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TRANSCRIPT
The Great Electric Airplane Race
26 May 2021

MILES O'BRIEN (Correspondent): The race is on to stop the climate emergency.

BRICE NZEUKOU (Ampaire, Inc.): We're seeing more and more people really paying attention to their carbon footprint.

MILES O'BRIEN: Aviation is a fast-growing offender, but is it too slow to respond?

SUSAN YING (Ampaire, Inc.): Aviation will become the final dinosaur that doesn't clean up, if we don't act right now.

MILES O'BRIEN: It's the high-hanging fruit, one the hardest climate challenges of all.

BERTRAND PICCARD (Solar Impulse Foundation): It's extremely difficult to get rid of the fuel, if you want to transport tons and tons of passengers.

MILES O'BRIEN: Could rapid progress in electric technology change the equation?

TERIK WEEKES (Elroy Air): Electric motors are at a certain point today, the battery systems are at a certain point today, we're within that edge of possible.

MILES O'BRIEN: New technology is driving a global race to push that edge.

SEBASTIAN THRUN (Kitty Hawk): This might sound crazy, but we believe it's the future of transportation for everybody.

MILES O'BRIEN: A new era may be closer than you think.

Are we flying the future right now?

JOSEPH OLDHAM (New Vision Aviation): We absolutely are.

MILES O'BRIEN: The Great Electric Airplane Race is cleared for takeoff, right now, on NOVA.

All right, Wendy, is this your first day flying?

A trip to the airport in Watsonville, California, shrouded in mystery. I've been invited here by apublicity-shy company, for a flight to an undisclosed location, to see a groundbreaking new flying machine. Beyond that, details are sketchy.

Our pilot is Wendy Kraft.

You've been flying for a long time. Is this the kind of thing you'd like to share with many more people, that ability to go anywhere, anytime?

WENDY KRAFT (Helicopter Pilot): Absolutely, especially in this area. I mean, having grown up in Santa Cruz, there wasn't really a traffic problem, back in the day, but now, traffic is horrendous.

MILES O'BRIEN: Helicopters are only for the lucky few. It's about a thousand dollars an hour to operate this one. And of course, they are noisy.

We fly for an hour. And then, without warning, there it is, sitting on a remote airstrip, a successor to the helicopter: an aircraft that flies without a drop of fossil fuel, part of an electric revolution in flight, one with the ambitious goal of democratizing the rare privilege we just enjoyed, and maybe, just maybe, helping save the planet.

The climate emergency is here and now. The greenhouse gas carbon dioxide is at the highest level it's been in at least 800,000 years. It's an existential crisis that is prompting action.

Globally, about 15 percent of the human carbon footprint comes from transportation. We see some signs of progress; electric car sales are rising as prices drop…

BRICE NZEUKOU: We're seeing more and more people really paying attention to their carbon footprint.

MILES O'BRIEN: …but aviation? It's one of the hardest transportation problems to solve.

Yet all over the world, engineers, entrepreneurs and aviators are trying to meet the challenge.

BRICE NZEUKOU: We believe it's going to happen sooner than most people imagine. If you fly on small commuter airlines today, you can expect some version of electric aircraft within the next five years.

MILES O'BRIEN: Today it is hard to see, but it may just be a matter of time. Because electric motors are so small, yet powerful and responsive, designers can distribute them all over an aircraft and replace control surfaces like ailerons, stabilizers and rudders. The motors reduce drag and are much more efficient.

They are experimenting, starting small, creating some flying machines like never seen before.

There's even more at stake than the climate emergency. Aviation has a serious pollution problem that is just now coming into focus. Just after dawn on a sunny, blustery October morning, in Boston, a pair of scientists are chartering a fishing boat.

BRICE NZEUKOU: We can definitely try to get to as close to the runway as possible.

MILES O'BRIEN: But environmental engineers Neelakshi Hudda and John Durant, of Tufts University...

BRICE NZEUKOU: How much closer do you want to get? Another hundred meters?

MILES O'BRIEN: ...are casting...

BRICE NZEUKOU: This might be a good spot. Might be a great spot.

MILES O'BRIEN: …for plumes of emissions, generated by aircraft heading into Logan Airport. Combustion of Jet A fuel in airplane engines is a bigger piece of the overall pollution pie than most people recognize.

NEELAKSHI HUDDA (Tufts University): The amount of Jet A that's consumed at Logan is about 25 percent of all the fuel that's consumed in the City of Boston by all the cars. And there are millions of people that live around big, large airports that are impacted by these emissions day in and day out. And it's a chronic insult, environmental insult, to those communities.

MILES O'BRIEN: They are out to answer a simple question: how pervasive is that chronic insult?

NEELAKSHI HUDDA: Basically, we are seeing a plume, downwind from the plane, which results in a spike in the concentrations that we are measuring.

MILES O'BRIEN: They are measuring the quantity and the size of toxic particles, the remnants of incomplete combustion.

Average size, 10 nanometers. That is really small particles. The smaller the particle is, the deeper it can penetrate into your lungs.

NEELAKSHI HUDDA: They have been associated with a slew of cardiovascular health effects, respiratory health effects, elevation in blood pressure, systemic inflammation, and have the capacity to actually penetrate the blood-brain barrier directly and deposit in human brain.

MILES O'BRIEN: Hudda has an electric car, outfitted with similar equipment. She drives through neighborhoods under the flight paths, continuously gathering data.

Her pioneering work began in Los Angeles, 2012. Driving a similarly equipped car, she systematically traversed the neighborhoods beneath the final approach paths to Los Angeles International Airport. She was able to identify a distinct plume from the airplanes that went much farther than she expected.

NEELAKSHI HUDDA: We went 20 kilometers, and I still don't think that's the end of it. I just ran out of battery, at that point, in my car. No one had suspected that they'd find a really clean signal 20 kilometers downwind of an airport.

If you look at the top 23 airports, about 10 percent of U.S. population lives within 10 miles of those airports.

We all benefit from aviation, but we all don't really pay for it equally.

MILES O'BRIEN: And yet we all pay a price for aviation's impact on the climate emergency. Before the pandemic, aviation accounted for about three-and-a-half percent of the world's climate-warming problem.

About two-thirds of jet fuel exhaust is CO2. Less than one percent are nitrogen oxides, which also cause warming. The other third is mostly water vapor, which, at high altitude, becomes ice crystals, contrails.

When the humidity is right, contrails spread and linger for hours, creating cirrus clouds. Thousands of flights, creating thousands of contrail-induced clouds, trap a lot of heat. They have about twice the impact on global warming as the CO2 from jet exhaust. And the problem is getting worse.

Global aviation is growing rapidly. It is predicted to double in less than 20 years. In stark contrast, other forms of transport are investing heavily in green alternatives.

SUSAN YING: If that trend continues, then aviation is going to become one of the top polluters of all industry sectors. Aviation will become the final dinosaur that doesn't clean up, if we don't act right now.

MILES O'BRIEN: It is a weighty issue, specifically, the weight of jet fuel. A Boeing 737 can hold more than 40,000 pounds of it. Sounds like a lot, but to replace the jet engines with electric motors, you would need 30 times the weight, or about 1.2-million pounds of batteries to get comparable range.

Solving that engineering challenge will be daunting, but the first baby steps have already been taken. In 2003, Bertrand Piccard co-founded the Solar Impulse Project, in Switzerland. The goal, to design and build a solar electric aircraft that could fly around the world.

BERTRAND PICCARD: For Solar Impulse, we had to make a very, very light airplane. The weight of a car will be flying at the speed of a moped and transporting one pilot and zero passengers. And like this, we could fly solar with electric engines.

MILES O'BRIEN: His partner in the audacious endeavor was Andre Borschberg.

ANDRE BORSCHBERG (H55): I had faith in the possibility to do it, but of course, I didn't know how. Could we collect enough energy? And could we use so little that it would make the flight through the night possible?

MILES O'BRIEN: In the end, it took 16 months, but they did circumnavigate the planet.

BERTRAND PICCARD: We made it.

What I wanted to do was to show that electric aviation had also a future, and that the technology already exists. It's not something that we can do it in a hundred years. We can do it now, and actually

we did it. Today, all the people who will say, “A clean aviation is impossible,” will look as stupid as the one who said to the Wright Brothers, “Your airplane will never fly.”

MILES O’BRIEN: Chandler Airport, in Fresno, California, has been in operation since the Wright Brothers era. Today, the art deco glory has faded, but Joseph Oldham is using this old underutilized place to help launch a new age of flight: aviation 3.0.

JOSEPH OLDHAM: This is the third revolution of aviation. The first revolution, of course, was powered flight. Second revolution was jets, in the 1940s, early 1950s. Electric propulsion is the third revolution.

MILES O’BRIEN: These are Pipistrel Alpha Electros, the first certifiedall-electric airplanes in the world. He has four of them in his hangar.

And he was gracious enough to give a fellow pilot the right seat.

All right, let’s do it. Contact.

JOSEPH OLDHAM: Yeah, clear.

MILES O’BRIEN: It was as simple as flipping a switch.

That’s amazing. That’s it?

JOSEPH OLDHAM: That’s it.

MILES O’BRIEN: It was weirdly quiet as we taxied to the runway.

JOSEPH OLDHAM: The noisiest thing on this airplane are the brakes.

MILES O’BRIEN: And watch what happened when we stopped to wait for traffic.

JOSEPH OLDHAM: You just sit here, just like an electric car.

MILES O’BRIEN: That’s just cracks me up.

JOSEPH OLDHAM: Yeah, anytime anybody goes in this airplane, that’s used to a conventional aircraft, this is what gets them.

CHRIS CALDWELL (Flight Instructor): Okay, Four Alpha Romeo you can go ahead and roll.

JOSEPH OLDHAM: Four Alpha Romeo rolling.

MILES O’BRIEN: It’s interesting. It doesn’t vibrate in the same way.

JOSEPH OLDHAM: Yeah, it's just very comfortable and very relaxing. Electric propulsion systems are so simple that really there's just nothing that you really need to be that concerned about.

MILES O'BRIEN: Are we flying the future right now?

JOSEPH OLDHAM: We absolutely are.

MILES O'BRIEN: It was a hazy day, the result of some raging wildfires nearby, a reminder of the climate emergency which makes the decarbonization of aviation so urgent.

How important do you think that is, to think about taking fossil fuels out of aviation over the long run?

JOSEPH OLDHAM: Well, it's huge. It's the only mode of transportation that really has not moved aggressively towards zero emission.

MILES O'BRIEN: He got the money to purchase the planes by applying for a grant from Fresno County to demonstrate advanced transportation technology. He believes the planes, along with charging stations at airports within range, will do just that.

JOSEPH OLDHAM: Well, we're heading in to land right now, so...

MILES O'BRIEN: You mind if I take it for a minute?

JOSEPH OLDHAM: No, go ahead.

MILES O'BRIEN: All right, good, thanks. Let's do it.

JOSEPH OLDHAM: Keep the ball centered.

MILES O'BRIEN: Yup.

JOSEPH OLDHAM: There you go.

MILES O'BRIEN: Ah, it's so smooth.

The range and endurance are still pretty limited by the batteries, so I didn't get much stick time, but it felt like a magic carpet.

JOSEPH OLDHAM: Electric propulsion opens up new opportunities for use of over almost 5,000 general-purpose airports in the United States that are mostly underutilized.

MILES O'BRIEN: Nice work.

JOSEPH OLDHAM: Thank you.

MILES O'BRIEN: The company that makes this airplane is based in Slovenia. Pipistrel is a pioneer of electric aviation. Founder Ivo Boscarol started tinkering with ultralight trikes in the 1980s. He designed these electric planes to be flight trainers for new pilots.

And Joseph Oldham also has that on his mind, as well. He is waiting for F.A.A. approval to start a flight school with these planes. And he thinks reduced maintenance and no fuel costs create an opportunity to bring more diversity into aviation.

While we spoke, Instructor Chris Caldwell was giving student pilot Michael Murphy a lesson, in a conventional piston-powered airplane.

CHRIS CALDWELL: Get that nose down just a little bit. There you go, doesn't take much.

Hey, you want to try a no-flap landing?

MICHAEL MURPHY (Student Pilot): Yeah, let's try a no-flap landing. Let's see how different that is.

CHRIS CALDWELL: Yeah.

MILES O'BRIEN: They are having fun.

JOSEPH OLDHAM: They're having too much fun.

MICHAEL MURPHY: That wasn't bad at all.

CHRIS CALDWELL: That was good, man.

MILES O'BRIEN: Mike is a mentee of Joseph Oldham's. He aims to fly for the airlines one day. He hopes to be part of the first generation of pilots to begin their training in state-of-the-art electric airplanes, not 50-year-old relics that burn leaded gasoline.

Do you think electric airplanes are going to be a game-changer for making aviation accessible to a broader spectrum of people?

MICHAEL MURPHY: Definitely, definitely. You're paying 200 bucks an hour to fly one of these little old 1960 airplanes, you know what I mean? So, definitely, I think it does open up more doors for people to get their foot into aviation, at least, just, kind of, start off by flying these little airplanes.

JOSEPH OLDHAM: What we're looking at is solving a pilot shortage and then, also, opening the door for more people of color, more people from different backgrounds, ethnicities, nationalities, and that's an international issue.

MILES O'BRIEN: Two seats and only an hour of flight before the battery runs out, the Alpha Electro is a case in point of the infancy of all-electric aviation. It is a long way from this to that: a long haul jet airliner.

The flight path between the two may be wending its way through this small hangar in Camarillo, California. Here, a small startup company called Ampaire has modified a 1974 Cessna 337 Skymaster, a twin engine: one pushes one pulls.

They replaced the forward piston engine with an electric motor and added a 600-pound battery pack to the belly. It's a hybrid they call the EEL.

BRICE NZEUKOU: I think we really need to focus on dialing in the propulsion system first…

MILES O'BRIEN: Brice Nzeukou is the Director of Business and Product Development.

BRICE NZEUKOU: We strongly believe in a fully electric future, but we're waiting for regulations to develop, for technology to develop, as well, before we will see full electrification. Hybrid is the way to enter the market.

MILES O'BRIEN: They have flown dozens of test flights. The electric motor does most of its work on takeoff and the climb to altitude, then the piston engine takes the brunt for cruise and descent. Fuel costs are reduced by 20 to 30 percent, maintenance bills cut in half.

BRICE NZEUKOU: We are trying to bring this technology to market as quickly as possible. And so, we felt that going the retrofit route and starting with hybrid, as well, versus fully electric, provided a great mix of performance cost savings and our ability to get it done technically, in a timely manner.

MILES O'BRIEN: Not long after this flight test, they took the EEL to Hawaii. The company partnered with Mokulele Airlines to see how it handles commuter airline operations, with frequent flights and short turnarounds between them.

BRICE NZEUKOU: That would be really tough to do in a fully electric plane, because you would have to plug in and charge. That's why this hybrid approach for us really made sense.

MILES O'BRIEN: Ampaire is hoping the next step will look like this: a converted 19-seat Twin Otter, with electric motors that run on batteries charged by an onboard turbine engine.

SUSAN YING: Welcome to my hangar.

MILES O'BRIEN: Susan Ying is Ampaire's Senior V.P. of Global Partnerships.

SUSAN YING: These regional airplanes buy turboprops or even jets. They're not making the profit. In some of the regional markets airlines, they're going out of business, because they have very thin margin. Electric aviation is going to change that.

MILES O'BRIEN: The idea of jumpstarting electrified aviation with hybrids, just as the Prius did for fully electric cars, is gaining traction in other places; like the Dogpatch. The San Francisco neighborhood that was once home of some shipyards, is now filled with young innovators thinking big.

TERIK WEEKES: Yeah, there it is.

MILES O'BRIEN: But in this case, not too big, or so Kofi Asante hopes.

KOFI ASANTE: And what would you imagine the time before overhaul is going to look like?

MILES O'BRIEN: He is head of strategy and business development for a small startup called Elroy Air. They are focused on an unpiloted vehicle that can carry 300 pounds of payload, for 300 miles, at 140 miles per hour.

KOFI ASANTE: If it's at one warehouse and needs to be in another warehouse, but it can't get there in time, all of a sudden, enable same day delivery in a way that wasn't previously possible.

MILES O'BRIEN: Batteries alone would not do the job—the range would be limited to 30, maybe 50 miles—so it also has an internal combustion engine.

Terik Weekes is Elroy's chief engineer.

TERIK WEEKES: In order to get something to market, one, we need to focus on an unmanned vehicle and then, two, focus on hybrid-electric vehicle. This technology allows us to have a more efficient aircraft and have something that's more economically viable. Hopefully, these vehicles will eventually become all-electric, but we just don't know when.

MILES O'BRIEN: They have hover-tested this model and now are designing the next iteration. They believe it can help in the wake of natural disasters or wherever there are obstacles to getting urgent items where they are needed; like vaccines.

KOFI ASANTE: Never before has rapid delivery, especially of urgent…like medical supplies ore-commerce, been this important. It's just shot through the roof, exponentially, overnight. Our goal is to try and be a part of that solution to help us get in a better spot.

MILES O'BRIEN: But Elroy is thinking beyond delivery drones to another mission, which began with another Elroy.

MILES O'BRIEN: Yes, that Elroy. The company was, and still is, dreaming of the Jetsons' flying car.

KOFI ASANTE: We believe that there will be a time where people are likely in flying cars and flying taxis. It's hard to tell whether that's going be now or at what point in time in the future.

MILES O’BRIEN: Imagine a world filled with flying cars.

Electric propulsion might deliver the freedom of flight to our doorsteps.

[EHANG SUBS]: Attention everyone; attention everyone!

MILES O’BRIEN: In China, one startup is testing the waters on drones big enough...

[EHANG SUBS]: The craft is about to be released.

MILES O’BRIEN: …to fly people, mostly on sightseeing tours of no more than 10 minutes.

[EHANG SUBS]: Release it, release it.

MILES O’BRIEN: It is the EHang 216: 2 passengers,16 propellers.

[EHANG SUBS]: The craft is now entering its flight path.

MILES O’BRIEN: It’s not the first flight for this passenger. Edward Xu is the Chief Strategy Officer of EHang.

EDWARD XU: It’s very smooth, just like an elevator. You don’t have to be a pilot. You’re just simply sitting as a passenger, and this aircraft will take you to your destination.

MILES O’BRIEN: The company claims it can carry 485 pounds, up to 80 miles per hour, for about 20 miles. Not nearly enough capability to change the face of personal transportation, but it has proven there are people willing to try it, even without a pilot.

The company claims more than 6,000 have flown so far.

EDWARD XU: Our company is a very innovative company, we are doing something to change the world. We are doing something that nobody has done before.

MILES O’BRIEN: But they have a lot of competition. EHang is among at least 200 startups across the globe, racing to fill the skies with electric vehicles.

KOFI ASANTE: For decades, aerospace has, for the most part, stayed relatively similar. And now, you’re starting to see a lot of groups starting companies. Whether it be for smaller drones or larger cargo drones or flying taxis or cars, there’s been all sorts of movements there.

MILES O’BRIEN: Before the pandemic, I met with aeronautical engineer Mark Moore, who sparked a lot of this creative thinking. In 2009, then with NASA, he designed a concept vehicle, called the Puffin.

MARK MOORE (Aeronautical Engineer): It was a single-person, electric, vertical takeoff and landing aircraft that really opened the door to everyone's eyes of what electric vertical takeoff and landing aircraft could be. And so, we actually called the Puffin the "gridlock commuter," and that name just instantly clicked.

MILES O'BRIEN: One of the people fascinated by Puffin: Google co-founder Larry Page. Soon after he saw it, he began investing in personal electric aircraft projects.

At a ranch, south of Silicon Valley, a small team from one of those companies, Kitty Hawk, is flight testing a single-seat electric aircraft called Heaviside. The company is led by entrepreneur and computer scientist Sebastian Thrun.

He invited us for a rare peek and a slick pitch.

SEBASTIAN THRUN: This might sound crazy, but we believe it's the future of transportation for everybody. If you put the car in the air, there's no obstacle; you go in a straight line; you're not in anyone's way. You don't need roads anymore. You're more energy efficient. You're faster, you're safer. Why would people not want that?

MILES O'BRIEN: It is an electric vertical take-off and landing vehicle or e-VTOL.

The propellers pivot the thrust from horizontal to vertical, allowing the craft to take off and land on a dime and still fly 180 miles per hour.

TEST DIRECTOR: Enabled.

MILES O'BRIEN: The Kitty Hawk team is flight testing, aiming to be certified for piloted flight by the Federal Aviation Administration.

TEST DIRECTOR: Tilting.

SEBASTIAN THRUN: We've built over a hundred fully functioning prototypes in the last years. We've done almost 30,000 individual flights, and we've learned a lot. We had, of course, incidents from which we learn. Luckily, no one was ever hurt. We have always been safe. But yeah, it's been an evolution to make sure that even the weakest part of the aircraft is strong.

MILES O'BRIEN: Thrun believes the way to reconcile his big dream of a Heaviside in every driveway, with safety, is automation.

SEBASTIAN THRUN: People without a full piloting skill set and certification should be able to hop into those, punch in their target address and get there. Before that, there's many steps we have to cross, but I see no technical reason why we couldn't accomplish this with this aircraft. The reason why we do electric is we are just super quiet, like, we fly over you and you can't hear us.

MILES O'BRIEN: Sebastian Thrun is a pioneer in the development of autonomous cars. He is the founder of Google's self-driving car project. He says self-flying aircraft are an easier challenge.

SEBASTIAN THRUN: All the stuff to hit, from your bicyclist to your playing child, to your curb, to your shrub, they're all on the ground. You go up 500 feet and there's nothing to hit. And as we go through this, we've made it safer and safer and safer, in part by adding more and more redundancy.

MILES O'BRIEN: But wait, no pilot? Automation might be safer, but I'm not sure I'm ready to take the likes of Wendy Kraft out of this picture. Which brings me back to my mysterious helicopter ride to get a glimpse of its 21st century successor.

JOEBEN BEVIRT (Joby Aviation): Maybe we should step over and see how it is to sit in the aircraft…

MILES O'BRIEN: JoeBen Bevirt founded Joby Aviation in 2009. The aircraft he and his team designed is now in flight testing for F.A.A. certification. It's the current leader in the race to fill the world with electric air taxis.

JOEBEN BEVIRT: This aircraft is the culmination of a decade of research and development into how to build an incredibly safe, quiet and cost-effective aircraft.

MILES O'BRIEN: It carries a pilot and four passengers, under six tilting motors.

JOEBEN BEVIRT: It provides us an aircraft which is incredibly good at hovering and incredibly good at cruising. That efficiency and cruise is what gets us our range and gets us our speed.

MILES O'BRIEN: He says it can fly 200 miles per hour and has a range of 150 miles.

JOEBEN BEVIRT: There are four batteries in the aircraft. The batteries that we have in this aircraft, right now, are the batteries that we're going to production with, and they provide us the range and performance that we need to fundamentally transform transportation.

MILES O'BRIEN: Joby designs, tests and builds almost all the components of its aircraft, giving new meaning to the term "vertical integration."

JOEBEN BEVIRT: We developed the battery packs, we developed the propulsion systems, we developed the actuators, we developed the inceptors. Everything that you see here is something that is being developed and manufactured in-house.

MILES O'BRIEN: Much of the work was done in secret, in a barn, on a secluded property among the redwoods, in Santa Cruz.

JOEBEN BEVIRT: I wanted a place to be able to experiment and try crazy things.

MILES O'BRIEN: There's an old quarry here, where they did a lot of early flight testing. These days it is home to a circular track where they test motors for endurance.

JOEBEN BEVIRT: There were a number of years where we went through a huge amount of iteration and trial and error to learn about what were the best aircraft configurations.

TECHNICIAN: Start confirmed.

TECHNICIAN: We're at idle. I'm going to bring it to 200 r.p.m.s.

JOEBEN BEVIRT: Electric propulsion opens up a huge amount of design freedom. It allows you to think really differently about how you apply the propulsion to the aircraft.

TECHNICIAN: Thirty-one knots, thirty-three knots.

JOEBEN BEVIRT: The aircraft that you've seen is the culmination of many years of exploration.

MILES O'BRIEN: Back at the airstrip, I met chief test pilot Justin Paines, who spent years in the Royal Air Force flying Harrier vertical take-off and landing jets.

So, how much easier is this to fly, relative to a Harrier, or for that matter, a helicopter?

JUSTIN PAINES (Joby Aviation): Chalk and cheese. I could put you in it, I could stand behind you, and we could go flying. And you'd be quite capable of flying the airplane. It's that simple to fly.

MILES O'BRIEN: The goal is to have the aircraft initially certified for flight with a pilot. The aircraft has flown hundreds of times, mostly by remote control.

Obviously, you're still learning, but is it flying the way you imagined it?

JOEBEN BEVIRT: Yes, this aircraft is flying incredibly well. It's a dream come true. And we're really excited to put it into production and share it with the world.

MILES O'BRIEN: Still media wary, JoeBen Bevirt allowed us to watch, but would not let us film one of their test flight tests.

I was impressed. It is remarkably quiet, much quieter than a helicopter.

But the video the company shot and shared with us has no audio, so the only public recording of its noise signature is captured in this promo, announcing Joby is now publicly traded by merging with a special purpose acquisition company.(1)

(1) Joby entered into a definitive business combination agreement with Reinvent Technology Partners on February 23, 2021 but the transaction has not yet closed and Joby is not publicly traded at this time.

JOEBEN BEVIRT: Thank you so much.

MILES O'BRIEN: On paper, Joby was worth $6.6-billion when it went public.[2]

The company hopes to have the aircraft certified in 2023.

JOEBEN BEVIRT: We want to be comparable in the cost to the price of a taxi, at launch, and substantial…and bring that cost down to the cost of personal car ownership over the coming years.

MILES O'BRIEN: Uber spent millions developing air taxi concepts, but, in the midst of the pandemic, sold its notional flight division to Joby.

No one can accuse JoeBen Bevirt of thinking small.

JOEBEN BEVIRT: In order to have the impact that we want to have, in order to transform the way everyone moves every day, we will need to make millions of these. Our mission is to save a billion people an hour a day.

MILES O'BRIEN: A billion people flying air taxis? How could that be safe?

At NASA's Ames Research Center, in Silicon Valley, they're tackling the air traffic control challenge. That's what led me here, to the legendary Vertical Motion Simulator.

Once upon a time, space shuttle astronauts honed their landing skills here. There's nothing like it anywhere else.

Controller: Back on glide slope...

MILES O'BRIEN: And now, NASA is using it to understand how to devise a safe air traffic control system for Advanced Air Mobility.

Hey Gordon. How are you?

GORDON HARDY (NASA's Ames Research Center): Hey, great, Miles.

MILES O'BRIEN: Let's go e-VTOL flying, shall we?

GORDON HARDY: Good to see you. Yeah. Hop in.

MILES O'BRIEN: Before the pandemic, veteran NASA test pilot Gordon Hardy gave me a glimpse of the future.

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(2) Joby is not publicly traded at this time.

NICK: All right, computer's ready.

GORDON HARDY: Cockpit's ready.

NICK: Operate.

MILES O'BRIEN: So, we're over San Francisco on a nice sunny day. So, I'm trying to imagine this city with hundreds of these aircraft buzzing around it.

GORDON HARDY: Yeah.

MILES O'BRIEN: What's that going to be like?

GORDON HARDY: Yeah, yeah. And hopefully not hitting each other nor falling out of the sky.

MILES O'BRIEN: Exactly.

But the world that Gordon is helping NASA create is designed to work without pilots like him. Eventually, autonomous air taxis will need to safely fly to and from convenient places, taking off, navigating, landing and dealing with emergencies all on their own.

It's a complex problem.

BRIAN: So, we should see it bank soon.

MILES O'BRIEN: In another building, not far away, engineers are immersed in a360-degree virtual depiction of the city, watching us fly.

BRIAN: We're tracking U.A.M. 003, currently. That's the vertical motion simulator.

SANDY LOZITO (NASA's Ames Research Center): All right. Looks good. And the speed is okay?

MILES O'BRIEN: Sandy Lozito is chief of the aviation systems division.

SANDY LOZITO: We have to think about all of those vehicles being in the airspace at the same time: different performance parameters, potentially different training for the ones that are piloted, and then how do we make sure that everything stays safe?

MILES O'BRIEN: In this world, the idea of a control tower is outdated.

SANDY LOZITO: Looks like we've got the V.M.S. going up and over the bridge.

BRIAN: Yeah, that's working perfectly.

MILES O’BRIEN: Before COVID, there were more than 45,000 flights, every day, in the U.S. It’s an intricate symphony, precisely conducted by air traffic controllers. But if e-VTOLs take off, there will be a lot more players.

SANDY LOZITO: We do not necessarily expect a centralized air traffic control tower to do it, with individual directives telling the pilots how to come in and out of the vertiport. And so, that’s a very different operation. There could be much more independence on the part of the pilots and the individual operators, as they move in and out of these areas.

MILES O’BRIEN: Independence? It sounds like a prescription for disaster.

But NASA has been working on this for the past few years, on smaller drones that don’t carry people. The lessons learned writing those rules are offering them a foundation.

SHIVANJLI SHARMA (NASA’s Ames Research Center): So, these would be its operations, right? Coming in around here and landing here, on top of this.

MILES O’BRIEN: Shivanjli Sharma is an aerospace research engineer at Ames. She and her team are using data from the simulations to write the algorithms that will allow air traffic control to be digital, more automated and distributed.

SHIVANJLI SHARMA: The goal would be to share information with other operators and folks like F.A.A., to make sure that everybody in the airspace knows where one another really is flying.

MILES O’BRIEN: In flight, an air taxi would continuously transmit its location to receivers on the ground.

SHIVANJLI SHARMA: As that vehicle is flying, we’re monitoring its position in relation to that four-dimensional volume. Are they inside that volume, are they outside of that volume? Are they in that volume at the time they predicted they would be?

MILES O’BRIEN: There are many hurdles. At low altitudes, in cities, G.P.S. and cellular signals can be unreliable. And what about security? Transmitting all this mission-critical, life and death information across shared cloud networks offers its own set of risks. And there’s one other big challenge: this new air traffic control scheme needs to work safely alongside the old one.

SANDY LOZITO: If there are tubes in the sky or particular lanes of airspace in which these vehicles may transport, we know that, at some point, they’re going to be near conventional aircraft, commercial aircraft, and we have to make sure that those can work together or can complement one another.

MILES O’BRIEN: Flying cars may seem distant to most of us, but for NASA engineer Starr Ginn it’s close to home. One of the thought leaders on electric aviation, she lives in a house with a hangar, right beside a runway.

STARR GINN (NASA's Armstrong Flight Research Center): I feel so lucky, right? I get to live in a sky park and can get in my airplane to go wherever I want. This whole time, in my mind, I've been thinking, "I want everybody to be able to have what I have."

MILES O'BRIEN: On this Sunday morning she and her husband Tony, also a NASA engineer, decided to air out their ThorpT-18, a speedy little homebuilt airplane.

STARR GINN: How low can you go?

TONY GINN: There's 200, 2-0-3.

STARR GINN: Can you go lower? Woohoo!

TONY GINN: Too much fun!

STARR GINN: That's the best feeling!

TONY GINN: Yeah!

MILES O'BRIEN: Fast as their Thorp is, she knows it could do better. The wing is not optimized for speed, deliberately.

STARR GINN: Typically, a general aviation airplane's wing's designed for stall, low speed performance.

MILES O'BRIEN: The faster air moves over a wing, the more lift it provides, and the greater the surface area of a wing, the more lift it can create. So, for safety's sake, wings are made wide enough to provide adequate lift at slow speeds.

But once an airplane levels off and starts flying faster, the added lift from that fat wing is no longer needed. In fact, it's a drag, literally. The extra surface area makes the airplane less efficient. Making a wing narrower would reduce drag, but at slower airspeeds, would not create enough lift.

Electric motors offer a solution to this dilemma. They are so lightweight that they can be placed all across that narrow wing. Even at slower speeds, the extra airflow from these motors adds lift. In a way, they're tricking the wing into thinking it is flying faster.

STARR GINN: You're blowing air over those wings, as if they think they're up in the air, just cruising, at your normal speed of flight.

MILES O'BRIEN: To test out the idea, she teamed up with fellow NASA engineer and Puffin creator Mark Moore.

STARR GINN: It was a very small contingency around the NASA aeronautics centers that were this different group of, I don't know, rebels.

MILES O'BRIEN: They attached 18 electric motors, made by Joby, to a slender wing and mounted it high above a truck to avoid interactions with the vehicle and the ground.

MARK MOORE: It looked like a Mad Max truck, with a big, distributed electric proportion wing that we drove across the desert, because we couldn't afford a wind tunnel.

STARR GINN: It wasn't any spectacular kind of thing, but it got us the information we wanted. At the same time, Mark and I were getting ready for a pitch to say, like, "We should really, like, put this on an airplane."

MILES O'BRIEN: They convinced NASA brass to create the first piloted experimental, or "X" plane in more than 20 years.

It's the X-57 Maxwell. It will have 14 Joby electric motors that will test the advantages of distributed electric propulsion.

MARK MOORE: You're not dependent on a single motor or controller, but you distribute that power across the airframe, so that if any one breaks, the vehicle can still fly.

MILES O'BRIEN: Sean Clarke is now the engineer in charge of the program.

SEAN CLARKE (NASA's Armstrong Flight Research Center): Putting 14 motors on an airplane is not obviously a good idea, but we want to take the time to find out, is it reasonable to build an aircraft around that configuration?

MILES O'BRIEN: Maxwell is a modification of an existing piston-engine aircraft. The new wing is only 40 percent of the width of the slow-speed wing it replaces, a huge reduction in drag.

It will take off with all 14 motors running. Once leveled off, the 12 smaller motors will be shut down, to conserve batteries, the props folded back.

It's a challenging conversion. The wiring required for all those motors, their electronics and the instrumentation has to fit in a tight space.

SEAN CLARKE: And it's on the inside edge, too. That's going to be a little bit tricky.

TREVOR: Yes. And then, we're also concerned a little bit about the edge, right where it comes out.

SEAN CLARKE: Oh, okay.

MILES O'BRIEN: But the Maxwell team has faced even more daunting challenges than this. In 2016, they ran a test on the lithium ion batteries. They stressed them, to see how safe they might be if they failed in flight.

SEAN CLARKE: What we found is when one cell fails, it makes the next cell over get really hot and it fails, and then the next one fails, and you have a chain reaction through all 5,000 cells in the airplane, potentially.

MILES O'BRIEN: So, they reached out to NASA experts who designed the batteries used by astronauts in space. The collaboration led to a much safer battery pack for Maxwell. They hope to fly it in 2021.

SEAN CLARKE: I'm really interested in these technologies finding their way onto passenger aircraft, to transport class aircraft, someday, but we need to work up to that. This is the next step up. We want to be able to put a pilot onboard and have our pilot understand and feel the response of the propulsion system and start working toward that transport class dream.

MILES O'BRIEN: The transport class dream, carrying hundreds of passengers and tons of cargo, hinges on range, speed and payload.

For now, batteries come up short on all fronts. And while they are getting steadily better, about five percent a year, the gap is so wide, it will take at least a decade for them to catch up, if ever.

Is there a way to decarbonize aviation sooner?

In Stuttgart, Germany, electrical engineer Josef Kallo is working with a company called H2FLY. They are making airplanes that run on hydrogen.

JOSEF KALLO (H2FLY): At the moment, the most promising technology, emission-free, is to have fuel cells with hydrogen.

MILES O'BRIEN: Fuel cells generate electricity through an electrochemical reaction. Hydrogen reacts with incoming oxygen to generate electricity. That current powers electric motors. The byproduct is water. Hydrogen has three times more energy density than jet fuel and is the lightest molecule of all. But at atmospheric temperature and pressure, it's a gas, so it takes up a lot of volume. And the energy can't flow out of the cell as fast as it can from a fossil fuel engine or a battery, so there's less power available for takeoff. But it offers much more range.

JOSEF KALLO: With the technology using a fuel cell with hydrogen, from today's perspective, we can say that we can go six times to eight times longer in range.

MILES O'BRIEN: Kallo and his team have been at it for 13 years. This is his sixth generation aircraft. It has batteries to provide enough power for takeoff.

In November of 2020, Kallo says, they test flew it more than 30 times, validating a range of nearly 500 miles.

JOSEF KALLO: This will prepare the way forward, to have much, much longer-range hydrogen fuel cell electric propulsion. And then, in that step, we will have very efficient planes, a very efficient electric propulsion, and also a very long range. So, I would say, from an economic point of view 80- to 100-seater with a range of 3,500 kilometers is feasible.

MILES O'BRIEN: Almost half of all emissions from aviation come from flights of less than 2,000 kilometers, or 1,200 miles. Hydrogen could make a big dent.

JOSEF KALLO: We are definitely in a revolution in the aviation. This is very exciting, very interesting times.

MILES O'BRIEN: They are times that demand action to address the climate emergency, but this solution does not rely solely on altruism. Electric aviation can rise on its own merits, because there is green in flying green.

BRICE NZEUKOU: Air travel will be more affordable. It will come from a ton more places. Electric aviation opens up the number of airports that we can actually offer a commercial service out of.

STARR GINN: We know all the pieces that have to be put in place. It's just, how long does it take to prove the reliability of that piece and then prove each of those pieces' reliability in a system? That takes time. It's going to happen.

MILES O'BRIEN: It's like Detroit in the early 1900s: inventors racing to define what the automobile would look like, a hothouse of innovation that started and stayed in garages for years and then seemed to change the world overnight.

Those competing in the great electric airplane race are convinced a revolutionary moment like that is in the air.

Solar Impulse pioneer Andre Borschberg is still chasing the dream in Switzerland. He has retrofitted a two-seat piston-aircraft with an electric motor.

AIR TRAFFIC CONTROLLER: Runway 25 clear for takeoff.

ANDRE BORSCHBERG: Okay, let's go for a nice circuit.

MILES O'BRIEN: The company he started is called H55.

ANDRE BORSCHBERG: There is only one switch, when you get into the cockpit, here. You know, pilots, you like to be free. Here you get free from the need to use the fuel tank.

All electric, no combustion, no CO2, no pollution. When you fly electric, you don't want to go back to combustion engine. It's so convincing that you say, "Now, I want to continue with this technology."

TERIK WEEKES: Electric motors are at a certain point today, the battery systems are at a certain point today, we're within that edge of possible where we think things will mature a lot quicker.

ANDRE BORSCHBERG: You cannot do everything in one day. But if we don't start today, we will not be ready in 10, 15 years, to be totally clean.

KOFI ASANTE: It almost feels like there's some part of the future that we think about as like, "At some point in time, this is inevitable." And now, we're all just mapping out the plan to try and to get there.

ANDRE BORSCHBERG: It's fantastic, eh? No vibration, little noise. It's the future.

IMPORTANT LEGAL INFORMATION

Forward Looking Statements

This document contains certain forward-looking statements within the meaning of the federal securities laws with respect to the proposed transaction between Reinvent Technology Partners ("RTP") and Joby Aero, Inc. ("Joby Aviation"). These forward-looking statements generally are identified by the words "believe," "project," "expect," "anticipate," "estimate," "intend," "strategy," "future," "opportunity," "plan," "may," "should," "will," "would," "will be," "will continue," "will likely result," and similar expressions. Forward-looking statements are predictions, projections and other statements about future events that are based on current expectations and assumptions and, as a result, are subject to risks and uncertainties. Many factors could cause actual future events to differ materially from the forward-looking statements in this document, including but not limited to: (i) the risk that the transaction may not be completed in a timely manner or at all, which may adversely affect the price of RTP's securities, (ii) the risk that the transaction may not be completed by RTP's business combination deadline and the potential failure to obtain an extension of the business combination deadline if sought by RTP, (iii) the failure to satisfy the conditions to the consummation of the transaction, including the adoption of the Agreement and Plan of Merger, dated as of February 23, 2021 (the "Merger Agreement"), by and among RTP, Joby Aviation and RTP Merger Sub Inc., a Delaware corporation and a direct wholly owned subsidiary of RTP, by the shareholders of RTP, the satisfaction of the minimum trust account amount following redemptions by RTP's public shareholders and the receipt of certain governmental and regulatory approvals, (iv) the lack of a third party valuation in determining whether or not to pursue the transaction, (v) the inability to complete the PIPE investment in connection with the transaction, (vi) the occurrence of any event, change or other circumstance that could give rise to the termination of the Merger Agreement, (vii) the effect of the announcement or pendency of the transaction on Joby Aviation's business relationships, operating results and business generally, (viii) risks that the proposed transaction disrupts current plans and operations of Joby Aviation and potential difficulties in Joby Aviation employee retention as a result of the transaction, (ix) the outcome of any legal proceedings that may be instituted against Joby Aviation or against RTP related to the Merger Agreement or the transaction, (x) the ability to maintain the listing of RTP's securities on a national securities exchange, (xi) the price of RTP's securities may be volatile due to a variety of factors, including changes in the competitive and highly regulated industries in which RTP plans to operate or Joby Aviation operates, variations in operating performance across competitors, changes in laws and regulations affecting RTP's or Joby Aviation's business and changes in the combined capital structure, (xii) the ability to implement business plans, forecasts, and other expectations after the completion of the transaction, and identify and realize additional opportunities, and (xiii) the risk of downturns and a changing regulatory landscape in the highly competitive aviation industry. The foregoing

list of factors is not exhaustive. You should carefully consider the foregoing factors and the other risks and uncertainties described in the "Risk Factors" section of RTP's registration on Form S-1 (File No. 333-248497), the registration statement on Form S-4 discussed below and other documents filed by RTP from time to time with the SEC. These filings identify and address other important risks and uncertainties that could cause actual events and results to differ materially from those contained in the forward-looking statements. Forward-looking statements speak only as of the date they are made. Readers are cautioned not to put undue reliance on forward-looking statements, and RTP and Joby Aviation assume no obligation and do not intend to update or revise these forward-looking statements, whether as a result of new information, future events, or otherwise. Neither RTP nor Joby Aviation gives any assurance that either RTP or Joby Aviation or the combined company will achieve its expectations.

Important Information for Investors and Stockholders

This document relates to a proposed transaction between RTP and Joby Aviation. This document does not constitute an offer to sell or exchange, or the solicitation of an offer to buy or exchange, any securities, nor shall there be any sale of securities in any jurisdiction in which such offer, sale or exchange would be unlawful prior to registration or qualification under the securities laws of any such jurisdiction. In connection with the proposed transaction, RTP filed a registration statement on Form S-4 with the SEC on April 2, 2021, as amended on May 14, 2021, which includes a document that serves as a prospectus and proxy statement of RTP, referred to as a proxy statement/prospectus. A proxy statement/prospectus will be sent to all RTP shareholders. RTP also will file other documents regarding the proposed transaction with the SEC. Before making any voting decision, investors and security holders of RTP are urged to read the registration statement, the proxy statement/prospectus and all other relevant documents filed or that will be filed with the SEC in connection with the proposed transaction as they become available because they will contain important information about the proposed transaction.

Investors and security holders will be able to obtain free copies of the registration statement, the proxy statement/prospectus and all other relevant documents filed or that will be filed with the SEC by RTP through the website maintained by the SEC at www.sec.gov.

The documents filed by RTP with the SEC also may be obtained free of charge at RTP's website at https://www.reinventtechnologypartners.com or upon written request to 215 Park Avenue, Floor 11 New York, NY.

Participants in the Solicitation

RTP and Joby Aviation and their respective directors and executive officers may be deemed to be participants in the solicitation of proxies from RTP's shareholders in connection with the proposed transaction. A list of the names of the directors and executive officers of RTP and information regarding their interests in the business combination will be contained in the proxy statement/prospectus when available. You may obtain free copies of these documents as described in the preceding paragraph.