demonstrations and test flights in many places, including Helsinki, Singapore, Paris, and Oshkosh, Wisconsin, so thousands of people have seen our vehicle fly. They've also *heard* it fly, so they've witnessed that this technology is extremely quiet. Our test flights have helped dispel the common misconception that these vehicles will be noisy.

Kersten Heineke: Which cities do you think will be the first to adopt AAM?

Florian Reuter: Mobility is a constraint in every city; that's why we see a huge global market demand for AAM. The more prone to congestion a city is today, the larger the impact of the air option will be. The biggest needs are certainly in the megacities that have an underdeveloped infrastructure—particularly cities in Asia, which is why we are putting a lot of emphasis on scaling our services in that region.

Kersten Heineke: You've mentioned sustainability a few times. Did you consider other energy options besides electricity?

Florian Reuter: It was clear to us that if we want to be part of the mobility options of the city of the future, 100 percent sustainability is a must. The only way to head in that direction today is by going all electric. Over the longer term, fuel cells might play a role, but we're certainly not there yet.

And it's not enough to just have rechargeable batteries that use 100 percent renewable energy. The production of your vehicle—not just the operations of your vehicle—must be fully sustainable as well. We still have a long way to go on that front. But I'd say the entire industry, and society at large, is searching for the right solutions.

A \$300 billion market?

Kersten Heineke: Many AAM players have been getting significant funding recently. How many will still be in business in 2030?

Florian Reuter: We are talking about an overall \$10 trillion mobility market potential. If AAM can get \$300 billion of that in the next ten to 15 years, that is a gigantic market opportunity, but it still represents only a very small fraction of the total market. So I see tremendous opportunity for growth for Volocopter and for many other players out there.

I predict there will be multiple players. But there probably won't be as many as there are in the automotive space right now, because it takes an investment of almost \$1 billion just to meet the initial safety criteria and get over the certification hurdle.

Kersten Heineke: Many stakeholders would all need to cooperate before air taxis can start flying over cities. What types of partnerships is Volocopter pursuing?

Florian Reuter: We want to transform the way that people move about our planet—and we can't do that alone. This is a massive undertaking. We're forming partnerships along the entire value chain so that we can bring urban air mobility to life.

Florian Reuter biography

Vital statistics

Born in 1979 in Aachen, Germany

Married, with two children

Education

Holds a diploma in industrial engineering from the Karlsruhe Institute of Technology, studied management and economics at the University of Barcelona, and wrote his thesis with Daimler in Japan

Career highlights

Volocopter

CEO

(2015–present)

Siemens Novel Businesses

Venture manager

(2009–14)

Contrium Consulting

Project manager

(2005–09)

Fast facts

Speaks German, English, French, and Spanish

Enjoys skiing, mountain biking, reading, and pioneering new technologies

On the supply-chain side, we have a very clear make-or-buy strategy, and we're partnering with parts suppliers who have a huge legacy in the aviation domain. On the ecosystem side, there are certain elements that need to change before we can unleash the full potential of AAM: those have to do primarily with the availability of landing sites—or what we're calling VoloPorts—as well as the availability of charging infrastructure and the implementation of next-generation technologies for managing airspace. We are happy to start with existing airspace-management technologies, but in order for our services to truly scale up, a technology shift—from traditional air-traffic management to universal traffic management—will need to happen.

We have partnered with numerous companies to help make this a reality, and we involve them in our test flights. For example, at the airport in Helsinki, we flew alongside legacy helicopters and large commercial airliners. We were demonstrating that we can integrate a Volocopter flight into the existing landscape, but also that we can work with partners to move toward universal traffic management.

The advent of autonomous aircraft

Kersten Heineke: What other cutting-edge technologies will you need in order to be successful in the next ten years?

Florian Reuter: We want our aircraft to be as lightweight as possible. At the same time, we want it to be as “performant” as possible, which directly relates to the energy and power density of the battery and the efficiency of the entire electric drivetrain. So we're pushing hard on those two elements and exploring what is possible, always with an eye toward meeting the highest standards in aviation and getting the aircraft certified.

After that, the next technology frontier is autonomous aircraft. Autonomy will free up an additional seat in the aircraft and it will make AAM much more affordable and scalable. When you talk about autonomy, most people think of sophisticated computer sensors and algorithms on board the vehicle, but if we want to ensure that we can provide our services at a safety factor

of ten to the power of minus nine—or one incident in one billion flight hours, which is the safety target that the European Aviation Safety Agency has given us—then we can't think only about the vehicle. We have to think about a system of systems. That has implications on the infrastructure that we use; it has implications on the reliability of GPS satellites, mobile-phone technology, and so on. So there are a host of technologies that we need to tie together to make sure that, ultimately, we can capture the full potential of AAM.

Kersten Heineke: How long will it be before we see autonomous aircraft? Five, ten, 15 years?

Florian Reuter: Many people were expecting that self-driving cars would exist by now. But there are two reasons why I believe we'll see much faster adoption of autonomous capabilities in the air than on the ground. First, airliners have been flying on autopilot for decades, so there's a level of autonomy that we're already very used to, and have mastered very safely, in the air. Second, the air is a much easier space to control than the ground. Of course, we have to be aware of "noncooperative members" in the airspace—like birds or illegal drones—so we need to have a plan for how to deal with those. But, generally speaking, participants in the airspace are much more technology-equipped and much better educated than those on the ground, simply because there's not much traffic up there.

Besides, the autonomy road map is being pushed not just by Volocopter and other members of this industry—it's also being embraced by regulators worldwide. They know it's coming and they see its advantages, so they are actively encouraging industry players to participate in the working groups to make autonomous aircraft a reality. I expect to see the first adoptions of fully automated flights within the next five years and, on a global scale, in five to ten years.

Kersten Heineke: What would you say to pilots who want to work for Volocopter but worry that in just a few years they'll be unemployed?

Florian Reuter: When we talk about the maturation of this industry, we think of it in phases. In phase one, we put a pilot in the aircraft to fulfill the traditional regulatory requirements. We make it easy for the regulator to simply accept the VoloCity and VoloConnect as aircraft that resemble a helicopter, to a certain degree, and can integrate into existing air-traffic-management systems and can use existing heliport infrastructure. That's how we can get started tomorrow.

For phase one, we have partnered with [pilot-training-services provider] CAE to make sure that we can train the necessary numbers of pilots to support our business expansion. But we want to scale our services, so, eventually, we want to take the pilot out of the aircraft. But we'll still need trained pilots to oversee the operations of passenger aircraft as well as cargo drones.

It will be a natural progression from being a pilot on board—which will become more boring because the vehicle will be much more automated—to being a pilot on the ground. I believe this offers a compelling career path for pilots; it gives them tremendous opportunity for growth in a tech environment.

No ordinary start-up

Kersten Heineke: What's the most difficult part of your job?

Florian Reuter: In this industry, you need an incredible amount of capital before you can start generating meaningful commercial revenue. This is a marathon rather than a sprint. Many of the start-up best practices—like A/B testing, "fail fast," and all that—don't really apply to this

industry. Keeping everyone engaged—the team, the public, investors—on this very long-term journey has been a challenge.

I always saw the potential for it; otherwise, I would have never left Siemens to join what was at the time a four-person start-up. But it was difficult to predict how fast the vision would come to fruition. And we had a lot of internal debate over the years because we saw other companies applying very different approaches. We constantly asked ourselves, “Do we need to be more aggressive in our timelines? Should we put more pressure on regulatory authorities? Should we stay with electric power or go hybrid? Do we need to go after longer-range missions?” and so on.

Looking back, I think staying true to our original DNA has served us well. It’s been very rewarding to live through the emergence of this whole new industry that, today, no one is contesting anymore. Everybody’s just asking, “How exactly is it going to unfold?” Where we are today is an extremely exciting point in time.

Kersten Heineke: In 2017, Volocopter changed its corporate language from German to English. Any advice for CEOs who are thinking about doing that in their companies?

Florian Reuter: We made that transition when Volocopter had about 15 employees; we now have more than 400. I recognized that even if we hired best-in-class talent in Southern Germany, we would not be good enough to compete on a global scale. We needed to attract the best talent from all over the world. It was obvious to me that the company language was one element that we had to change to support our growth ambitions.

But language is just one element—it’s a highly visible one, but it’s not enough. You then need to change many other things: organizational structures, internal policies, IT systems, and so on. And in our case, we also needed to expand geographically. The city of Bruchsal is around the corner from where the automobile and the bicycle were invented, so we think of Volocopter as writing the next chapter in that history—but how many people have heard of Bruchsal? Probably not that many. So we’ve opened additional sites in Munich and Singapore, and we’re about to open an office in Paris.

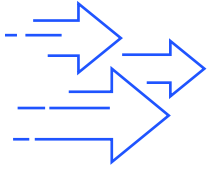
Any company that has global ambitions must go through these kinds of transitions sooner or later—and I think there is great merit in doing it sooner. If your vision is to become a multinational company, start acting like one from the outset.

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Florian Reuter is the CEO of Volocopter. **Kersten Heineke**, a partner in McKinsey’s Frankfurt office, conducted this interview.

[For more from Florian Reuter, see the videos accompanying this article on McKinsey.com.](#)

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