Battery Caffé - Batteries in Aerospace - Transcript

Innovate UK.

Hi. Welcome everyone to this new episode of the Battery Caffe, focusing on Batteries in Aerospace. I'm Debra Jones and I'm part of the Chemistry and Industrial Biotech Team at Innovate UK Business Connect, and I'm hosting today's episode alongside my colleague Silvia Boschetto.

Oh, hi everybody. So, my name is Silvia Boschetto, and I look after batteries within the Clean Energy and Built Environment Team at Innovate UK Business Connect. It's great to be here today at the Battery Caffe, and we're looking forward to the conversation today. Now, just as a quick reminder, the Battery Caffe is an initiative of the Cross Sector Battery Systems Innovation Network, a community funded by Innovate UK Business Connect and the Faraday Battery Challenge. The Innovation Network aims to open new markets for the battery industry and promote lots of innovation in batteries and help to decarbonise, from a wide range of end users.

Thanks, Silvia. And today, we're lucky enough to be joined by three guests, Kate Cooke from Collins Aerospace, Jacqui Castle from the Aerospace Technology Institute, and Jack Nicholas from Qdot Technology. Welcome and could each of you briefly introduce yourself and explain your current work in relation to Battery Technology in Aerospace?

Hello and thanks for having me on, my name's Kate Cooke. I'm the Senior Manager for Energy Sources at Collins Aerospace, which is part of RTX Businesses. I'm based at Collins facility in Solihull, where I work on the battery system development. Prior to joining Collins, I spent the last 25 years working in automotive, so a very different kind of field from aerospace but I'm so excited to be joining aerospace at this point. I've worked previously at Nissan and at Jaguar Land Rover, where we were developing electrified propulsion systems for vehicles, and with the rise of hybrid electric and clean aviation, it's a great time to join this team and to be part of the propulsion architectures for aircraft. And, these high voltages, the different systems, and that's exactly what my team are working on at Collins.

Brilliant, thanks. And Jacqui, do you want to go next?

Yeah. Hi there, everyone. I'm Jacqueline Castle. I'm CTO at the Aerospace Technology Institute. It's really great to be here. So, thanks for the invitation. I'm accountable for defining the UK Aerospace Sector Technology Strategy, which has roadmaps for technology research needed to grow the UK aerospace sector and deliver more sustainable flights in line with net zero 2050 goals. So, the ATI funding program enables world class UK research and batteries are one of the many technologies that are of interest.

Great. Thank you. And last, but by no means least, Jack.

Hi Debra. Yep, thank you. Thank you for introducing me. So yeah, I'm Jack Nicholas, CEO and Co-founder of Qdot Technology. We're a spin out from the University of Oxford that's developing emission free powertrains for aviation. My background is more academic based, so I spent a lot of my career in academia working on jet engine technology with companies like Rolls Royce, and kind of have a particular passion, and I guess, background in heat transfer and thermal management in particular. So I really founded Qdot with the idea of trying to, I guess, accelerate the industry's transition from being based on fossil fuels, primarily at the moment, to a cleaner future.

Thank you so much for all those introductions now to all our listeners, please make yourself a coffee and sit down and join us as we talk about battery trends, opportunities, solutions in aerospace. One of the primary ways that the aviation industry is working to reduce carbon emissions is through the application of hybrid electric propulsion systems in future aircraft. These architectures, they really have the potential to reduce the emissions by millions of metric tons of fuel when implemented across an entire fleet. It's kind of similar to those electric cars and hybrid electric aircraft, they'll continue to have traditional fuel burning engines, but with electric motors and generators and battery systems on top of those systems to reduce the fuel burn on takeoff and landing. RTX hybrid electric propulsion is a major focus. And Collins is collaborating with our sister business, we have Pratt and Whitney working on multiple demonstrator programs as part of that, we're leveraging all of the legacy that we have within Collins, within Pratt and Whitney, and with the whole RTX business to really develop and supply all of this technology to this emerging market. We are working on power systems, on electric motors for all different hybrid applications, from mild hybrid through to quite a large hybrid system in electric aircraft. In order to do that, we're working on high voltage battery systems that we're developing, and we're required to produce hundreds of kilowatts in today's aircraft to the megawatts of the aircraft of the future. So, batteries have a really integral role to play, and we're studying how we can do that and a large part of that is also how we get them ready for certification and how we meet that critical need of ensuring that we meet the regulatory requirements of the battery systems for the future passenger.

Thanks, Kate, that's wonderful to get that from a big picture view because that's a very broad, broad area that you've given us a context with. And I'm just wondering, Jacqui, you know the ATI, you've been doing lots of roadmaps and lots of technology roadmaps around low emissions in aircraft and zero emissions technologies. Can you talk us through some of the highlights?

Yes, our technology strategy is destination zero. So that's got three roadmaps, including one on ultra efficient technologies and another on cross cutting enabling technologies. But the one that you're sort of alluding to and for this discussion is the zero carbon road map and that captures the propulsion systems and structures developments that are needed to enable aircraft to have zero carbon tailpipe emissions. So, included on the roadmap are batteries, hydrogen, combustion and fuel cell technologies. So, in terms of batteries, though, I consider that there are two potential avenues to develop the technologies. And firstly, and it's probably the one that's more talked about, is to use the batteries to power smaller eVTOL or sub regional size aircraft. So, the current weight of battery packs and therefore their specific energy capability negates the opportunity to scale beyond this size without having significant development in the fundamental battery chemistry. So, in this category, one of the highlights in the UK is the work that Vertical Aerospace is doing under their ATI funded category enhanced battery development project. So, they're working to develop the design and manufacturing and qualification capabilities that are needed to enable the UK to have a competitive production of primary propulsion battery systems. So, Vertical's focus is not on the cells of the batteries themselves, but on integrating the existing high grade, mass produced cells into highly sophisticated battery packs, which are then designed specifically to address the stringent safety needs that you would have for obviously, an aerospace application. But the second potential application of batteries for aerospace is much as Kate has just mentioned, and that's to utilise them as complimentary power sources in hybrid propulsion systems or on more electric aircraft applications, and that can then apply to larger commercial aircraft. So, this offers the potential to more efficiently size the gas turbine engine and reduce fuel burn and thus reduce carbon emissions. So, these applications also have a lot to overcome, especially in terms of the battery energy density challenge, as mentioned. But in addition, there will be other requirements necessary, such as those related to the higher altitude operations. So, there are many aspects that we're looking at on the road maps and on the cell technologies themselves. The Faraday Institution is the UK Independent Institute for electrochemical energy storage research and all of the sort of early stage commercialisation activities. And their research program is really focused on optimising the performance of lithium-ion technologies, as well as exploring new battery chemistries beyond lithium-ion so the ATI is regularly engaging with the Faraday Institution to inform them of the battery technology requirements for aerospace. So, there's really lots of different applications that we're working on at the moment. It's great.

Yeah, thanks for that, Jacqui. And I think it's really good to get a better understanding of how the UK aerospace industry is working on trying to achieve the net zero, 2050, target. And I think the other thing that you've highlighted is a lot of the examples of where we're looking at applications coming through. So, thank you very much for all of that.

Yes, thanks Jacqui. It's really clear that the sector's going through a period of really disruptive innovation, with advances in engineering technologies and technique that's allowing us to get more efficient product development but it's also opening up the sector, so a new range of technologies and lots of startups in the space. So Jack, Qdot Technology is known for its advanced thermal management systems in battery packs. And can you explain to us a little bit more detail around why thermal management's so critical, particularly in aerospace applications, and how Qdot addresses those challenges?

Yeah, sure. I guess I'll take a little step back and kind of lead into that, if that's okay. I'll pick up a little bit on some of the things that Kate and Jacqui mentioned. So, I think, one of the key things for listeners to understand when we talk about batteries and aerospace is there's lots of different combinations of powertrain technology. So, there's all battery solutions, as have been mentioned, that kind of typical air taxi. There's hybrids, but there's different flavours of hybrid. So there's hybrids that use combustion systems and there's hybrids that use fuel cell systems. And so, we're in that latter category, so we focus on battery and fuel cell hybrid systems. So, trying to combine the best of both, leveraging the kind of high energy density of hydrogen and the kind of high specific power capability of batteries. So that's important in this context, particularly in regard to thermal management, because the demands on the battery change depending on what type of powertrain you're looking at. So, in our particular case, we are much more interested in achieving very high power levels, very high power densities out of our batteries, more so than we are obsessed with kind of energy densities. And what that generally means is you've got very small packs with very high currents passing through them, lots of heating because of that. And so actually being able to keep those batteries cool during that process is a really critical challenge, basically, and particularly for aerospace, where every gram of weight counts. You're always trying to kind of minimise your pack, minimise the weight of your thermal management system, the kind of surrounding aspects of your design as well. And generally, you're trying to take as much energy out of those cells as possible, because you cannot afford to be carrying dead weight anywhere.

Thanks, Jack, that's great. It's really good to see that, you're demonstrating that these technologies work in these particularly challenging environments.

Yeah, and Kate, so we talked about energy density as a key challenge for battery system applications in aerospace. Do you think you could tell us a bit more about that, please?

Sure. I mean, as Jack and Jacqui have mentioned, weight is really critical, and it's one of those trades in aerospace. We're always looking at trades of weight versus energy density versus cycle life. And finding that kind of sweet spot is really the bit that's the key challenge. You know, am I going to give up energy density? How does that affect my cycle life? How does that affect the safety of the battery system? If you loaded a battery from your current aircraft and tried to use it for a propulsion system, currently, it would simply weigh way too much. There's those batteries that literally weigh about 10 kilos, and you're only really getting a 20 volt system. It's not a high voltage system. It's not what we need on aircraft. So we're now looking to sort of reflect some of the changes that have happened in the automotive industry and reflect it into the aerospace industry but really make sure as well that it meets our energy entity, and it also meets the requirements that we need in aircraft, in terms of safety and altitude and pressurisation and all of the different challenges within the requirements for a battery system on aircraft. If we added a battery system now, we didn't really understand the package weight and the requirements around those cells. We could really prove up to ourselves that actually hybrid electric won't work and this is really something that's key in what we're developing at Collins. So as far as energy density, we're talking about the usable energy density in those batteries, and we're working to address those challenges by looking at lightweight advanced materials within the battery system and containment. We're also looking at advancing technologies, like Jack, and in thermal management to make sure that those cells are kept at the temperature that they will perform the best in that system. And also within the advanced health monitoring system. So, to make sure that we are ready to catapult those energy storage systems into the aircraft and that the pilot and all of the outer air framing network have got all of that communication and interfacing systems ready. At present we don't have high voltage batteries on aircraft. There isn't anything certified, and we're applying decades worth of our experience at Collins in different high power generation systems to batteries, and reflecting the aspects of engineering that we really understand really well and putting that in, that capability, into batteries.

Thanks, Kate. I think it's really, really key that we look to take learnings from other sectors and employ them or deploy them into new areas because we don't want to be reinventing the wheel every time. And there's lots of good, good lessons learned that we could take on board. So, we've talked about aircraft. Jack you've been developing battery pack for long range UAVs. So, could you talk a little bit about how the requirements of the UAVs differs from manned aircraft, and the kind of innovations that you're bringing to this space specifically?

We see UAVs more as a beachhead market rather than a kind of design philosophy that requires something very different from manned aviation. In fact, actually, we design our packs to manned aviation regulations in preparation to be able to deploy them in those applications in the future. So, as I said, the demands for our hybrid application generally means very high C rates. I hope the audience understands what I mean when I say that. I'm assuming so. So, we're talking kind of C rates in the region of eight to 15 C which is pretty beyond what you find in automotive applications, particularly as we're talking about using those C rates for periods of times in kind of the minutes. So, in a very high performance car, you might get those C rates during a very rapid acceleration, but not for the period of minutes you'd expect in these type of applications. Where we have particularly focused is on VTOL aircraft. That's because where hybrids really show an advantage is when you've got a very non uniform power profile for your aircraft. So, if you say you've got a very high power demand during takeoff, but maybe a very much lower power demand during cruise, the bigger that difference is between those power demands, the more advantageous that kind of hybrid approach becomes. That's one aspect. The other aspect is also it can be used to help things like life. So, if you can use a battery that allows you to keep your fuel cell operating at a very kind of steady set point, it means you can also prolong the life of a fuel cell as well. So, we're not specifically targeting UAVs only, but we see it as a very attractive, I guess, initial opportunity to get our technology into the air and get flight hours because ultimately, we can all talk about flying aircraft but at the moment, I don't really see any in the skies. So, I think the sooner we get things in the air and we get flight hours under our belt, and we can understand how this technology actually performs in real life applications, the better.

Thanks, both of you for those insights on batteries and requirements. It's good to understand how you're both trying to look at the markets as well, I think. That was an interesting insight and discussion. So, the aerospace industry is notoriously conservative when it comes to adopting new technologies due to safety, so it was good to hear what you're thinking in those sort of areas. Now, I'll put questions to both Jack and Kate. What do you see as the biggest commercial opportunities for batteries in aerospace? And what do you think needs to happen to accelerate that adoption? I think we've probably spoken a little bit about this but it's good to get some specifics, maybe. Starting with you, Kate.

As I mentioned earlier, so these new high voltage battery systems are required for all different types of propulsion systems, as Jack says, so from series to parallel even through to hydrogen fuel cell applications. And we've really got the potential to reduce the aviation industry's carbon emissions by millions of tons. So, the opportunity for me is really clear, but really we've got two major development challenges that we're working on, and this is key for us. So, the first is safety. Demonstration of safety is going to be key, with a focus on preventing any failures, containing any events, and ensuring compliance with the highest possible aviation standards. As you mentioned, the aviation industry is conservative. We've got 10 to the nine of safety requirements across the board, and this is something where our engineering teams are studying and researching and developing tools and models and the development of these aspects of the battery system, to ensure that safety can be contained. We have a safe by design approach that's really flexible as well, so that we can adopt future battery cell technologies. We all talk about different battery cell technologies, different generations of battery systems and this is something that's going to be key for us in the aviation industry, to move with that as well. This isn't just a traditional airplane system, where it'll be 30 years between a generation change, there'll be a change to the flexibility of our systems, to adopt cell technology so that we can get advantages of energy density increase and safety. And the second is cycle life. So, we're looking at high C rates, as Jack says, and that's got an impact into the cycle life. Similar to a car, we'd like the battery system to be able to last for a significant new cycle. And that's why cycle life and the testing and the validation that we're doing is really emphasising the importance of those aspects. So, making sure that we choose the right cell technology, the right architecture of our system, to make sure that we can hit safety and we can for sure, proof and be certifiable, and also the cycle life. We're working on the thermal management systems and health monitoring systems that will allow us to prove that to the airframers and to the industry, but we're really focused on those compliant areas. And we're also looking as well at what is our design for recyclability? What is the second use of these batteries? How will we be maintaining them? What is the infrastructure behind that? And as part of Collin's teams, we have many different areas of the engineering teams across the business that are working on different aspects of that, from new innovation in how we develop the batteries and therefore how we really meet our sustainability goals in terms of that design for safety and design for recyclability. Over to you, Jack.

Yeah, don’t think you've left me much to say there. So, I think it's worth maybe asking the question, what do we think aviation might look like in 20 years time? Is maybe an interesting one. From my perspective, I don't see battery technology replacing kind of long-haul flights. I think they will stay powered, probably by SAFs, but there's definitely opportunity in the kind of regional aircraft size, maybe a bit larger and below, for batteries to play many different roles, I suppose, from something as simple as powering the aircraft during taxiing so it doesn't use fuel when it's taxiing to take off to very kind of large hybrid systems that combine with gas turbines or fuel cell systems as well. I guess within that as well, you've probably got potentially different chemistries for different applications, which adds another dimension to it. And I guess that's something we haven't discussed about future chemistries and the requirements. Maybe we'll touch upon that in a minute. Overall, we see batteries, and particularly from our side hybrids, hybrid battery packs, playing a really large role in trying to help decarbonise aviation in the future.

Thanks to both of you for that. A question for Jacqui. As the ATI looks to strengthen the UK aerospace capability, we talked a bit sort of about lessons learned from other sectors. What role does collaboration with international partners play in advancing and increasing the adoption of battery technology for aviation?

Well, aerospace is a global sector, of course, so collaboration with international partners is really important. I mean, the UK aerospace industry is mainly focused on developing the battery management and the packaging aspects of it. So, all of what we've just discussed around efficiency, thermal, safety needs, rather than developing the actual sales or technology itself, so much. So, we collaborate internationally with regard to the specification of the cells themselves. I think we also play a really key role working with the international airworthiness authorities on battery safety regulations and qualification aspects. And also, in addition to this, there are key international projects where the UK companies are engaged. That includes, for example, NASA's electrified power train flight demonstration project, so that aims to progress hybrid electric flight technologies. So that would be aimed at commercial aviation with ground and flight tests over the next five years. There are other examples, like the collaboration of BAE Systems with Heart Aerospace. They're a Swedish electric aircraft manufacturer, and BAE Systems will define the battery system for their ES-30 regional electric aircraft. So, there's lots of opportunities. And one of the most important roles that we can have, I think, with international partners, is to convene a strong international voice on the requirements for battery use in aerospace because the current forecast for battery specific energy and its influence on aircraft usage means really that battery demand for aerospace applications is much lower than that for automotive. And automotive developments are really primarily focused at the moment, now on cost reductions. So it's really key that the aerospace sector keeps raising its profile, and it explains the use cases to ensure that future battery technology developments are shaped by aerospace requirements as well, and not just automotive. So, there's a lot we can do internationally, certainly.

That's really good to hear. Thank you all of you for your really good insights. It's been an absolute whistle stop tour, I appreciate, of the batteries for aerospace, what's going on and what we see the future looking like. So, thank you to all our guests, and thank you all for listening. We hope you've enjoyed this discussion as much as we have. I'm going to take quite a lot of stuff offline, I think we're going to carry on after we finished recording. So don't forget to visit our online hub on the ukbatteriesnetwork.org and register to receive our updates and participate in the networking area of the hub. See you next time.

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