

Ricardo Quarterly Review

Winter 2022/23

RQ

A focus on the latest in innovation,
sustainability and technology



READY FOR TAKE-OFF

How hydrogen is fuelling
the aviation revolution

ELECTRIC AVENUES

Why CEO Edward Hightower
is moving Lordstown Motors
in new directions

STYLE COUNSEL

Exploring the creative interface
between design and engineering

In the air and on the
ground, future mobility is

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RQ NEWS

Latest developments from around the global Ricardo organisation

Cleaning up our cities

Contract to maintain the UK's Air Quality Emissions Scenario Modelling Tool

Ricardo has won a three-year contract to develop and maintain the UK's Air Quality Emissions Scenario Modelling Tool. The appointment follows on from the initial construction of the model by a Ricardo-led consortium in 2019.

The outputs of the tool are already being used to shape strategies that offer routes to delivering national emissions reduction commitments such as the UK's Clean Air Strategy, the National Air Pollution Control Plan, National Emission Ceilings targets, Environment Act air

quality targets and the UK's net zero strategy. It's also addressing international objectives through the Gothenburg Protocol, which set emissions ceilings for sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia.

The tool has been used by the Welsh Government to assess emission reduction policies and develop evidence-based, target-setting legislation around air pollution, while local authorities across the UK are deploying it to understand their baseline emissions and test different

The Air Quality Emissions Scenario Modelling Tool is shaping strategies to deliver the UK's emissions reduction commitments

mitigation options such as Clean Air Zones.

Maintaining the tool is the latest example of Ricardo's work to improve urban air quality. In February 2022, the company supported Britain's first zero emissions zone scheme covering nine streets in the centre of Oxford. Ricardo's air quality specialists have also assisted in the review of London's Ultra Low Emission Zone (ULEZ) and have been working with local authorities in Bradford, Southampton and Cardiff to complete Clean Air Zone feasibility studies.

Support for Toyota's first UK-based hydrogen light commercial vehicle

Ricardo is involved in a multi-year project to produce Toyota's first zero emission hydrogen-powered light commercial vehicle in the UK. The Hilux hydrogen variant will be manufactured and assembled at Toyota's facility in Derby. It's scheduled for prototype production in 2023.

The project has been created in partnership with the Advanced Propulsion Centre (APC), a non-profit organisation based at the University of Warwick that facilitates funding to UK-based research and development ventures addressing low carbon emission powertrain technologies.

Ricardo's role is to integrate the complete hydrogen fuel cell, fuel storage system, and controls including design, analysis and validation. The integration will ensure efficient operation of all systems to give an excellent vehicle range and support longevity and reliability. The company will also assist with the delivery of a complete turnkey



solution, creating greater agility for Toyota in the UK supply base and a quicker turnaround in the design of low-volume manufacturing.

"Our growth in this industry is underpinned by our engineering expertise in hydrogen fuel technology and its integration into a variety of applications across several sectors, including light commercial vehicles," says Adrian Schaffer, President of Emerging Mobility, Automotive and Industrial at Ricardo.

Assessing the risks of ammonia as a shipping fuel

Flagship report highlights potential impact on marine ecosystems



The shipping industry faces increasing pressure to decarbonise. Ammonia generated from renewable energy is a possible alternative to fossil fuels. On behalf of the Environmental Defense Fund (EDF) and with support from Lloyd's Register, Ricardo has delivered a report examining the potential environmental impacts of spillages were ammonia to be widely adopted.

Due to the scarcity of real-world data, Ricardo specialists used PHAST (Process Hazard Analysis Software Tool) modelling to focus on the impacts of large spillage scenarios. The potential effects on aquatic environments and associated ecological receptors were assessed according to whether a spill occurred during bunkering or in the case of a ship colliding and sinking. The study also looked at possible mitigation measures and specific spill management practices.

The findings were that spills of

ammonia as a shipping fuel could negatively impact certain habitats and species more than others, and that the likelihood and gravity of such spills would be highly dependent on ship type, hole size, temperature or even time of the day.

"Examining the impact of ammonia is a challenge because of the vast range of conditions a ship might face while at sea or even when bunkered," says Lauren Dawson, Senior Consultant in Ricardo's Water and Environment Practice.

"Critical factors include the various ship and storage types, the underlying principles which determine the fate of ammonia in the environment and the diversity of aquatic habitats and species that could be affected. Ultimately, what we found is that ammonia is more threatening to fish species, and particularly to ecosystems with less saline water and higher temperatures."

Download 'Ammonia at Sea' at: bit.ly/ammoniareport

Key revisions to European air quality legislation



Enhanced protection for human health and the environment

Ricardo has made a significant contribution to the European Commission's revision of the Ambient Air Quality Directive, which sets air quality standards for European Union (EU) member states. This directive underpins the improvement of air quality to reduce the figure of 300,000 premature deaths per year and a number of noncommunicable diseases such as asthma, cardiovascular problems and lung cancer.

A team of air quality experts led by Ricardo carried out an impact assessment into options to revise the legislation. Using scenario modelling to 2050, these included the potential impacts of new air quality standards in relation to public health, the environment and business. Ricardo provided economic expertise to the impact assessment which showed that the societal benefits of the proposed revision far outweighed the costs.

A further study, also led by Ricardo, set out suggestions to improve support for local authorities in achieving cleaner air through strengthening air quality monitoring, modelling and plans.

Ricardo has provided expertise to the EU in air quality and climate change since the 1990s. "We have the longest-established specialist air quality team in the world and, with more than 130 experts, one of the largest," says Beth Conlan, Ricardo's Technical Director – Air Quality. "This is reflected in the UK's position as a world leader in air quality expertise. Our corporate mission is to create a safe and sustainable world so we are honoured that the European Commission chose to entrust this seminal project to us."

Designated Body status for Ireland's railways

Latest addition to portfolio of rail recognitions throughout Europe

Awarded by the Commission for Railway Regulation (CRR), Designated Body (DeBo) status allows Ricardo to check compliance against the National Rules for railways in Ireland. The recognition means Ricardo can offer a 'one-stop shop' for all relevant independent assurance services to clients and Original Equipment Manufacturers (OEMs) wanting to provide new or upgraded railway subsystems in Ireland.

Ricardo has several projects underway with Irish clients and OEMs, where accredited Assessment Body (AsBo) and Notified Body (NoBo) services are already being provided. The DeBo service can be seamlessly bolted onto these services to give clients a smoother project assurance journey.

Ricardo already has accreditations, appointments or recognitions to provide DeBo services in five European countries.



Securing the supply of critical electric vehicle components

A partnership between Ricardo and battery cell manufacturing experts InoBat will enable the supply of battery cells, modules and packs to high-performance automotive manufacturers for their electrification programmes.

Drawing on its expertise in proprietary battery cell research and development and large-scale battery cell production, InoBat will manufacture, test and supply cells. Ricardo's role will be to design, assemble and test the battery packs then supply them principally to customers in the automotive market but also in other sectors such as aerospace and defence.

The collaboration enhances Ricardo's capability in the production and supply of critical electric vehicle (EV)

components. In April 2021, the company received UK Government funding to assess the commercial viability of a facility to assemble battery packs for UK manufacturers producing fewer than 10,000 EVs per year. These manufacturers include some of the world's best-known prestige brands.

"Our future manufacturing strategy is very much aligned to the emerging need for EV components for high-performance automotive vehicles and other equally demanding applications," says Martin Starkey, Managing Director for Ricardo Performance Products. "This partnership will speed up the adoption of electrification in these critical sectors by providing a robust supply route for key battery products."

The Ricardo and InoBat partnership will provide a robust supply route for key battery products



Meet a new Superstar of STEM

Jessica Bohorquez, a Water Systems Engineer with Ricardo's Energy and Environment team in Adelaide, was recently announced as one of Australia's newest Superstars of STEM.

The Science & Technology Australia initiative is funded by the Australian Government's Department of Industry, Science and Resources. Jessica is among the next cohort of 60 scientists, technologists, engineers and mathematicians to join the programme and receive training to help inspire future generations of young Australians into STEM. Currently she supports Ricardo's hydraulic modelling capability and has taken part in the concept design of water infrastructure and water systems operation projects.

"We know it's really hard to be what you can't see," explains Science & Technology Australia's Chief Executive Officer Misha Schubert. "That's why this game-changing programme is helping to smash stereotypes and give women and non-binary talent in STEM the crucial skills and confidence to step into expert commentary roles in the media."



SMART certification for Belgian rail

Swiss rolling stock manufacturer Stadler has commissioned Ricardo Certification to test and certify FLIRT3 Limburg multi-system trainsets against the requirements to operate in Belgium. The trainsets are currently in service in Germany and the Netherlands, with operator Arriva seeking to extend to Liège.

Ricardo Certification has completed a successful test programme using its own SMART software, which was developed in 2016 for analysing electrical interference data against Dutch requirements and has since been extended for analysis against

Belgian requirements and the Jade train detection systems used in that country. Functionality for automatic processing and analysis of brake system test data will be completed soon.

Test programmes typically involve a range of stakeholders with varying priorities, high technical complexity and unforeseen operational challenges. Normally, it takes weeks for testing teams to obtain results and move on to the next phase. In contrast, SMART software gives overnight results, contributing to the fastest and most cost-efficient testing and authorisation possible.

Ricardo Certification is helping to get FLIRT3 Limburg multi-system trainsets operating in Belgium



A VIEW FROM

WE CANNOT SIT ON OUR HANDS AS WE WAIT FOR FUTURE GRADUATE ENGINEERS TO BE TRAINED UP: THE SKILLS SHORTAGE IS IMMEDIATE

Mind the gap

Universities have a key role to play in meeting industry's electrification skills shortage, say

Peter Gammon and **Juliette Soulard**



Peter Gammon is a Professor of Power Electronic Devices at the University of Warwick and has led projects developing bespoke power devices for electric vehicles, space, industrial machines and the grid. Juliette Soulard is Associate Professor at WMG, supporting the development of the UK supply chain for power electronics, machines and drives.

Electrification is coming. The Government's target to have all vehicles produced in the UK as electric alternatives by 2030 is no mean ambition. However, the challenge of retraining a workforce that is skilled in manufacturing petrol and diesel vehicles to be equally as competent in producing electric alternatives is a huge one.

Over the next decade, the automotive sector in the UK faces a significant skills shortage, chiefly due to an ageing workforce. New data suggests that one-third of predicted UK automotive sector jobs will need replacing by 2031, comprising some 55,000 roles.

Our research at Warwick has shown that 63 per cent of all power electronics, machines and drives (PEMD) jobs will be subject to 'significant change' in the next ten years, rising to 84 per cent when only considering electric machines. Meanwhile, the current pool of technicians and engineers will be in high demand from multiple sectors also making the transition to electric, including energy, aerospace and rail. All these factors make the challenge facing the automotive industry even more acute.

Education, academia and industry must tackle this upcoming surge in demand for PEMD engineers over the coming decade. Engineering departments from universities, such as ours at Warwick, have a vital role to play.

problem of the small number of domestic students wishing to study engineering, despite its many opportunities. So we must be active and proactive in our attempts to reach out to students and increase participation.

Engineering as a career suffers from the perception of being a highly difficult subject, which is something we must try to tackle. One way in which engineering can inspire today's teenagers is its ability to offer solutions to climate change through electrification, a subject near to the hearts of many young people.

Second, we can make engineering more accessible by expanding the number of technical and vocational routes from secondary schools to industry. The small number of institutions that offer degree apprenticeships must expand as we rise to meet the upcoming challenge.

We cannot sit on our hands as we wait for future graduate engineers to be trained up: the skills shortage is immediate. We therefore need industry-focused programmes such as short courses, workshops or MSc programmes delivered flexibly to reskill existing employees, particularly those who are perhaps still starting out in their careers.

At the University of Warwick there is a keen interest in responding to this problem, including collaboration between the School of Engineering and WMG (formerly the Warwick Manufacturing Group). We recently received £1 million from Innovate UK's 'Driving the Electric Revolution' challenge which has enabled us to roll out the Warwick Electrification Deployment (WELD) project. WELD is a skills-based initiative that will transform our PEMD delivery programmes in the University. Outreach programmes will develop new resources for schools and help inspire the next generation of engineers, while a Degree Apprenticeship in PEMD will be a first of a kind in the UK.

WELD will also help to expand Warwick's industry-focused PEMD training, including an increase in the existing electric drivetrain programmes delivered to leading companies across the automotive industry. A new hands-on facility will bring the manufacture, assembly and testing of IP-free eMachines onto campus.

We hope that companies within the UK automotive sector will engage with the WELD programme. There will be increased local opportunities for training and up-skilling of the current workforce. And by engaging with our teaching programmes, the increased exposure to the company from a greater number of graduates will help secure the future pipeline of talent. [RQ](#)

First, we must increase the number of bachelor's and master's level graduates coming through into the workforce. Of course, this expanded offering by universities and the wider automotive sector means little if we do not have the students willing to take up these courses. In the UK we have a continual



THE BIG PICTURE



East Anglia, UK

Agriculture provides 60 per cent of the food we eat, employs almost half a million people and contributes more than £120 billion to the UK economy. The sector also has a crucial role to play in managing the countryside and delivering environmental and rural community benefits that are enjoyed far beyond the farm gates. However, rising costs, labour shortages, volatile markets and the climate crisis are just some of the challenges that have left farmers and land managers battling on many fronts.

Ricardo supported the initial and interim phases of the Future Farming Resilience Fund (FFRF), a scheme developed by the UK Government's Department for Environment, Food and Rural Affairs to give advice and guidance to farmers. The company has now been chosen to deliver the

full two-and-a-half-year FFRF programme.

Ricardo's experts provide three key support pillars – environmental, financial and mental health – aimed at enhancing the performance and building the robustness of England's farming community. This will draw on knowledge gained from running the Farming Advice Service for England and the Farm Advisory Service for Scotland, which have helped more than 100,000 farmers through events and advice sessions.

The programme will include environmental reviews in response to issues such as drought, flooding, pests and diseases, thus helping to minimise risks, reduce greenhouse gas emissions and improve water, soils and air quality.



“THIS PROGRAMME IS GOING TO HELP FARMERS ALL ACROSS ENGLAND PREPARE FOR THE CHANGES IN AGRICULTURAL POLICY DURING THE AGRICULTURAL TRANSITION AND ADAPT TO CLIMATE CHANGE”

DAVE FREEMAN, ASSOCIATE DIRECTOR,
AGRICULTURE, RICARDO

The FFRF stimulates improvements to efficiency in areas such as nutrient management, diversification and sustainable land and carbon management. These, in turn, will benefit other sectors of the economy including wider outputs through the supply chain, together with increased affluence and investment in rural areas.

Ricardo will be working with delivery partners from Anderson Farm Business Consultants, a group of leading consultancies for agriculture professionals, to provide commercial and financial guidance around the impact of changing subsidies, budgeting for a viable future and succession and later life planning. Ricardo is also partnering with a farm community network to offer mental health and wellbeing advice in

recognition that farming is a demanding and high-stress occupation.

“This programme is going to help farmers all across England prepare for the changes in agricultural policy during the Agricultural Transition and adapt to climate change,” says Dave Freeman, Ricardo’s Director, Agriculture.

“Our experience delivering the Farming Advice Service for England and Farm Advisory Service for Scotland means we are uniquely placed to give the knowledge, confidence and support that farmers need. We can help them embrace change, develop business plans and maintain their vital roles as environmental stewards and providers of secure, high-quality food. 🌱



ELECTRIC AVENUES

Ahead of his appearance at the Ricardo Mobility Summit in March, **Edward Hightower**, CEO and President Lordstown Motors, talks to *RQ*'s **John Challen** about the company, its future plans and the challenges of electrification



Edward Hightower is the epitome of a car guy. With a background in the automotive industry that stretches back more than 30 years, he has a vast amount of experience that has prepared him for his current position of CEO and President Lordstown Motors. The Ohio-based company is looking to take on the commercial vehicle fleet market with a range of high-quality electric vehicles [EVs].

Over the years, Hightower has plied his trade at Ford, BMW and General Motors, working in engineering, product development and leadership roles, having started out as a chassis engineer. Born and raised in Chicago, he has had a passion for automobiles his whole life and has worked with Original Equipment Manufacturers [OEMs], Tier One suppliers and aftermarket operations over the course of his career.

Just over a year ago, he took on a new challenge – to help turn around the fortunes of Lordstown Motors, with the intention of growing the business and preparing it for the electric revolution. Initially joining as President, he also assumed the role of CEO six months ago at a critical time for the business.

What was the motivation for joining Lordstown Motors?

I was in fourth grade when I decided I wanted to be in the auto industry. From that kid growing up in Chicago to now, I have always had a passion for what is possible with cars and I'm really excited about the transition to EVs. I could see the plans that Lordstown Motors had and also what was possible working with Foxconn, the world's leading consumer electronics contract manufacturer. Foxconn has made a major investment in our company and we believe its EV ambitions can match our own – we complement each other well.

How have things evolved at Lordstown Motors since you arrived?

We started production of our Endurance SUV in the third quarter of 2022 and sales began in the fourth quarter after receiving full homologation and certification. The first customers received their trucks just after Thanksgiving.

We also have an agreement to be Foxconn's preferred vehicle development partner for North America and we plan to develop EVs together. The model will allow small OEMs – like us – to gain scale without having to do everything





Production of the Endurance SUV began in the third quarter of 2022 with sales following in the fourth quarter after receiving full homologation and certification

“I HAVE ALWAYS HAD A PASSION FOR WHAT IS POSSIBLE WITH CARS AND I’M REALLY EXCITED ABOUT THE TRANSITION TO EVs”
EDWARD HIGHTOWER





“RICARDO HAS ALWAYS BEEN AT THE CENTRE OF PROPULSION SYSTEMS, YOU KNOW, WHETHER IT’S ICE OR NOW ELECTRIFICATION. AND ALSO REGARDLESS OF WHAT TYPE OF VEHICLE IT IS” EDWARD HIGHTOWER

→ themselves. Therefore, we will be the team that takes the components and subsystems – whether they are from Foxconn or its open-source platform, MIH [Mobility-in-Harmony] – and works on the product strategy, design, engineering, testing, industrialisation, certification, homologation and launch of all the EV products for North America.

How did the relationship with Foxconn and the role as preferred vehicle development partner come about?

The sale of the plant was completed in May 2022 but we’d been talking about it since late 2021. In addition to the asset purchase agreement, we formed a contract manufacturing agreement for Foxconn to build the Endurance. However, it was always our plan to forge a longer-term relationship with Foxconn for future vehicle development. In November 2022, Foxconn announced an additional investment in Lordstown of \$170 million,

with \$70 million straight to the company and \$100 million for future product programmes.

Foxconn has aspirations to be a supplier of several EV components itself, which makes sense considering all of the electronics modules that are in an EV. Lordstown will be a key part of this vision. We will help by engineering and integrating more of their hardware and software into production vehicles.

How has production changed since the Foxconn partnership?

The business is pivoting to an innovative, asset-light business model, because we didn’t need to operate an assembly plant that could potentially build over 300,000 vehicles. We sold our plant, in Lordstown, Ohio [hence the company name], to Foxconn – and, as part of the deal, they agreed to build the Endurance there. As well as the plant, we transferred about 420 Lordstown Motors employees to Foxconn.

It would be a challenge for any global

OEM to fill a plant that size, so the ability to pivot – where vehicles from multiple OEMs can be built in the same place – is a game-changer. Our own manufacturing costs are now fully variable, instead of fixed due to what is within the four walls of a plant, including the workforce. The transition towards electrification with a leader in manufacturing, not automotive, is exciting. There’s a huge opportunity for Foxconn – and Lordstown – to be a key part of that transition.

Where does the Endurance SUV sit alongside its rivals?

We compete in the same segment as the Ford F-150 Lightning and I think there’s room for both products in the market. We’re focused on commercial fleets, while Ford covers that, but also private buyers too. Lordstown’s mission is to accelerate the adoption of electrification and we decided to focus on vehicles that get driven the most – trucks. To impact the number of internal combustion engine (ICE) miles driven and transition them to EV miles, focusing on the commercial fleet space is essential.

Endurance has three core strengths. First, it’s a full-size pickup with four in-wheel hub motors. That means we can control the traction directly at each wheel, making the truck very capable on

EDWARD HIGHTOWER: A LIFE IN MOTION

- BS General Engineering, University of Illinois Urbana-Champaign
- MBA, University of Michigan
- 2021-date: CEO and President, Lordstown Motors Corporation
- Previously held new product development, engineering, strategy, marketing, P&L leadership and senior executive roles at Ford, BMW and General Motors. Also worked as a hands-on growth, strategy and operations consultant at AlixPartners LLP and Motoring Ventures LLC, which he founded.
- Extensive experience in emerging markets in Asia, Africa and Latin America and served as an advisor to Kiira Motors, a Uganda-based manufacturer of electric buses.
- Author of 'Motoring Africa: Sustainable Automotive Industrialization', published in 2018 and based on industry experiences in China, India, South Korea, Mexico and Brazil. The book makes the case and offers an actionable roadmap for building sustainable manufacturing businesses in six African countries.

Which models are likely to emerge first?

Good question – and one I can't really answer! Lordstown is focused on the commercial fleet space and there are several other vehicle types and segments that are of interest to our commercial fleet customers, which we are considering.

In addition, we would consider a consumer version of the Endurance for another OEM, so we would think about a similar version of anything else in our future portfolio.

What are the challenges that Lordstown faces on the road to electrification?

The biggest one is that demand is currently far exceeding supply. That's why it was important for us to launch our product in a timely manner. The fleet market is even more receptive to the transition towards electrification because people pay more attention to total cost of ownership, so can see costs reducing.

Being a new OEM is another challenge we're working through, but that will come with time. We've also had a few supply chain challenges when we launched Endurance, but no different to those faced by every OEM.

What has impressed you about Ricardo and why is it so important to speak at Ricardo's Mobility Conference?

Ricardo has always been at the centre of propulsion systems, you know, whether it's ICE or now electrification. And also regardless of what type of vehicle it is – passenger car, commercial vehicle, two-wheels or many more. As someone who is passionate about the industry and who loves talking about it, the opportunity to speak at Ricardo's conference is an exciting one for me.

Looking ahead to the commercial fleet sector in 2030, what needs to happen for the transition to EV to be a success and are you confident that it will be?

We need to continue to build the charging infrastructure and to maintain the downward curve in vehicle prices. As production costs are an enabler to lower vehicle prices, our innovative business model will help us to create great products, lower costs and create more value for the customer. 🚗

The fleet market is particularly receptive to the transition towards electrification as more attention is paid to total cost of ownership

all road surfaces. Second, and from a safety standpoint, Endurance is a five-star crash rated vehicle – essential for fleets because they need to keep their workers safe. Third is value, demonstrated by Endurance's capabilities, considering its price tag of around \$63,500. For some rival products, customers would have to spec optional packages to get to the same level of capability – and spend more than they would for our truck.

How does your partnership with Foxconn represent an innovative direction for the industry?

Multiple OEMs can share common components such as hardware and software. Usually, OEMs look to develop platforms for multiple vehicles of their own brands themselves. Our approach is enabling that to happen beyond one large OEM doing it for itself. As a result, multiple smaller OEMs, such as Lordstown, can get the benefits of scale without having to build the infrastructure themselves.

Also, on the hardware and software side, the key challenge when launching modern, high-tech vehicles is ensuring that all of the different modules in the software can work seamlessly. The arrangement we have with Foxconn will help make that process much easier.

What opportunities are there for other OEMs to work with Lordstown Motors?

We are open to anyone working with us on the vehicles that we have and any vehicles we might have in the future. We made it clear that our Endurance – which is now fully certified, homologated, in production and on sale – is on a platform they could use to enter the second most popular segment in the US, full-sized trucks.

We can build a version of the Endurance, or a vehicle on the Endurance platform, for OEMs who are going to spend significantly less than they would do if they had to develop everything from the ground up themselves. Because we're focused on the commercial vehicle space, if the manufacturer wanted a vehicle for the consumer space, there would be a real opportunity there.

Where will the Lordstown Motors product portfolio go after the Endurance?

We've already started pre-development work on vehicles that we will be developing in collaboration with Foxconn and the MIH Consortium. There are many different segments beyond full-sized trucks and that's what we're looking at – the growing markets. If another OEM wanted to partner with us on one of those vehicles, we certainly have a capable team that could allow them to do so.

RICARDO MOBILITY SUMMIT

Edward Hightower is among the speakers at 'Convergence: Energy and Mobility in 2035' on 9 March at The Madison in Detroit. To apply, visit: bit.ly/globalmobilitysummit



FUTURE SUSTAINABLE TRANSPORT

Immersion BEATERS

When TotalEnergies was looking for a project partner for its immersion cooling technology for batteries, Ricardo was the ideal candidate. **John Challen** explains why



A player in the market is French integrated energy company TotalEnergies, which has created an immersion-cooled battery technology for EVs. When looking for a project partner, Ricardo's experience with thermal management helped it win the contract. "During our discussions, Ricardo understood very quickly what we wanted to achieve, which meant we had even more confidence in their capabilities," recalls Gérard Quoirin, Product Engineer Battery Fluids for TotalEnergies.

While immersion cooling has been used

in niche applications from other vehicle manufacturers, the project – dubbed Phosphor – represents a world-first mass production vehicle with the technology. It aims to improve battery thermal management, the main benefits to the vehicle being faster charging times, better performance and lower prices. Solutions such as the one at the heart of Phosphor replace the traditional traction battery cooling system with the immersive one.

Within Phosphor, the battery is cooled with dielectric fluid, which enables a higher

power capability than the systems already currently available on the market. That higher power, says Quoirin, can reduce charging times from two hours to 30 minutes.

This time reduction was an important factor and, as Quoirin points out, indicates how expectations when running EVs have changed: "EVs have evolved very quickly and now there are bigger batteries and much more performance. But it's clear that from 2026 or 2027, it will be difficult for Original Equipment Manufacturers

[OEMs] to sell a vehicle if you can't recharge it in less than half an hour.

"In five years' time, customers won't want to wait three hours to charge their vehicle. To fulfil these desires, we need to increase the power of the charge and offer a bigger cell capacity. Constraints of the cooling system will be higher and the current technology can't manage the heat generated by the cell," adds Quoirin. "Immersion cooling is a solution and Phosphor demonstrates how it is possible."

Making comparisons

To make life easier, TotalEnergies and Ricardo kept the dimensions of the cooling system the same but simplified the design. "We could have changed everything, with a design that was 100 per cent optimised for immersion cooling, but then making a comparison between the car with immersion cooling and without it would be more difficult," explains Quoirin. "We decided not to change the number of type of cells, therefore the battery volume remained constant."

TotalEnergies and Ricardo used a production vehicle – a Volvo XC60 plug-in hybrid – although a wide range of applications are possible, says Quoirin. These include static storage systems, trains and off-road applications. "We made the modifications on an SUV because it was easier to identify the improvements," he says. "But we benchmarked all vehicles on the market."

The timescale of the project – work started in November 2020 and was completed by April 2021 – meant face-to-face time was limited due to Covid-19 restrictions. Therefore the majority of the discussions between the Ricardo and TotalEnergies teams were done remotely. That, according to Quoirin, didn't pose a problem: "I was on the project 100 per cent and supported by different colleagues, but most of the work – including the final product review – was done via video conferencing. It would have been better if we could have completed the project in person, but we didn't have an issue."

This situation meant that Ricardo was responsible for the four key elements of Phosphor. "The first phase was a feasibility study, which included numerous tests on the original base vehicle so we had a reference point," recalls Quoirin.

"The second phase was dedicated to the design of the new batteries and the validation of the changes. When the design for the new cooling system was frozen, the Ricardo team undertook physical verification of the battery and then the vehicle."

The final phase saw Ricardo engineers

"IT'S CLEAR THAT FROM 2026 OR 2027, IT WILL BE DIFFICULT FOR OEMs TO SELL A VEHICLE IF YOU CAN'T RECHARGE IT IN LESS THAN HALF AN HOUR."

GÉRARD QUOIRIN, TOTALENERGIES

repeat the original tests, using the new battery and immersion cooling system, comparing it to the results from stage one.

Weight and cost savings

Overall the project was a success but there were challenges. "We had a hurdle to overcome with thermal runaway because there were so many scenarios to be considered," says Quoirin. "Another challenge was finding the right materials because we discovered some materials were not compatible with each other in the new design. Unfortunately, the list of materials that we could use was limited but we knew the most important thing was to optimise the design of the battery and reduce the volume necessary to achieve the desired level of cell cooling."

In contrast, there were a couple of highlights that stick out for Quoirin, including testing the battery to its limit: "We claimed that immersion cooling can prevent fires breaking out. Therefore we tested the theory by first taking the original battery and module from the Volvo and heating one cell and after one hour, the module caught fire," he recalls. "However, when we repeated exactly

the same test on the immersion cooled module, we exposed it to heat for seven hours and nothing happened. So we arguably have the safest batteries in the world!"

Another big positive was the realisation that immersion cooling can reduce the weight and cost of the car. "We can reduce the cost of the battery by six per cent, which can be quite a lot of money," Quoirin adds. "The battery is cheaper because the design is more simple. Today, the assembly of the current battery cooled by standard technology is quite complex. For example, it requires several ports, aluminium components and thermal pads to get the best contact between the cell and the cooling plate. All of those parts are very expensive. By comparison, immersion cooling is very simple – the cell just goes inside the dielectric fluid."

With the project now complete, the next phase is talking to battery and vehicle manufacturers to show them the advantages of immersion cooling – a process that has already begun, says Quoirin. "Their first feedback is surprise – after that they are excited because they can see we have a real solution to the problem." 📺

Immersion cooling can reduce both the weight and cost of a car – the battery is cheaper due to a simpler design



“INDUSTRIAL DESIGN IS NOT JUST ABOUT STYLE: IT IS MULTI-DISCIPLINARY, TAKING IN EVERYTHING FROM MARKETING TO SOCIOLOGY TO TREND ANALYSIS”

THE STYLE COUNSELLOR

Maurizio Tancredi brings world-class industrial design expertise to Ricardo's Rimini Technical Centre in Italy. *RQ's Ian Adcock* takes notes on the aesthetics of sustainable mobility



In case anyone hadn't noticed, the transportation sector is undergoing its biggest technological revolution since the internal combustion engine replaced the horse 137 years ago.

It's not just that vehicle emissions and sustainability are now the overriding priorities for Original Equipment Manufacturers (OEMs), no matter whether they are producing two-, four- or multi-wheeled vehicles. There are shifting attitudes towards vehicle ownership, especially among the young, as well as emerging autonomous and connectivity technologies and the negative impacts of pollution, energy demand and transportation in the world's megacities, mainly in developing nations.

At the same time, the traditional OEMs' business model is being tested by new disruptors and alliances – think Tesla,

Sony-Honda, Foxconn and any number of fledgling electric vehicle producers.

But, having spent time talking with Maurizio Tancredi, Ricardo's Chief Style and Industrial Designer, these are the challenges that get him and around 30 colleagues in Rimini out of bed each morning and inspire their working day.

“Nowadays it's not just a matter of styling a product,” he insists. “We need to think differently to ensure we consider the whole experience of a brand by going into it in more depth and detail. Design should be a reflection of the customer, how he or she is thinking, their work, the ecosystem they live in. Everything is different.

“We cannot think about repeating an already established product, we need to think differently. We also must remember that everyone is more conscious about the environment and sustainability.”

EARLY INFLUENCES

The word ‘sustainability’ crops up frequently during the course of our conversation and was one of the key attractions for Tancredi when he joined Ricardo two years ago. An early and influential mentor was Gino Finizio, the designer and architect who died last year. Finizio worked for a wide range of brands including Alfa Romeo, Aprilia, Fiat Auto and IBM, later becoming co-director of the ‘Transportation design and management’ course at the Politecnico di Milano.

Finizio pioneered the ‘minimal and sustainable’ concept, while his book ‘Architecture & Mobility: Tradition and Innovation’ examined the car as an object that changed the 19th-century city into a metropolis of suburbs and highways. He explored how urban planning, architecture and design ideas can create a new

R





“OUR CUSTOMERS KNOW RICARDO AS A WORLD-LEADING ENGINEERING CONSULTANCY. WE ARE ALSO A WORLD-LEADING CONSULTANCY IN INDUSTRIAL DESIGN FOR TRANSPORTATION”



Tancredi's mentor Gino Finizio pioneered the 'minimal and sustainable' concept and wrote the influential book 'Architecture & Mobility: Tradition and Innovation'



→ philosophy for cars as a type of domestic moving space that interacts with the urban environment.

After studying mechanical engineering at the University of Basilicata and Sapienza University of Rome, followed by a Bachelor of Architecture in industrial design at the latter institution, Tancredi worked for Ducati and Benelli motorcycles. He then became a chief designer in the personal watercraft sector, where he won a Good Design Award from the Chicago Athenaeum, one of the world's oldest and most celebrated awards programmes. Later, as design project leader for global powersports specialist BRP, he won a prestigious Red Dot Design Award for a snowmobile developed to cope with the extreme conditions of the far north and combining high-tech efficiency with riding comfort.

"Sustainability is something I have been working with for many years," he says. "I also felt I needed to go back to my career roots and love of motorcycles. Joining Ricardo allowed me to do just that and embrace the challenge of designing lightweight vehicles for sustainable mobility."

MULTI-DISCIPLINARY APPROACH

"Our customers know Ricardo as a world-leading engineering consultancy," Tancredi explains. "But hand-in-hand with that, we are also a world-leading consultancy in industrial design for transportation. It is unique within the market to be able to offer this holistic service of engineering capability and design capability – and it's complete, end-to-end product development incorporating engineering and design. This is a really important and significant part of our business."

"My job is to bring industrial design knowledge and expertise to the studio here at the Rimini Technical Centre, and to develop the studio and the design team so that we help existing or new customers respond to product challenges where they need one team of experts to take them from idea creation to production."

"Industrial design is not just about style: it is multi-disciplinary, taking in everything from marketing to sociology to trend analysis. Customers need trusted technical experts who understand all these facets and can guide them on the

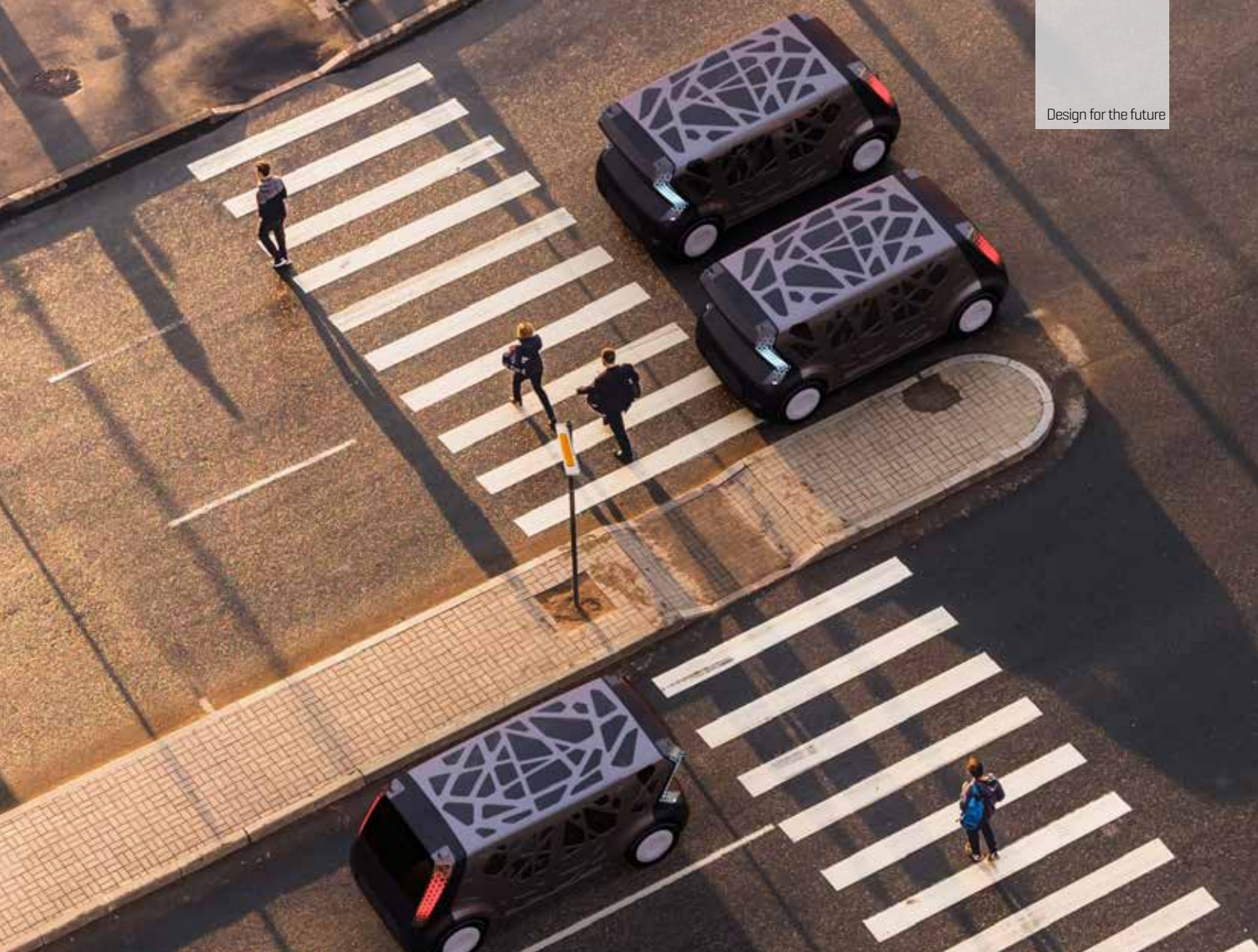
product development journey."

Given that he designed and built his own Yamaha-powered motorbike (see photo on p3), Tancredi is passionate about transferring his knowledge of two-wheelers to other mobility sectors: "A motorcycle is a unique vehicle with lots of challenges: you don't have much space, it needs to be lightweight and packaging is an issue. We can leverage motorcycle philosophy and apply these techniques to different industries and vehicles."

"With a car, the engine, chassis and all the components are invisible, shrouded by the bodywork – so you can think more like a stylist, you are dressing something. In the motorcycle industry, the chassis, engine and a lot of components are exposed, so they need to be aesthetically pleasing, a sort of inside-out effect. The human rider is not just sitting on the bike but is part of the vehicle itself, so the ergonomics are critical – here we are talking more about industrial design."

STEEL APPEAL

Most of the design work done at Rimini has to remain confidential. However, one



publicly acknowledged example is the Steel E-Motive initiative commissioned in 2021 by WorldAutoSteel, the automotive group of the World Steel Association and its engineering partner Ricardo. Steel E-Motive seeks to highlight steel's advantages over other materials for level 5 autonomous battery electric vehicles.

"It was a challenging brief to design a vehicle that could be deployed in a mobility-as-a-service system using steel in a smart way to illustrate that it's a material of choice for fully autonomous vehicles," Tancredi recalls. "Engineers and designers usually employ lightweight materials, such as carbon fibre or alloys.

"We designed the vehicle so it looks like a piece of architecture, a modern building, but one that has to pass crash testing as well as deliver passive safety. There's a unique rocker design that offers superior crush force and protection – not only to the occupants but also to the high voltage battery internals.

"Accessibility is also at the core of the vehicle design: the requirement for low step-in height drove the vehicle's primary structure and is enabled by a

novel battery case solution. A very wide door opening provides ample access for people and goods, while the unique door structure provides reduced outswing to the roadside."

LOOKING TO THE FUTURE

Having spent his working life with various OEMs, Tancredi describes working for a multi-discipline engineering consultancy like Ricardo as 'very different', but in a wholly positive way: "Usually OEMs have programmes in advanced design where they are thinking towards the future but always tied to a particular paradigm or specific business model, and with a kind of historical context that makes it a challenge to shift the brand.

"Working in a multi-discipline engineering and design consultancy is more like industrial design. We can work with different approaches depending on the client – some of the start-ups, for example, are very open-minded and come up with ideas that are not yet feasible! It's different disciplines with more opportunities – and because we have the chance to work on all sorts of products we can transfer our

learnings from one project to another.

"My background as a mechanical engineer helps me understand the limitations of technology and materials, making sure an idea isn't diluted from concept phase to point of sale. Sometimes in the car industry you see early sketches then you see the final product and it's like night and day. At Ricardo we are sure that what you see at the beginning is much closer to what goes on sale."

Designers not only have to capture today's zeitgeist, they have to predict where it will be in three, four, five years' time. "Future mobility faces many, and very different, challenges," Tancredi concludes. "We are in a transition phase in many disciplines socially, and we're at the crossroads environmentally. So products need to take all this into account.

"People live differently, move differently, consume differently. There's also integration of services and business models are changing. As an industrial designer I have a responsibility to try and change the paradigm between the designer, the consumer and the product. ^{RC}

Steel E-Motive: a challenging brief to design a vehicle that could be deployed in a mobility-as-a-service system highlighting steel as a material of choice



THIS MUCH I KNOW...

KATIE MILLARD

Katie Millard is a Principal Consultant with expertise in the management and delivery of low-carbon transport projects and programmes, including 'White Van Plan' for UK Power Networks



Transport is one of the largest contributors to the climate crisis, accounting for 24 per cent of the UK's total emissions in 2020. UK Power Networks, the distribution network operator for electricity covering London, the south-east and east of England, has worked hard to understand its domestic and larger business customers in terms of future customer needs and potential impacts on the electricity network as we transition to net zero but identified a gap when it came to small or medium-sized enterprises (SMEs). In 2020 Ricardo was commissioned to develop a research project investigating how best to help SMEs make the transition to electric vehicles (EVs), part of Ricardo's growing portfolio of work on the transition to sustainable logistics and business fleets.

There are 2.3 million SMEs within the UK Power Networks licence areas. They have a big part to play in reaching the UK Government's net zero carbon emissions target by 2050. Our research estimated that one in three SMEs in UK Power Networks' areas operate a business vehicle – a total of around two million. The aim of the project was to develop detailed knowledge of the SME customer segments, understand how these businesses use vehicles and identify the barriers they face in transitioning to electric mobility. Initially my role was as stakeholder engagement lead, planning how we were going to engage the SMEs, and in the later stages I became project manager.

SMEs can be hard to reach because they are typically time-poor. An SME is officially classed as a business with up to 250 employees but in fact about 95 per cent of those in UK Power Networks' areas only employ up to four people. With Brexit, the pandemic and the cost-of-living crisis, they've got plenty to be thinking about before they start to consider EVs. The risk, however, is that they get left behind and this causes greater problems for them later down the line.

SMEs also defy definition. The project had the witty title 'White Van Plan' but many SMEs pointed out that they don't even own a van, let alone a white one!

Our route to engagement was to consult more than 20 organisations that represent or work closely with SMEs. These covered 18 SME industry sectors from agriculture to utilities. In total we analysed a fleet dataset of more than 27,000 SMEs, reviewed 1,200 online survey responses, conducted a literature review of more than 80 documents and spoke to 80 key stakeholders.

SMEs have varying levels of ambition in the transition to EVs. It depends on their perceived barriers and when they think these will be overcome. Three themes emerged as particular obstacles: cost, infrastructure and information.

The greater upfront cost of an EV compared to an internal combustion engine vehicle is a big challenge for SMEs. So is the cost of workplace or depot charging infrastructure and connections. Our findings also highlighted the limitations of public charging, especially in rural areas, along with the reliance among some SMEs on larger or specialist vehicles that have fewer alternative fuel options.

UK Power Networks are innovating to meet the technical challenge of new EVs. Just one single 50kW rapid charger can have the same network impact as a block of 25 new flats¹. The more EVs that are sold, and the more chargers installed, the greater the need to create smart solutions to unlock capacity. In early 2021 there were more than 100,000 EVs in UK Power Networks' licence areas while their forecast is for 4.5 million EVs on the road in London, the south-east and east of England by 2030.

SMEs are keen to see case studies from 'businesses like us'. We frequently heard about a lack of access to clear guidance and tailored information, together with limited understanding of charging requirements and a belief that there may not be a vehicle suitable for their needs. Without the time to carry out research, uncertainty can hold SMEs back. UK Power Networks have responded to our findings by setting up a dedicated SME EV information and knowledge hub (see footnote for link). They're also running SME roadshows to provide face-to-face advice. Meanwhile, our team is working with local councils across the UK to lead by example and normalise operations of zero-emission fleets, making them seem more feasible and attractive to SMEs.

I love projects that focus on people. 'White Van Plan' was rewarding to work on because I'm interested in consumer behaviour and how we can make recommendations to support change, in this case to sustainable mobility. Not just in the UK, either: at Ricardo we are providing advice on green logistics to countries including Mexico and Argentina, where we know the market comprises a lot of SMEs. And we're working with multinational corporations who want to green their fleets – so not just SMEs but large-scale businesses as well. 

¹innovation.ukpowernetworks.co.uk/facilitating-net-zero/electric-vehicles/



Greener fuels, greener skies

Demand for air travel continues to grow faster than other transport modes, creating a decarbonisation conundrum.

Rui Neiva and **Gareth Horton** address some of the big questions and identify potential solutions for the aviation sector



Aircraft are not the only aspect of aviation needing to decarbonise – major airports have ambitious net zero goals and are increasingly taking a holistic view of their carbon emissions

The European Green Deal is the European Union's (EU's) long-term growth strategy to make the continent climate neutral by 2050. To reach this target Europe must reduce its net greenhouse gas emissions by at least 55 per cent by 2030 compared to 1990 levels, and in 2021 adopted 'Fit for 55' – a legislative package to deliver the European Green Deal.

Last December, the European Commission reached an agreement with the European Parliament and Council to help make the aviation sector 'Fit for 55', setting in law its contribution to the target. Ricardo provided the European Parliament with expertise across the aviation value chain, from policy to strategy to technology innovation and implementation.

What's next? To answer this and other questions, *RQ* spoke to Rui and Gareth.

What's the decarbonisation challenge for aviation?

Aviation emissions in Europe increased by an average of five per cent year-on-year between 2013 and 2019. Even though aviation emissions fell dramatically

during the pandemic, they are still projected to grow further. To achieve climate neutrality, the EU needs to reduce transport emissions, including aviation, by 90 per cent by 2050 compared to 1990 levels.

Currently aviation represents only a small part of overall transport emissions. However, demand for air travel is still growing faster than other transport modes. While electrification is already a proven technology for decarbonisation in the rail or passenger car sectors, it's far less applicable for the aviation sector because of energy needs, the density of batteries and the sheer distances that aircraft travel.

The aviation sector could face potential reputational damage if it increases its share of total emissions as it is the slowest to decarbonise. And if the industry fails to make progress in reducing its emissions intensity, regulators may feel obliged to take action by curbing demand for air travel.

What's needed is urgent action to transition to low-carbon solutions, taking into account the long timeframe

to develop the technologies, roll out infrastructure and replace fleets.

What progress is being made by the industry and governments?

The aviation industry and governments already have initiatives in place but they will need to continue taking action and, in some cases, ramp up efforts. Here are four key areas:

- **Sustainable aviation fuel:** drop-in replacement fuel is one of the most significant for decarbonising aircraft. Options include biofuels, advanced biofuels (made from sustainable feedstocks, preferably waste) and electrofuels/synthetic fuels. Drop-in fuels are favoured as a technology solution because of the need for high energy density and the realistic timeframes for implementation. They have the same characteristics as conventional aviation fuel – kerosene – but on a net life cycle basis they have the potential to reduce significantly the level of emissions.



TAKING FLIGHT

Ricardo is helping to drive progress throughout the aviation industry

Policy expertise gained from advising the European Commission (EC) and governments around the world means Ricardo is uniquely placed to advise on regulation relating to climate change. As part of the guidance provided to the European Parliament (see main feature), Ricardo experts produced a roadmap for achieving aviation Green Deal objectives by 2050¹ which projected the introduction and deployment of potential aircraft technologies and emission savings.*

Ricardo studies supported most of the aviation-related policies proposed by the EC in the 'Fit for 55' package, including a study of taxation options for the fuel used on flights within the EU, and another assessing possible ways to implement a mandate for a minimum percentage of sustainable aviation fuel to be used in all EU airports.

The company also supports the EU Aviation Safety Agency in activities carried out by the International Civil Aviation Organisation's working groups that assess potential changes in aircraft certification regulations.

Ricardo is also supporting the wider aviation sector, including government bodies and funding institutions around the world, as they seek to accelerate the production and use of sustainable aviation fuels, considering the full range of feedstocks and production processes to

maximise the near-term potential for emissions reductions from the use of these advanced fuel options.

Creating net zero airports

On the airport side, a recent report with the Energy Institute² showed, using life cycle assessment (LCA) analysis, how adopting different technologies to refuel aircraft could cut greenhouse gas emissions.

Ricardo is supporting major UK airports with their net zero strategies, including emissions inventory calculations; carbon action planning; emission reduction strategies; fleet management such as replacing or retrofitting airport vehicles; and adopting more sustainable modes of transport.

The company's knowledge of aviation policy, road vehicle technologies and overall LCA is becoming ever more important due to recognition that emissions aren't only generated during use, but also during other life cycle stages such as production and disposal. This is no less important than the improvements promised by sustainable aviation fuels.

¹bit.ly/3XohabY ²bit.ly/3GTRIEe

*Please note that in relation to this study, all views expressed here are Ricardo's not the European Parliament's.



“THE AVIATION SECTOR COULD FACE POTENTIAL REPUTATIONAL DAMAGE IF IT INCREASES ITS SHARE OF TOTAL EMISSIONS AS IT IS THE SLOWEST TO DECARBONISE”

RUI NEIVA, PRINCIPAL CONSULTANT,
SUSTAINABLE TRANSPORT

Sustainable aviation fuels have become increasingly available in the last five years, helped by investment from companies and governments. For example, the UK Government has committed £165 million in taking sustainable aviation fuel capability to production level through the Advanced Fuels Fund programme, which Ricardo manages. Commercial-scale development is moving forward at pace; this is really the key for decarbonising most long-distance flights in the future.

- **Better aviation engine performance and efficiency:** aircraft continue to evolve in their engine efficiency and performance – a plane today, transporting the same number of people the same distance, burns around 70 per cent less fuel than it would have done using 1960s jet aircraft technology. Technologies that have been

researched during the last two decades may also help to produce a step change of a 15-25 per cent reduction in emissions if applied to the next generation of aircraft engines.

- **'Green propulsion':** in the longer term, completely different energy sources such as battery electric or hydrogen could be key for decarbonising smaller aircraft performing short- or medium-haul flights. For a flight from Southampton to Edinburgh, for example, it's possible that by 2040 a battery electric aircraft will be in use. For medium-haul journeys, such as flights within the EU or the US, we could see aircraft becoming hydrogen fuelled in that same period – although this will require a massive investment in green electricity to deliver the full environmental benefits. [See pages 24-25 to read more about hydrogen-powered aircraft.]



**“FOR A FLIGHT FROM
SOUTHAMPTON TO
EDINBURGH, FOR
EXAMPLE, IT’S POSSIBLE THAT
BY 2040 A BATTERY ELECTRIC
AIRCRAFT WILL BE IN USE”**
GARETH HORTON, PRINCIPAL
CONSULTANT, AVIATION



A plane today burns around 70 per cent less fuel than it would have done using 1960s jet aircraft technology

- **Decarbonising airports:** aircraft are not the only aspect of aviation needing to decarbonise. Major airports have very ambitious net zero goals and are increasingly taking a holistic view of their carbon emissions. This means analysing emissions from aircraft ground operations; the thousands of different vehicles and machines, from

refuelling trucks to baggage trucks to aircraft ‘tugs’; clean energy supply for the airport; even looking at the transport options used by employees, suppliers and passengers for their journeys to the airport and increasing modal share towards trains and buses.

Measures bring costs, of course, so balanced trade-offs may be needed to avoid further damage to an industry that has been on something of a roller-coaster with the pandemic.

What’s the future looking like?

We have four predictions:

1. For the European Green Deal to work, even the more advanced aircraft technologies alone will not be enough. Airlines will need to use sustainable aviation fuels at scale to meet Green Deal requirements in the next ten years. Investment in sustainable aviation fuel production and distribution will need to increase considerably.

2. Besides fuel producers and airlines, other major industry players will have a role to play in decarbonising aviation by 2050. Hydrogen and electric aircraft will be in use on a number of shorter routes and longer-range, zero-emission aircraft will be gradually introduced.

3. Renewable energy will be critical to support the transition; delivering synthetic fuels or hydrogen fuel will require massive investment in clean electricity generation so that these fuels are actually green.

4. In a decade’s time a majority of landside vehicles at large airports will be electrified. In 20 years virtually all of them will be, even in smaller airports. 

Rui Neiva is Ricardo’s Principal Consultant, Sustainable Transport, and Gareth Horton is Principal Consultant, Aviation





FUTURE SUSTAINABLE TRANSPORT

Redefining connectivity on a global scale

Cranfield Aerospace Solutions' Chief Executive **Paul Hutton** explains the role of hydrogen in the green aviation revolution

The introduction of zero-emission aircraft will enable us to re-think our approach to regional connectivity and the way we currently fly. A recent report by Project NAPKIN [see panel] stated that zero-carbon emission flight is entirely possible from the middle of this decade on sub-regional routes, on aircraft ranging in size from seven to 19 seats. The report also projected that it could be cost-effective to replace the entire UK regional fleet with safe, certified, zero-carbon emission larger aircraft by 2040, comprising 50 to 90 seats.

Last year's Aerospace Technology Institute's FlyZero study¹ and Airbus's 2022 technology summit both showed that significant research and development progress is being made with larger aircraft powered by hydrogen. Indeed, hydrogen combustion could potentially be used by larger aircraft from the mid-2030s.

But we do not have to wait until then.

There is an immediate role for hydrogen – and it will start small. Along with Ricardo's expertise in fuel cell technology, we are working to convert the propulsion system of a Britten-Norman Islander nine-seat aircraft to gaseous hydrogen. Our goal is to bring it into commercial service by 2026, flying routes of up to 200 kilometres.

We are encouraged that greater consideration for the sub-regional element of air travel is now taking place. Adjusting to net-zero aviation by 2050 (and even more stringent targets in certain countries) means operators across the world are viewing shorter journeys in a fresh light. Newer, sub-regional routes, relying on smaller, zero-emission aircraft flying from smaller airports close to the communities they serve, are increasingly being viewed as crucial building blocks and a way to prove hydrogen technology before it is matured to larger aircraft.

Resurrecting sub-regional airports

Air New Zealand is leading the way in considering how shorter routes could be served by smaller, zero-emission aircraft where traditionally much larger aircraft have been used, albeit inefficiently. At Cranfield Aerospace Solutions we are delighted to be the sole hydrogen-powered aircraft partner of Air New Zealand's Mission Next Gen Aircraft, the flag carrier's ambitious zero-emission aircraft programme. We will be working with three other companies worldwide to support Air New Zealand's mission to have its first zero-emission demonstrator flight in the sky from 2026.

This rethink will, of course, have knock-on effects to fleet management and operational models. But in this new age of aviation, everything needs to be reassessed. And with kerosene prices predicted to rise significantly as a result



“In this new age of aviation, everything needs to be reassessed”

Paul Hutton, Cranfield Aerospace Solutions

climate emergency while multiplying jobs and creating economic opportunities. Countries like the UK can flatten the research and development curves of the technologies, drive down costs and make adoption easier on a global scale.

The importance of targets


Targets are essential to help sustain the momentum required to reach our environmental goals. It is encouraging that in aviation stringent targets are not only being agreed upon, but some nations are choosing to set even more challenging ones. The International Civil Aviation Organisation's long-term global aspiration of net-zero carbon emissions by 2050 marks a turning point, by providing an international policy framework for the global aviation community to adhere to. But this should only be considered as the bare minimum.

There is much ground to cover between now and 2050 and many countries are throwing down the gauntlet to industry by implementing more near-term targets. Take, for example, the US states of California and Hawaii, both of which require net zero to be reached by 2045. In

terms of aviation, Norway has a target of zero-emission internal flights by 2040 and the UK Government also intends to consult next year on a target for domestic flights to reach net zero by 2040.

These targets clearly demonstrate the commitment to decarbonise aviation and have an important signalling effect in driving industry – and associated investment – to accelerate sustainability developments.

The road to true zero-emission aircraft will be complex. Different technologies will coexist for a period until a complete switch to zero-carbon and zero-emissions aviation can be achieved. But whatever the technology, there must be no let-up in pace: as an industry we must not be complacent. We must assume that eventually governments will intervene in response to public pressure and curtail air traffic volumes if the aviation sector does not meet its environmental goals.

We must all play our part, too – on the small scale and on the large, collaborating at home and with our compatriots on the other side of the globe. 

¹ati.org.uk/flyzero

of carbon taxes and the price of hydrogen predicted to fall as more renewable energy comes on stream for production, the cost equation is now changing.

Further investigation should also be given to how many sub-regional airports could be resurrected to serve sub-regional passenger services. In many cases the infrastructure is already there – it just needs an upgrade, and could additionally create a local hydrogen generation hub, powering not only the aircraft but the airport itself and possibly the surrounding community.

From an industrial competitiveness point of view, whichever nation takes a lead on delivering these early sub-regional green aircraft will have a significant strategic advantage over their competitors. The UK Government is sending the right signal with the publication and now implementation of its 'Jet Zero' strategy, setting out how we will achieve net-zero aviation by 2050. But there needs to be a greater sense of urgency.

Policy can drive innovation and, through innovation, the world has a unifying pathway towards addressing the

A sub-regional airport upgrade could also create a local hydrogen generation hub, powering not only the aircraft but the airport itself



Project NAPKIN – towards a UK hydrogen flight network

Project NAPKIN [New Aviation, Propulsion, Knowledge and Innovation Network] brings together three airports/airport groups [Heathrow, London City, Highlands and Islands], three manufacturers [GKN Aerospace, Rolls-Royce, Cranfield Aerospace Solutions] and three academic institutions [University College London, Cranfield University and the University of Southampton].

Its recent report, 'Making Zero-Carbon Emission Flight a Reality in the UK', evaluates 25 modified and original aircraft concepts to explore their impact on the five 'As' of Aircraft, Airport, Airspace, Airline and Air Passenger. By taking a whole systems approach, the project sheds light on

ground infrastructure, energy demand, noise performance and emerging passenger sentiment.

Project NAPKIN sets out how a UK hydrogen flight network can be achieved, taking account of aircraft capability, routes, commercial viability and scale. This shows where green hydrogen-powered aircraft can successfully be adopted in realistic market conditions.

The full report and associated studies are available at: heathrow.com/company/about-heathrow/future-flight-challenge/napkin



TAYLOR IN BRIEF

Title: Marketing and Communications Manager, Ricardo, based in Detroit
Background: Bachelor of Arts degree in Journalism, Michigan State University; marketing and communications roles for various consulting and engineering companies; since 2016, strategy development and oversight, key messaging, market research and competitive analysis, and digital marketing for Ricardo

“MY ROLE HAS EVOLVED TO FOCUS ON MEETING CUSTOMERS WHERE THEY ARE NOW, ANTICIPATING WHERE THEY WILL BE 20 YEARS FROM NOW AND SIMPLIFYING AND DE-RISKING THAT FUTURE”

A day in the life...

TAYLOR LEE

Getting up to speed for the Ricardo Mobility in 2035 Conference

Ricardo's Mobility Summit entitled 'Convergence: Energy and Mobility in 2035' is coming up in March. This one-day, in-person summit will bring together thought leaders, decision makers and industry disruptors from across the automotive sector to imagine what the future of mobility looks like.

My role is to facilitate the event from concept to completion. In addition to the core responsibilities around managing the venue and ongoing marketing and comms, I've been busy securing high-profile speakers and panellists. I'm delighted that we've got an impressive line-up, including Edward Hightower, President and CEO of Lordstown Motors [see pp10-13]; George Coates, Technical Director of WorldAutoSteel and Julie Fream, CEO and President of the Original Equipment Suppliers Association.

The conference is for people with their finger on the pulse of the future of mobility. Automotive C-suite and senior executives, leaders in the venture capital, private equity and tech start-up spaces, automotive and mobility suppliers, and policy innovators are all welcome to apply.

Our event will highlight some of the central themes from CES, the world's


most influential tech event and proving ground for global innovation, which I attended in January. One such theme was new technologies and products to address concerns over automotive safety and security.

From platforms that support Amazon Alexa automotive security, to software-based interior and exterior monitoring systems, to new telematic control units designed to support the development of advanced vehicle safety and mobility features, the CES show floor was filled with solutions for Level 4 [fully autonomous in controlled areas] and Level 5 [fully autonomous anywhere] vehicles.

Our role at Ricardo is to support our clients in managing these disruptive changes. We profoundly understand automotive technologies, from components to system level. We have experienced software engineers who understand deeply embedded software development. We have a digital engineering team who understand how to process data and make sense of it through machine learning and simulation processes. And, of course, Ricardo's strategic consulting team can help our clients understand market trends and be better prepared from both technology

and business strategy standpoints. This is a unique combination of competencies.

I've been with the business for seven years and my role, like that of my colleagues, has evolved to focus on meeting customers where they are now, anticipating where they will be 20 years from now and simplifying and de-risking that future so they can realise the promise of their growth faster. This means continuously innovating to immerse ourselves in the opportunities and risks of the next generation of technologies, so we can guide our clients from an informed position.

Companies in the automotive and transportation sectors need to adapt. My work involves marketing the historic and world-class capabilities our company was founded on but positioning our expertise in an exciting new era for mobility. The Ricardo Mobility Summit is a perfect opportunity for networking and connecting in-person with like-minded changemakers. 

The Ricardo Mobility Summit, 'Convergence: Energy and Mobility in 2035', is on 9 March at The Madison in Detroit. To apply, visit: bit.ly/globalmobilitysummit

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PLANNING FOR UNCERTAINTY

If your strategy is robust against our scenarios, then it will very likely be robust against whatever reality brings us.

Scenario planning is a well-established tool for developing a strategy that embraces the inherent uncertainty of the future. **Ricardo has created four scenarios from the perspective of the world in 2035** to test robustness, to highlight gaps between vision and existing strategies, and **to identify opportunities and challenges for businesses.**

VIEW THE SCENARIOS AT RICARDO.COM/MOBILITYIN2035
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