SCOTTISH MORTGAGE INVESTMENT TRUST

Joby Aviation: the Uber of the skies

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Paul Sciarra (PS): Flying cars, the sort of Jetson future that has been talked about for a while, it is happening right now.

Tom Slater (TS): I think it's just really exciting to see this idea from science fiction becoming a commercial reality.

PS: We will have quick, safe, quiet, green aerial transportation in many large cities and smaller cities around the world.

TS: It's such a universal need, that it's an enormous market if they can get it right.

Claire Shaw (CS): Hello and welcome to season two of Invest in Progress. I'm Claire Shaw, a director and investment specialist in the Scottish Mortgage Team. In this podcast we aim to take you behind the scenes to hear the conversations that take place between the Scottish Mortgage managers and the visionary leaders of some of the world's most exceptional growth companies.

As we are a UK investment trust, we can only market Scottish Mortgage to certain audiences and in certain jurisdictions. Check out the podcast description to ensure this content is suitable for you. And, as with any investment, your capital is at risk.

You may be listening to this podcast in the car, on a bus or in a taxi, struggling through a congested commute. And we know that road vehicles are a massive contributor to pollution in city centres. What if there was a way to reduce urban congestion and provide an alternative mode of transport which is greener, quieter and quicker.

Welcome to Joby Aviation, a company at the forefront of transforming the way we travel. Joby has developed an electric aircraft that it plans to operate as a commercial taxi service in the sky.

And today we will be joined by Paul Sciarra, the Executive Chairman of Joby. Before we welcome Paul, I'm here with Scottish Mortgage Manager, Tom Slater. Welcome, Tom.

TS: Thank you.

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CS: A few of our listeners might be thinking right now, are we talking about flying cars here? This sounds like something from a sci-fi film. How should we think about this company? When I think about Joby, my frame of reference is almost this 'Uber of the skies'. Am I on the right track here? How would you describe this company?

TS: Well I think in a way we are talking about flying cars. I think it's just really exciting to see this idea from science fiction becoming a commercial reality. What we're talking about in modern parlance is eVTOLs or electric vertical take-off and landing aircraft.

And what they're doing is basically taking the confluence of a number of technology trends and using it to enable a completely new form or transportation, which has the potential to deliver on the promise of the helicopter but that the helicopter failed to deliver on for a number of reasons, one of which is that they're extremely loud and it makes them very impractical to operate in urban areas.

And the other of which is that you have these pieces of metal flying around at about head height at hundreds of miles an hour, which people find very scary and off-putting. And I think the eVTOL form factor addresses those big shortcomings of helicopter aviation.

CS: Great. Well, Tom, after your chat with Paul it will be your turn to be in the hot seat. I'll be asking you a bit more about our investment case for Joby Aviation but until then I'll hand over to you and Paul.

TS: Thanks, Paul, for joining me.

PS: Wonderful to be here, Tom. Thanks a lot for making the time too.

TS: It's certainly not quite as nice a setting at the last time we spoke. It was a nice summer's afternoon in Idaho.

PS: Yes. We'll make this do nonetheless.

TS: For the listeners that don't know, can you tell us what is Joby Aviation?

PS: So Tom, Joby is the leading developer and soon operator of all-electric vertical take-off and landing aircraft. You can think about these as aircraft that take-off and land like a helicopter but fly like traditional aircraft. Fully electric, in terms of both its propulsion and its energy, delivering quiet, fast and green aerial transportation for trips anywhere between zero and a hundred miles.

TS: Before I ask more about the company, can we focus on you for a minute? People might be surprised by your unconventional route into Joby because in 2008 you co-founded Pinterest, a software company, consumer internet company. You were President and CEO there for a long period of time. And then, in 2014, you

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became Executive Chairman of Joby. What sparked your interest in Joby? Talk us through that journey.

PS: The timeline of Pinterest, Ben and I founded that company back in 2008 and I was obviously very excited about the trajectory the company was on but knew at some level that there was other things for me to do. And just around that period it was the moment just before the launch of the Model S, where I think Tesla was showing what was possible with electric vehicles on the ground.

But the question for me was what other areas of transportation have the opportunity to be impacted by that? And maybe one of the obvious leaps was to aviation. But it felt like an important moment in terms of this big shift and this felt like an important white space that at that point was not being sufficiently explored. And I think that was really the spark of the interest that I had in the category.

Surveying the market at that point, there were not many folks that were working on this. It is only now, ten years after, that there are a large number of companies that are working on the category, but it was very much a backwater.

TS: What about for you personally. You'd come from being based in downtown San Francisco working in a high-velocity software company to, you're out in the sticks working on this project that was ten years to become a reality. That must have required really quite a big mindset shift.

PS: Yes, it certainly did but in many ways, from a very personal standpoint, I think it was a good thing. It is very easy to essentially fall into recreating what you've done before and I can say that for me, I nearly did it. I had an idea for another consumer internet company, a small team. I was sort of ready to go on that. But it felt for me that would have been in many ways fighting a battle that I'd already fought. So there was something both challenging but also very exciting about taking on something that was very different.

TS: What was the problem that you saw Joby was trying to solve?

PS: I think you can take that on two different levels. On one hand it was can you build an interesting, that is interesting for consumers, fully electric aircraft? And then the second question is how could you ensure that it was delivering real value to end consumers on the other side?

The question that we pushed was, 'Let's think about something that can have even wider applicability' but that would in turn mean an aircraft that had a pilot on seat, in turn a number of passengers sitting behind and could be used for something that looked a lot like an aerial Uber.

I should add that when we think about what Joby aircraft can deliver, it's about getting people to where they want to go faster. And one of the fundamental

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problems, at least in the developed world making that happen, is an inability to build new infrastructure, new bridges, new roads, new tunnels. The costs are astronomical, whether it's here in the US or in Europe.

So one of the promises of aviation as a sector in terms of electrifying is that it doesn't require that same fixed ground infrastructure that has been so difficult to build. That's why if felt like an important area to focus on, both in terms of its impact by this change to electric and also its ability to deliver something that was really differentiated from a transportation standpoint.

TS: Can we go back to those very early days when you joined? I think there were five employees at that time. You were working in the mountains near Santa Cruz. Just tell us a bit more about that time, the challenges that you faced as you started to build the company from the ground up.

PS: Before I get to the challenges. I will say the benefits. We had a small and very passionate team that had already done some very ground-breaking work in many of the components that have been necessary to build this aircraft over time. So the technical grounding of the team was really strong.

I think the big question at that point and certainly some of the key challenges were, one, what is the right form factor? How do we make the right progress against our eventual end goals to credibly de-risk it and in turn fund the business over time? And those were some of the things that I think were the biggest challenges.

Going to electric not only has an opportunity to reduce operating costs, obviously limit the carbon footprint, reduce the noise of aircraft, which is critically important for getting high-frequency, high-density operations in and around cities, but it also allowed for aircraft designs that simply were not possible when you started with a turbo.

TS: For our listeners that are struggling to visualise what the aircraft looks like, can you just talk people through what the product looks like, how it works?

PS: Sure. The fundamental design is something called a tiltrotor. Maybe the closest equivalent is the military aircraft, the Osprey, the V-22. But our aircraft is different from that. It is a fuselage with a wing and then six propellors distributed, two on either wing and then, in turn, two on the tail. Those translate from 90 degrees, so upward-facing during take-off and land, and then tilt down to zero degrees as it moves from vertical take-off and landing mode to forward flight configuration.

We knew that in order to get to ranges that were interesting from a consumer standpoint we would have to take on some of those technical challenges of transitioning and that was part of the reason, Tom, why we were careful in the early days to work through subscale versions and then an initial full-scale version to ensure that we had the right aerodynamics and, in turn, the right controls to

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make that transition not only possible but comfortable for passengers that would be seated in the aircraft.

But I take a lot of comfort in the fact that now, ten years later, the vast majority of the companies that are thinking about this space, both big and small, have in many ways converged on the same sort of aircraft that we started with ten years ago.

TS: Let's talk about that perspective of the passenger. If I land at JFK Airport in New York it's gridlock. How do I book a Joby air taxi? Where do I go? How long will the journey take?

PS: That was actually, you can call it a hero route, one of the critical routes that we had in mind from the very beginning, so it's an absolutely great example. Let's imagine you're getting off your Delta flight. You may have already booked, in conjunction with your commercial flight, your trip on a Joby from JFK to Manhattan, in turn to your hotel.

You get off the Delta flight. You're directly on to your Joby vehicle. We're flying the ten minute, ten mile flight to Manhattan and there's an Uber car waiting at the vertiport location to take you directly to your hotel. We want to try to build something that is really seamless between these different modes of transportation because that's the thing that is going to save passengers the most time and deliver the most value.

TS: You're going to be flying these vehicles over highly-populated areas. What does the safety profile look like of the vehicle? Should people be worried about the deployment of this technology?

PS: We started with safety as the number one goal and it began actually with the overall aircraft design, Tom. The reason for six propellors is to create redundancy, a redundancy that you don't see in the V-22, for example, or certainly with helicopters. We wanted to ensure that there were zero single points of failure. In forward flight configuration as many as four of those propellors can fail and you can still maintain nominal flight.

But maybe the broader question of not just certification but public acceptance was also on our mind too. So we tried to design the aircraft to have touchstones that felt familiar to people, so car-style doors instead of traditional helicopter-style doors. It feels like getting into and out of an SUV as opposed to climbing over the wing of a small aircraft. We wanted to give people a sense that this was something familiar, even it was obviously something that was very unfamiliar in terms of what it could actually deliver.

TS: Could you talk about where in the world you might start to deploy this first? And then the other question that the example prompted for me is this going to be

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an expensive luxury for first class air passengers coming into JFK or where do you see the demand coming from?

PS: To your question on markets, this has been a key focus of the company, especially over the last year as we get closer and closer to FAA certification, as we've begun to actually scale production. Now a lot of our attention has been shifted to 'What are the right markets to commercialise in? How do we build the right route network? And what are the right partners in those cities to make it as successful as possible post-launch?'

We haven't named individual cities yet but we have indicated that we are very much focused on New York, LA and South Florida, here in the US as some of the first potential markets for the service for reasons that will probably be obvious to your listeners, significant density, lots of traffic and an opportunity to deliver significant time savings to consumers from day one.

To your second question, Tom, on cost, we designed the aircraft specifications with a pretty simple equation. We wanted to maximise the number of passenger seat miles that we could deliver per given unit of time. That pushes us to an aircraft that has greater capacity than the two seats that we may have started with, so four passengers, a faster speed and minimal charge time.

Those are the ingredients that get you the highest passenger throughput and what that does is it allows you to amortise your fixed and variable costs over a larger number of seats and drive down the cost point over time. All that said, we do expect that in the early days we're going to be aircraft limited and it will probably begin as a premium service or at least premium-wise relative to ground transportation.

But we tried to be thoughtful that through manufacturing scale, through operational efficiencies in each individual market we'd be able to drive that price point down over time to get to something that was progressively more affordable to larger and larger numbers of people. But even from day one you should consider this as something that is probably in order of magnitude cheaper than a helicopter.

TS: And you've made phenomenal progress with the aircraft. What about the infrastructure that you need to support a commercial service? What do you need to build? What are the opportunities and challenges there?

PS: We designed the aircraft to fit in essentially the same area as a helicopter today, so we can take advantage of helipads that may already exist in the cities that we start to operate from day one. At the same time, we've begun, in conjunction with both regulators and commercial real estate partners, to work through the provisioning of new infrastructure that would densify a network beyond the existing helipads that are already out there.

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And one of the things that we have going for us, Tom, in that effort, is that we spent a lot of time on this aircraft to ensure that it was very quiet. That's 100 times quieter than a helicopter at flyover, ten times quieter during take-off and land. And the reason why that's important is that the biggest gate to getting new helipads approved in various cities is mostly around the noise. All of the effort in New York to limit helicopter operations has been driven by community disturbance around take-off and land.

We knew that we would have to build a far quieter vehicle to get community acceptance for new vertiports and we've now, through more than 10,000 flight tests, proven what this noise profile looks like. So that has really changed the dynamic of our conversation, both with partners on the real estate side for new infrastructure and with the local regulators that would have to support them.

And it certainly strikes many people as strange to be both an aircraft manufacturer and an aircraft operator but there actually are important historical analogues to that. In the very early days of aviation, the beginnings of commercial aviation, Boeing owned United and was the manufacturer but also the operator of those vehicles and it was only a strange antitrust suit back in the 1940s, when they were getting government subsidies for airmail, that broke apart the manufacturers from one side and the operators on the other.

But in the very early days of new product introduction a higher level of vertical integration may be important because there may not be an operator that can operate this vehicle in the right way. There are pieces of it that need to be put together to make that work and we wanted to make sure that we designed the company and designed the approach to at least some of these markets to ensure that from day one.

Again, Tesla analogues are always a little bit tricky but you can think about it as the same way that Tesla not only built their first vehicles but also had to build a charging network in order to deliver the right value proposition to consumers on the other side.

TS: With any new technology there are always hoops to jump through, whether that's climate or around regulatory approvals. Can you just talk us through the process from a regulatory perspective?

PS: In order to fully operate these aircrafts, here in the US and around the world, there are three pieces to the certification. One, the type certification of the aircraft. Second, the production certification of the facilities that they're produced in. And then, third, the operational certification.

We knew from a very early stage that we would have to achieve each of those goals to get to a final service and we had the advantage of beginning the conversations with the FAA very early in the programme. So we had lots of

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opportunity to work with them to get to a final rule set that we could then build and, in turn, test against. And it has helped, in turn, that this category that has variously been called urban air mobility or advanced air mobility has gotten more and more attention out of DC.

It was at one point a backwater that folks were not concerned about but now I think they see that we're at a pivotal moment in aviation, in moving from combustion vehicles to, now, electric aircraft. And they feel, whether it's on the executive side, whether it's on the congressional side, that ensuring the US is a leader in that next revolution is important. So we've been getting a lot of lean from all the right places to help ourselves move as quickly as we can through each of those pieces of certification.

I think the environment now, from a regulatory standpoint, is actually better than I have ever seen it, in part because this category has gone from a backwater that people were happy to dismiss to now something that feels critically important in the US and the developed world for the future of aviation and has both geopolitical and geoeconomic significance.

TS: Could we touch on your partnership with Toyota? They've been there with you from the early days. How are they helping you? Why is that partnership important?

PS: It began, as you noted, quite a few years ago before the company became a public company with what I think is still the largest automotive investment in an eVTOL company anywhere in the world by multiples. And alongside capital, they were also very excited and have delivered on real assistance in the design and scale-up of the manufacturing programme for the aircraft.

We have more than 30 Toyota engineers that are shoulder-to-shoulder with our manufacturing engineers at our facility here, in California. We recently made an announcement around our next scale production facility in Ohio. They will be shoulder-to-shoulder on both the design and execution of that effort.

And the reason why it is important for us is that when we think about volume for these aircrafts, we are starting now with a pilot facility that can do tens of aircraft per year. The next facility is designed for hundreds of aircraft per year. At hundreds of aircraft, that is already one of the highest volume production ramps of any aircraft in aviation history, maybe absent when they were rolling them off the manufacturing lines in Detroit around World War Two.

So we need to think about production processes and production approaches that are closer to low-volume automotive as opposed to high-volume aviation from day one. So they've been a wonderful partner in this effort and we think there are opportunities to really deepen that relationship over the long arc as we get to higher and higher volume production in time.

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TS: I think our listeners will be listening to this and thinking this is science fiction, flying cars. How long are we going to have to wait for this? But you've recently reached this really important milestone of actually delivering the first aircraft. Talk to us about that and what it signifies.

PS: We delivered the first aircraft to our first customer, which is the US Air Force, at their facility at Edwards Air Force Base close to Mojave here, in California. That is a critical milestone for Joby and we think actually the industry as whole, as it marks the first eVTOL aircraft delivery to a customer anywhere in the world and it is a critical piece of showing the public that, yes, flying cars, the Jetson future has been talked about for a while but in fact it is happening right now.

Over the course of the next 12 months, you will see more and more aircraft not just doing testing at our facility but out there operating in the real world against missions that are important to that particular customer. And that's really important for Joby because we're going to learn many of the things that we need to learn for commercial service well ahead of actually having to execute on it. And I think it's also going to be really important for the broader public to say 'This is coming, it's working and they should expect it in their town relatively soon'.

TS: We've talked about the early days, the product development, the regulation. As we come to a close, let's take a step back. You are a pioneer in this industry. What are the lessons you've learnt from pioneering an industry that other entrepreneurs might get value from?

PS: I think one of them is what we touched on, which is that every overnight success that people hear about often has a longer backstory than people appreciate. There is a lot of work before it reaches public consciousness that is often forgotten in the eventual winners of companies. And at least from an entrepreneur's standpoint, whether it's with Pinterest, in turn whether it's with Joby, it's important to prepare yourself for a long time of working in relative obscurity before any success, if you're lucky enough to have it. That is certainly, I think, an important lesson to take away.

I think in terms of this industry in particular however, it was really valuable for Joby to have a long period of time to build successive versions of this aircraft before we've landed on the vehicle that we're now certifying and beginning scaled production of. It is very difficult when you're building something brand new to get everything right and we benefitted greatly from almost ten years of careful iterative development across this aircraft. And I don't think it would have been easy to do it any other way.

TS: Paul, we ask all our guests the same final question and I think for Joby it's actually particularly relevant. What does the world look like if you succeed in delivering the company's mission?

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PS: I think we will have quick, safe, quiet, green aerial transportation in many large cities and smaller cities around the world if we're looking out ten to 15 years. You will be able to do that trip from JFK to Manhattan in ten minutes instead of the hour and a half that it might take you. And you will be able to get to places far more easily, like Northern New Jersey to Connecticut, at speeds that are not possible right now given cars on the ground and ground infrastructure as it currently exists.

But scoping up, we think of the future of transportation as one that really has three characteristics. First, it is increasingly electric or green. Second, it is increasingly on demand and I think you've already seen that move in ride sharing and other things. And, three, it is multimodal. It's about getting you the right vehicle for the trip that you're taking. Maybe it's a car. Maybe it's a scooter. Maybe it's a Joby aerial vehicle or a series of those stitched together. And those three things I think are the real promise of the future of transportation. A way to get people to where they want to go faster, greener and with just the right mode of transportation that they need at that given moment.

TS: It's a vision which I think is going to touch everybody's lives over the coming decade and I think it's just so exciting what you've managed to achieve so far in this journey. Thank you so much for joining us today. It has been fascinating.

PS: Appreciate it, Tom. Thank you so much.

CS: I think after your conversation with Paul there, Tom, our listeners are going to have quite a different perception of what electric air taxis are and how close to reality we are in this industry.

TS: Yes. I always learn something when I talk to Paul and hopefully it was interesting for our listeners as well.

CS: In this season we're going to finish off each episode by asking the managers the same five questions about their investment case. Tom, I think the first question that will be of interest to our listeners is how did you actually come across Joby in the first place?

TS: I have a colleague based in San Francisco. It came from some of the work that he did. So thank you to Chris Evdaimon. And I think another part of it, in terms of thought process, is if you look at some of the trends that have enabled Tesla, as one of our big winners of the past, then from a mindset point of view it takes you to what other products and industries could that transform? And the other thing is following some of the people that started in that organisation that have then gone on to do different and interesting things at other companies.

CS: Talking about people, we talk a lot about the importance of the leadership of companies, the vision, the ability to almost drive companies towards that

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opportunity. From your perspective, what is it about Paul that makes him special, have those characteristics that you really look for in our investment cases?

TS: I think what Paul had when he came to Joby is successful entrepreneurial experience. He'd been part of the founding team of Pinterest. He'd taken on some of the challenges that went with that business. And he didn't have to get back into the market and work on building another business but he had that drive and he had the experience of doing it the first time round. He was ready for an even bigger challenge. And so I think that's part of what makes it special.

Another part of it is the chemistry of the broader team, whether it's the people in engineering, the people in operations who combine those different skills that you need to get an undertaking like this off the ground.

CS: Paul referenced there's a number of players in this market but Joby really seems to be at the forefront in terms of that path to commercialisation. What is it about Joby? What is its competitive edge, do you think, that they have over others?

TS: I think it's a combination of a number of things. Being early. He talked about this idea that were an overnight success after ten years. So they were one of the first players in this. I think working closely with the regulators is another, to understand 'what is the path to certification?' because that is a really challenging and important piece to get right.

But I think there's a number of other factors that are also quite intangible but really important. The approach to raising capital. This is a really capital-intensive undertaking. How do you think about capital raising, both as a private company but then transitioning into the public markets? How do you get the partners in to provide the right capital? How do you get the experience in, both in the operating team but also the partnerships that they've had, whether it's with Toyota or Uber or Delta Airlines? So it's all of those things.

Then maybe a final one to add is working with the Department of Defense. If you're on the path to a consumer product but it's going to take you a long time to get there, what are the ways that you can deploy the technology, test, learn, iterate before you get to that FAA approval stage?

CS: And I think the next step from there is with all of our investment cases there are naturally risks and challenges. What do you think is the most significant challenge that Joby has to overcome and how well placed do you think they are to overcome the challenges that they may face in that path to seeing them operating in the skies above New York?

TS: There's a number of challenges but I think the first and obvious one is around safety and certification. They have to have a product which is safe and is certified to be safe and that is a huge undertaking in the modern aerospace industry and it's existential. If they don't get that right they will fail.

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From a business perspective I think one of the big challenges is that they've had a singular focus or almost a singular focus since the inception of the business, which is to create this aircraft, to design, find a way to manufacture and get certified this aircraft. But over the next small number of years they have to pivot. The goal changes completely, which is 'How do you manufacture this at scale and then how do you operationalise it?'

So you've got to see this transformation within the business from focusing on design and development to scale-up and operations and I think that, for me, is the big challenge over the next five years.

CS: Then, Tom, maybe just a final question. We talk a lot about the purpose of Scottish Mortgage is to identify, own and support the world's most exceptional growth companies, that is what we're trying to do. How is the scale of the opportunity for Joby? How big could this be?

TS: If you think about the number of passenger journeys that happen in modern cities and the amount of time that's lost to congestion. If they can drive down the cost of transportation from this mode of transport and the efficiency that it might bring, if you think about how long the journeys are, how many passengers you might have on each journey, what the cost per mile might be, you very rapidly get into an opportunity that's worth billions, tens of billions. So I think it's such a universal need that it's an enormous market if they can get it right.

CS: Perfect. Thanks, Tom.

So that just leaves me to say a huge thank you to our guest today, Paul Sciarra of Joby.

Next up, we welcome the CEO of Moderna, Stéphane Bancel. Moderna is best-known for developing a Covid vaccine, and being instrumental in getting the pandemic under control. Many might think this company is a one-trick-wonder, but tune in to hear how their technology could cure the most problematic viruses affecting human health worldwide. Moderna is the company we get asked about more than any other right now so this is one you will not want to miss.

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