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Does hydrogen have a home in mobility?

Jaiwon Shin weighs in on **urban air mobility** | **Ample**'s founders back battery swap | **Volkswagen** sheds light on fully autonomous van project | **StreetScooter** awaits investment lifeline | **Panasonic** revolutionises dashboard display with augmented reality

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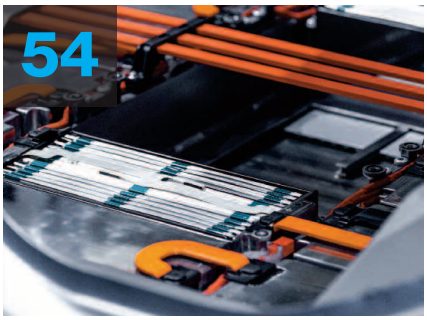

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Does hydrogen have a home in mobility?

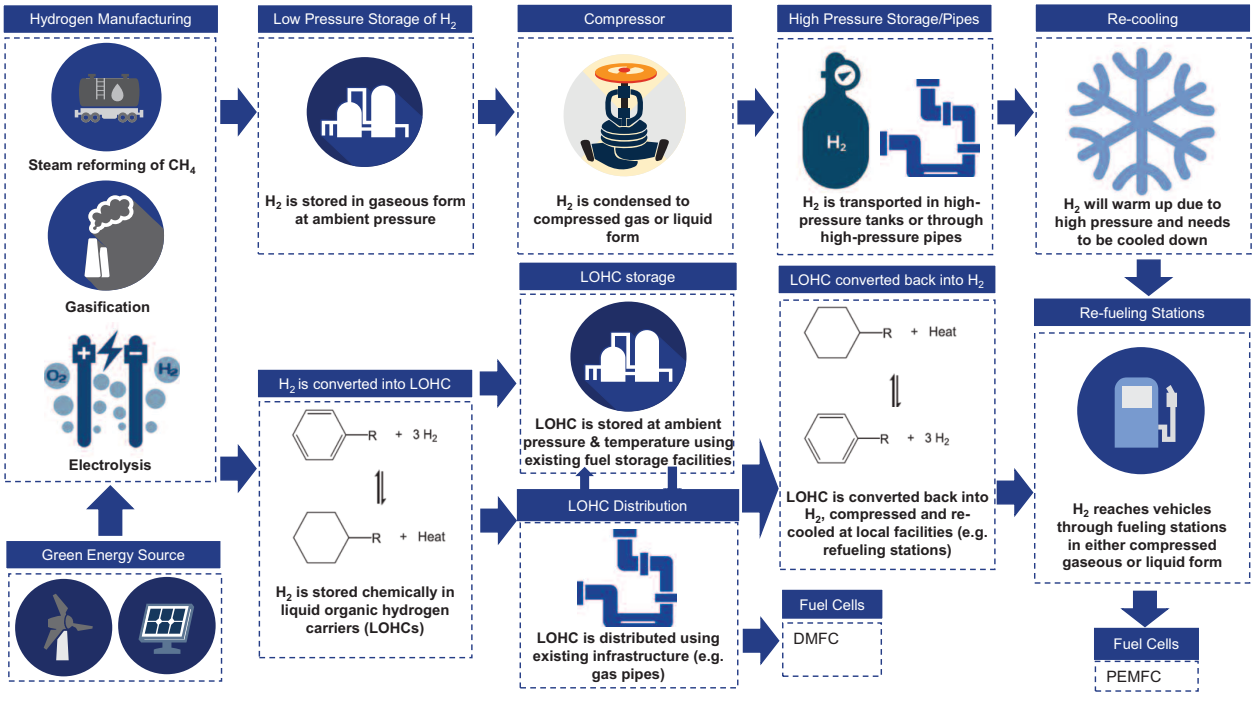
Hydrogen-fuelled mobility has the potential to address transport sector emissions, but it is not without its challenges. By Michael Zhan and Michael Bunker

Despite rapid growth in the uptake of battery electric vehicles (EVs)–especially cars and vans–a zero-emission solution has yet to be decided upon for the transport sector, which is responsible for considerable carbon emissions.

In the UK, heavy goods vehicles (HGV), maritime, buses and rail account for at least 26% of the country's transport emissions. Using the UK as a case in point[1], this article explores the challenges and opportunities for hydrogen fuel in addressing these emissions.

The application of hydrogen fuel in road transport is a highly involved process from energy generation to the fuelling of vehicles at refuelling stations. There are four key considerations: the potential benefits and current gaps of hydrogen fuel in

The value chain of hydrogen fuel in transport



transport; the relationship between hydrogen fuel prices and production methods; compression, storage and distribution (CSD) infrastructure; and carbon capture facilities for blue hydrogen.

> “Whilst hydrogen has real potential as a zero-emission fuel, it requires significant collaboration between government and industry, and an energy systems-wide approach to make it commercially viable and sustainable from well-to-wheel

Benefits of hydrogen fuel cell technology

Supply chain and market competition: Given the limited supply of rare metals to make EV batteries, hydrogen will soon play an indispensable role in delivering zero emission transport (notwithstanding the need for batteries in FCEVs). In addition, the natural abundance of hydrogen means it has the potential to level competition in the automotive sector, whereas the supply of raw materials for EV batteries is controlled by a few large players.

Accessibility: Hydrogen can be transported to areas which are not easily accessed by the power grid network.

Powertrain applications: Hydrogen has a higher gravimetric (per unit of mass) energy density than both diesel and EVs, especially when compressed. This means that less space and weight is required for the fuel, making it more suitable for long-distance driving and vehicles with higher traction requirements, such as HGVs.

Environment and end of life challenge: FCEVs need fewer rare metals obtained through carbon-intensive mining activities. Only a small battery is required to regulate the speed of each vehicle. A smaller battery also means that FCEVs are less exposed to end of life and residual value-related challenges and risks when compared to EVs.

Economic opportunity: Hydrogen is a relatively less-trodden path to decarbonising transport. Given the UK’s relative strength in this space, especially Scotland, it opens up opportunities for inward investments and economic growth.

Current gaps in hydrogen fuel cell technology

Maturity and reliability of technology: The pace of maturity in hydrogen technology could vary from one application to another. The first five years of the Aberdeen Hydrogen Bus Project have reportedly seen a number of reliability issues with the single decker buses. A second phase involving double decker buses for the next five years is now taking place to further progress its maturity.

Similar demonstrator projects are planned to prove the concept in other road use cases, and in March 2021, the UK government announced a number of investments to support research, development and trialling of hydrogen fuel cell use cases. This includes £3m (US$4.16m) for the development of a Hydrogen Transport Hub in North East England, and £4.8m for the development of an HGV hydrogen fuel hub in Wales.

Competition from battery technology: The development of hydrogen fuel is racing against the clock as battery technology innovations continue apace, including for HGVs. Tesla, for example, has developed a battery-electric truck which has a potential driving range of 300 to 500 miles.

Storage complications: At normal temperature and pressure, hydrogen exists in gaseous form, meaning it must be compressed first. Hydrogen fuel also needs to be stored and transported under high pressure or in

Figure 1.1: Fuel cost comparison over a fixed distance of 100 km

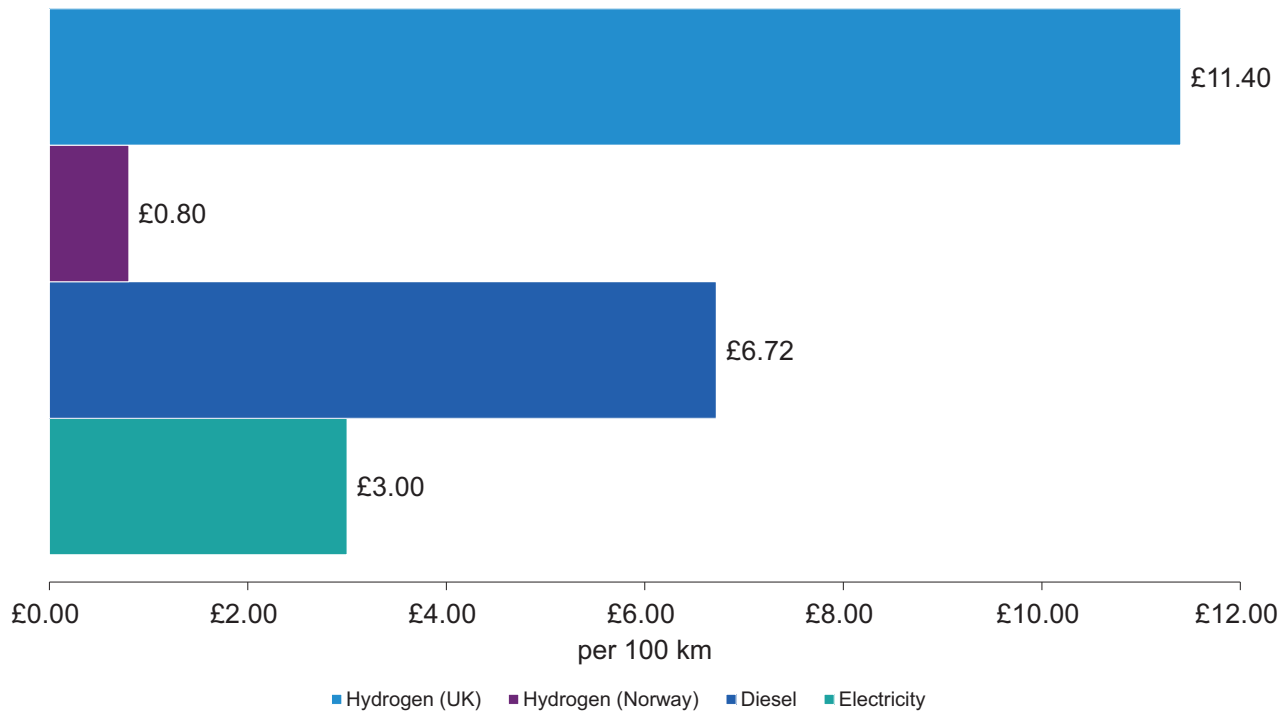


Figure 1.2: Comparison of costs and emissions of hydrogen produced through a variety of production methods[5] [6]

Means for production	Cost range (USD per kg of H2)	Scale of production required by 2030	Capital Costs (USD m)	Carbon emissions	Energy conversion efficiency
Water Electrolysis	6.60 - 8.25	2,000 tonne a day	499.6 - 504.8	Low (or Zero)	70 - 80%
Steam Methane Reforming without CCS	4.50 - 8.00	30,000 tonne a day	180.7	High	70 - 85%
Biomass Gasification without CCS	4.00 - 7.20	50,000 tonne a day	146.4 - 149.3	Medium-High	90%

cryonic environments, creating logistical challenges.

Emissions: Although hydrogen drastically cuts emissions, without abundant renewable energy, much of the production process is still dependent on fossil fuels.

Green hydrogen is expensive: Water electrolysis, the only zero-emission process of hydrogen extraction, is very expensive at its current scale of production.

Understanding the challenges

Hydrogen fuel prices: The price of hydrogen fuel in the UK remains markedly higher than that of other fuel types (shown in Figure 1.2). With green hydrogen further exaggerating these costs, there is a need for stimulus in the form of government support to bridge the cost premium of hydrogen over other fuels–at least in the short term–if it is to be a commercially viable zero-emission alternative in the next four to five years.

Benefits to these enablers can be seen in the case of Norway, where the combination of forging new hydrogen production methods with government incentives, such as tax exemption, has led to a dramatic reduction in production costs.

Indeed, a study conducted by the California Energy Commission has estimated the cost of hydrogen per kg could fall from US$14-US$18 to US$6.60-US$8.25 by 2030, which is comparable to the cost of diesel today[2].

Hydrogen production methods: There are two methods at the forefront of hydrogen production. The first is steam methane reforming, which involves the steaming of natural gas. It is the cheapest and most widely used method in hydrogen fuel production today; 1kg of hydrogen requires approximately 0.490MJ of electricity and 3kg of natural gas which is equivalent to 165MJ in total. In kWh terms, this is roughly equivalent to 46 kWh/kg of hydrogen[3].

The second is electrolysis, which works by separating hydrogen from water using electricity. This method is less widely used but is the only zero carbon emission approach to produce hydrogen. The amount of electricity required is approximately 55 kWh/kg

A hydrogen generation container from ITM Power

of hydrogen[4]. Whilst being a fully zero emission method for producing hydrogen (subject to the use of renewable energy), electrolysis is still the most expensive production method. A 2030 projection outlining the costs and emissions of the differing methods is shown below.

Conversion, storage and distribution infrastructure

In principle, hydrogen can be stored and transported in two forms: pure liquid/gas, or in the form of liquid organic hydrogen carrier (LOHC) which allows it to be stored and transported with existing infrastructure. Capital and operating costs of CSD infrastructure for hydrogen are influenced mainly by the costs of conversion, storage and distribution.

Handling hydrogen in its gaseous form is the most cost-effective approach to CSD. However, LOHC as a means for storage is beginning to demonstrate cost parity with storage mechanisms involving hydrogen gas, not least because it minimises the requirements for new infrastructure by being able to use existing liquid fuels storage and distribution infrastructure. Further research has also indicated that there is an opportunity to combine the stored carbon dioxide in carbon capture and storage (CCS) facilities with hydrogen to create a LOHC, allowing it to be reused in the hydrogen economy.

Together with the nascency of the technologies, ongoing concerns include that a large scale of LOHC demand will be required to incentivise LOHC manufacturers to build a facility which will enable the optimisation of heat energy involved in the

exothermic (hydrogenation) and endothermic (dehydrogenation) reactions required to lock and unlock hydrogen. In addition, a large amount of energy is required to facilitate the dehydrogenation reaction at ~10 kWh/kg of hydrogen fuel.

Notwithstanding these concerns, investment in large-scale LOHC developments is taking place, with examples including Hyundai investing in Germany-based Hydrogenious LOHC Technologies GmbH, and Japan's circular supply chain set up between Brunei and Kawasaki City utilising toluene-based LOHC technology.

> "Given the limited supply of rare metals to make EV batteries, hydrogen will soon play an indispensable role in delivering zero emission transport

Carbon capture facilities for blue hydrogen / LOHC

CCS is the process of capturing and storing CO2, which will be essential in offsetting the carbon emissions resulting from the production of blue hydrogen. The most notable move in the UK on CCS is the plan of a major Norwegian energy player, Equinor, to create a new hydrogen and CCS facility near the city of Hull, which would be the largest of its kind.

However, the high cost of CCS has thus far kept the technology from entering mainstream use, with cost fluctuations dependent upon the source of the carbon captured, the distance to the storage site, and the nature of the storage site itself. The Carbon Capture & Storage Association (CCSA) estimated that the early CCS projects in the power sector would cost around US$69-US$103 per tonne of reduced carbon dioxide. Furthermore, possible environmental and climate change damages can be caused by CO2 leakages from carbon storage sites.

Conclusions

What does this mean in terms of opportunities for the government and key players in the market? Based on the considerations set out above, the following actions are relevant to various stakeholders.

Automotive OEMs should conduct demand projection analyses to inform product strategies, and production and aftermarket infrastructure planning. They should

work with CDS infrastructure providers to identify refuelling requirements and opportunities to reduce costs. On CCS, they should consider vertical integration investment opportunities.

Government and local authorities should develop a system-wide approach to the provision of renewable energy derived from hydrogen fuels, and encourage R&D and investment in CSD infrastructure through grant funding and tax policies. On CCS, they should develop environmental standards for CCS facilities.

Energy, oil and gas companies must perform full demand, cost and benefit analysis of blue hydrogen and CCS versus green hydrogen to inform investment strategies, as well as analyses of handling pure hydrogen versus LOHC, and blue hydrogen combined with CSS versus green hydrogen.

New entrants and academics must work towards innovative solutions to unlock efficiencies in the value chain, and develop innovative solutions which address the cost challenges in CSD infrastructure. They should also develop solutions which will allow stored carbon to be re-utilised, potentially in the manufacturing of LOHC.

Financiers will have opportunities to explore across the entire value chain.

In conclusion, whilst hydrogen has real potential as a zero-emission fuel, it requires significant collaboration between government and industry, and an energy systems-wide approach (including heating and power) to make it commercially viable and sustainable from well-to-wheel. Furthermore, additional research, development and trials are required to improve the performance characteristics of hydrogen fuel cell electric vehicles (FCEVs), and to further reduce the cost of hydrogen production and fuel cell manufacturing.

[1] *https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018*

[2] *https://cafcp.org/sites/default/files/Roadmap-for-Deployment-and-Buildout-of-RH2-UCI-CEC-June-2020.pdf*

[3] *https://www.researchgate.net/figure/Steam-methane-reforming-inputs-and-outputs-to-produce-1-kg-hydrogen-41_tbl1_282393135*

[4] *https://cleanenergypartnership.de/en/faq/hydrogen-production-and-storage/?scroll=true*

[5] *https://cafcp.org/sites/default/files/Roadmap-for-Deployment-and-Buildout-of-RH2-UCI-CEC-June-2020.pdf*

[6] *2019, Kayfeci et al, Elsevier, Solar Hydrogen Production Processes, Systems, and Technologies, Chapter 3*

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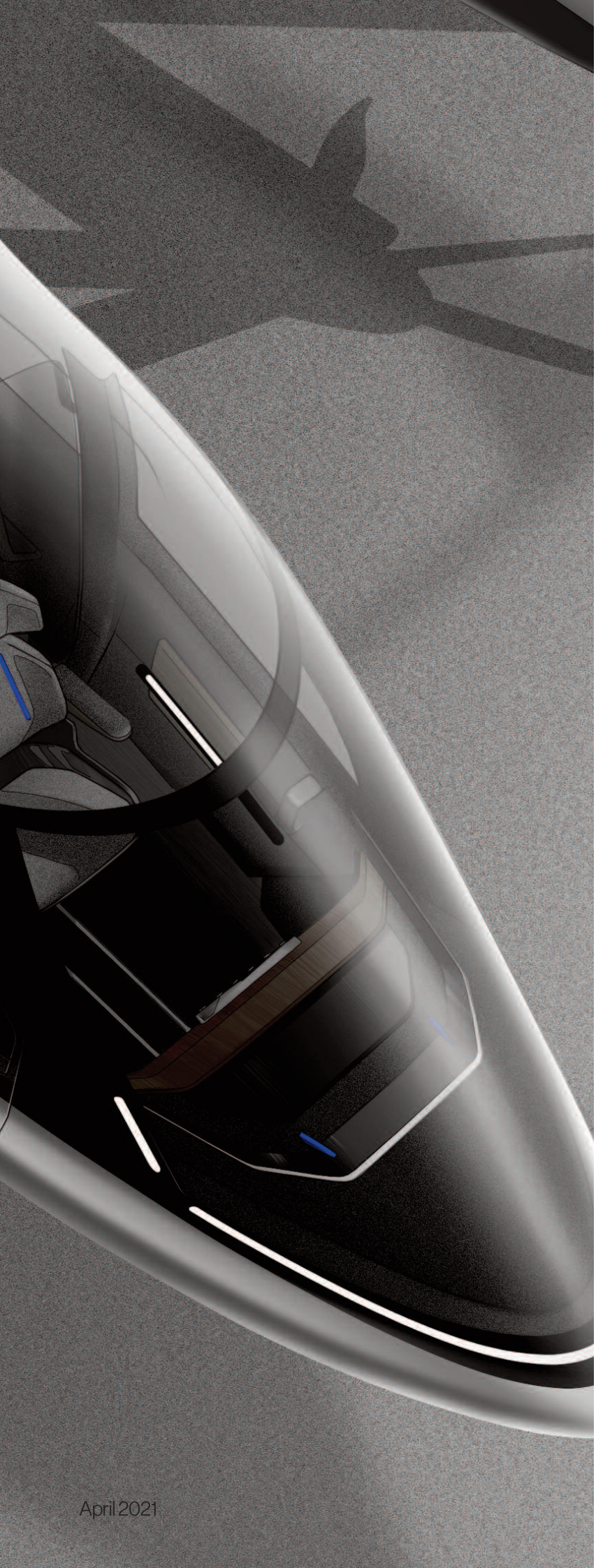
Multi-modal mobility success hinges on cracking the third dimension

Ground transport alone cannot support the projected growth of urban populations, warns the C-Suite at Hyundai's Urban Air Mobility Division. By Megan Lampinen



Urbanisation, congestion, emissions regulations and an unquenchable desire to move from A to B are placing more demands than ever on city transport systems. Many believe that the industry is heading towards a future of multi-modal mobility, where various forms of connected transport are used in different stages of the journey: an autonomous ride-hailing taxi picks someone up at the door on a rainy morning and takes them to the train station, and after the train ride, as the weather clears, they hop on an electric scooter for that last mile into the office. The idea is to spread the population of travellers across various modes, reducing the pressure on any one mode at a single time and optimising individual journeys in real-time.

In theory it sounds like a mix of ride-hailing, buses, trains, bikes, scooters, and private passenger cars could cover all the necessary use cases of today's travellers, but what happens when that travelling population grows? The world population is forecast to grow to 9.7 billion people in 2050, and two-thirds of this total will be concentrated in urban areas. To handle that sort of volume of travel demand, the industry may need to take to the skies.

Hyundai's vision

That's the view of proponents of urban air mobility (UAM), including Hyundai Motor Group. While Hyundai's roots are in vehicle production, the automaker is actively transitioning to become a smart mobility provider, and believes the third dimension will become a critically important part of integrated mobility solutions in megacities. With that in mind, it brought in aeronautics expert and former NASA Associate Administrator Jaiwon Shin to steer its Urban Air Mobility

The S-A1 concept can carry up to four passengers, is capable of vertical take-off and landing and has a cruising speed of 180mph at an altitude of 1,000-2,000 ft

Division. Today Shin serves as Chief Executive of UAM as well as President of Hyundai Motor Group.

"There is absolutely no way, in my mind, that ground system transport only can support the projected growth of metropolitan areas," Shin tells *Automotive World* He points to the concept of latent demand, adding: "No matter where you put new streets or new lanes to support ground systems, they will be filled up in a matter of weeks. And the cost is prohibitive."

Shin and his team do not expect air taxis to replace other modes of mobility but rather fill out the multimodal ecosystem vision. "We want to make mobility not so much a choice between modes but a service that people can take advantage of," says Pamela Cohn, Chief Operating Officer of the Urban Air Mobility Division. This service, she clarifies, must be integrated, intermodal and seamless. "It shouldn't be a question of 'do I want to take an UAM vehicle or a ground vehicle?', but more an issue of 'I need to get to point B from Point A' and an app guides you through a seamless journey."

The plan

Having a vision is one thing, realising it is another. The shift from vehicle manufacturing to UAM has not been as dramatic for Hyundai as it may seem, Shin explains: "Hyundai Motor Group has many advanced manufacturing technologies and capabilities associated with mass production, which is important for UAM because we will need tens of thousands—or hundreds of thousands—of aircraft to serve the global community. It's very different from the traditional aviation industry." Unlike aeroplanes, UAM vehicles are expected to carry just a handful of people.

He also suggests that advances with autonomous driving and electrification will aid Hyundai's

efforts on this front, particularly around sensor suits and control technologies. “There are many similarities and capabilities that we can leverage,” he says.

Hyundai publicly unveiled its UAM vision at CES 2020 in the form of an electric air taxi prototype, the S-A1. Human-driven to start, this will eventually become an autonomous vehicle ferrying people and goods from urban hub to urban hub. Engineers are currently at work on what will eventually be a safe, quiet, affordable and high-performing vehicle, with a launch date set for 2028. Meanwhile, another part of the UAM team is working to make sure the world is ready for it. “Much of our focus has been on the ecosystem around the vehicle as opposed to the vehicle itself,” says Cohn. For instance, recent milestones include a partnership with Urban-Air Port for a hub project in Coventry, in the UK, and a similar collaboration through Urban Movement Labs with the Los Angeles Department of Transportation in the US.

> “UAM is just a fancy flying science project if we do not have infrastructure in place to support it

More than just the vehicles

Infrastructure is a big part of the necessary ecosystem, and this covers both physical infrastructure, such as the vertiports from which the vehicles take off and land, as well as digital infrastructure, like the data management system. “UAM is just a fancy flying science project if we do not have infrastructure in place to support it,” Cohn tells *Automotive World*.

Even with this in place, though, there must be an element of public acceptance. Hyundai has been engaging with the public to better understand their experiences and

concerns around UAM. “If you go outside of the more tech-focused communities to the average folks that would need to use these technologies, they do not know enough about it,” she concedes. “We haven’t talked enough about UAM in the mainstream media for people to even understand what the concept is.”

Shin echoes Cohn’s concerns on this front: “Public acceptance could be quite challenging, especially at the beginning. There are always some early adopters with new technology, drawn to it out of curiosity or a sense of fun, but that will not trigger mass uptake.” The key, he believes, will be in conveying the great convenience UAM offers. Providing them with the chance to experience the technology could be essential.

Then there are issues around air traffic control, and this is where Shin’s background could really come in useful. While at NASA he started the sUAS (small unmanned aerial systems) Traffic Management (UTM) programme for drones. “In essence this is a distributed system, not a centralised one, and each operator can share information to prevent the drones from colliding with each other,” he explains. “It’s rather like the landscape of cell phone providers, with multiple operators who will operate their drones by sharing information, the location of drones and so on.”

This differs from a conventional air traffic management system but the heart of UTM, he believes, is suitable to manage the emerging UAM industry. “It’s still a challenge,–I’m not trying to minimise the importance of new air traffic management, but the basis is being established there,” Shin asserts.

There are also technical challenges with the vehicle itself still to iron out, particularly around the zero-emission propulsion system. “It has to be eco-friendly,” he insists. “You cannot have an internal combustion engine pumping out emissions. Almost all UAM vehicle developers are going after all-battery powertrains but the energy and power density of batteries is not there.” At the same time, the solution must end up being cost effective, allowing operators to make a profit. For that, the human driver may need to be taken out of the equation, and that means perfecting autonomous operation.

In the vanguard

Regionally, Shin expects the US, Europe and Asia could pave the way on UAM. US culture is heavily based on private vehicles and its public transport, outside of major cities, pales in comparison to what is seen across Europe and Asia. Combined with

horrible traffic congestion, he believes this will produce "ripe condition for opening up the third dimension within the megacities."

lose out on the first mover advantage, but it's a calculated risk. "There is always benefit to being the first one out there but we do not

> There is always benefit to being the first one out there but we do not think that the first mover is the one that wins this market

The first applications, though, may not involve human passengers. UAM could find an early use case in transporting cargo, particularly in island regions. It's also a more forgiving use case for new technology. "Cargo doesn't complain," Shin points out. "When you don't have to carry people, many things could be done faster. I'm not suggesting that we can make the vehicle less safe, but if you change the mission profile or flight profile, if that involves a steep climb and steep landing to save time and energy, cargo won't complain. Both technically and demand-wise, the logistics market probably will open first."

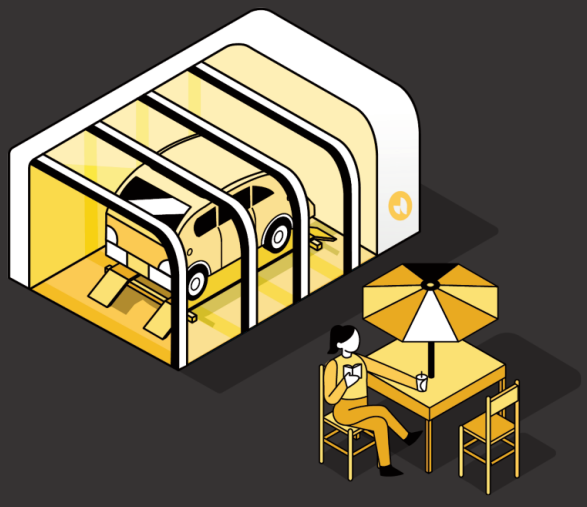
Whether it's carrying people or cargo, Hyundai's timeline for market launch is a relatively long one. While it has not yet confirmed a launch date for cargo applications, it doesn't expect to have an all-electric intracity air taxi on the market until 2028. That pretty much guarantees it will

think that the first mover is the one that wins this market," says Cohn. "We do not think that the market is going to be ready until about 2028, both in terms of infrastructure and public acceptance."

Shin emphasises the immaturity of the whole UAM space, which represents a brand new industry. "It is different from Volkswagen coming up with a new model, where all the infrastructure, policy and sales networks are in place," he says. "When you consider everything around air traffic management, the challenge of setting up vertiports in city centres, consumer acceptance–I do not think 2028 is late. We are not only trying to develop a new vehicle but also working with numerous other segments of industry that need to come together to form a comprehensive ecosystem. Unless all these elements are developed together and advancing together, this endeavour will not succeed."

Power to the people: battery swapping could bring EVs to the masses

Battery swapping tech could slash recharging times and costs, and create a more flexible battery economy. By Jack Hunsley



Alongside range anxiety and high entry costs, recharging times are one of the most common concerns among potential electric vehicle (EV) buyers. But what if there was a way to make the re-charging experience more 'gas-like'?

This is what Californian start-up Ample is attempting. The company has spent the last seven years in stealth, but has recently opened three battery swapping stations in and around San Francisco–stations which it claims can get EVs back on the road in as little as five minutes. In January 2021 it also revealed a partnership with Uber on the ride-hailing company's electrification strategy. To learn more, *Automotive World* spoke with Ample co-founders Khaled Hassounah, Chief Executive, and John De Souza, President.

Ample claims its stations can be used by any EV

Faster, better, stronger

Battery swapping is by no means a unique concept in automotive, with the likes of Tesla and Nio having engaged the technology, but where Ample believes it stands out from the crowd is that its tech can be applied to any EV. "Think of it as a double-A battery standard for an EV battery," Hassounah explained. "It varies by the size of the vehicle and how much space is available, but it's built so that it can be installed as simply as a regular battery and within it, we install our modules that are easy to take in and out."

Rather than plugging vehicles into a charging point, vehicles are driven into a pod-like structure that can adjust automatically according to the given vehicle's wheelbase. The vehicle is then lifted, and the battery is removed from underneath using a robot. A fully-charged battery is then inserted. The whole process takes between five and ten minutes, placing Ample's solution on a similar playing field to today's fast charging tech. It is also a much cheaper alternative when compared to fossil fuel vehicles. "It clocks in at about 10% to 20% cheaper than gas today," added Hassounah. "We are already working with five OEMs and all of them can swap in the same station."

Not only is Ample's tech brand-agnostic, but it can also keep up with the latest battery trends. "Right now, when you're buying a car, sometimes people are hesitant because they're not sure if the next car or battery technology might be better," De Souza told *Automotive World*. "We take that anxiety away. You can keep your car for ten-plus years because you'll have access to better batteries and you do not need to worry about your battery degrading or having to replace it at a huge cost."

New and different battery chemistries can also be integrated. "The moment our batteries go into any vehicle, they quickly understand which vehicle they are working with and it can vary

the operating characteristics to match what the car expects to see," Hassounah added.

Industry interest

The early signs are that the industry is interested. Ample has raised more than US$70m in funding to date, with investors including Shell and Repsol.

> "We have a system that's ready to be scaled and deployed and allows us to deliver energy to EVs with very little capital expenditure required to build an infrastructure

Uber also sees the start-up as a key contributor in its aim to electrify all its rides in the US, Canada and Europe by 2030. "Uber's challenge at the end of the day is that it has to make the economics work," said Hassounah. "The company cannot just say it will go electric and spend the money to do it. It has to do it in a way where it is profitable for business and its drivers."

That latter point is the most critical from Ample's perspective. "EVs so far have been targeted at more affluent customers, people that have the luxury of charging overnight at home," added De Souza. "If you want all these ride-hailing vehicles to go to electric, drivers need access to chargers and where most people live is not where the chargers are currently being built. Our solution gives real access to everybody."

Ample also hopes to use its ride-hailing foundation to rapidly scale-up in major cities across the world. This will aid not just the ride-hailing sector, but the average commuter too. "We have a system that's ready to be scaled and deployed and allows us to deliver energy to EVs with very little capital expenditure required to build an infrastructure," said Hassounah. "Given just a few weeks and whole cities will be ready for a gas-like experience for EVs. When we go to London and Madrid and Los Angeles and the rest of Europe, we'll be able to do the same as we have in the Bay Area."

Ample also sees renewable energy as a critical component of its stations. The company will use wind and solar energy at its battery storage pods to supply the required electricity, a

"Think of it as a double-A battery standard for an EV battery" – Khaled Hassounah, Chief Executive

move it claims solves one of the biggest challenges around EVs and renewable energy production. "This allows us to work with renewable energy to ensure that as fleets are using the pods we can pull as much renewable energy as we can into vehicles," said De Souza.

One billion vehicles

Ample's ambitions are certainly bold, with Hassounah hoping the battery swapping tech can help get "one billion EVs on the road by 2030," though BloombergNEF projects that by this date EVs will account for just 8% of the world's 1.4 billion passenger cars and even by 2040 that there will be just under 500 million EVs worldwide. Statistics aside, Ample hopes its tech will enable rapid uptake.

"If you were to try to sell someone a wonderful fossil fuel car but you had to tell them that the only drawback is that it takes one to two hours to fill the gas tank, nobody would buy it," said De Souza. "People want to go electric. They want to help decarbonise the environment. If you want to get to a billion cars we need to make the recharging process at least as easy, if not easier, than filling a fuel tank."

Will battery swapping prove to be the dominant charging solution? Even Ample is unsure. "If you're charging your car overnight and drive in the day, traditional charging is a wonderful solution," said De Souza. But given the high utilisation rates of ride-hailing vehicles and the promise of Level 4 and 5 autonomous vehicles that may operate up to 24 hours a day, battery swapping could be a critical component in enabling a truly electric mobility future. "Companies are spending huge chunks of money developing autonomous vehicles with the promise that they'll unlock high utilisation rates," said De Souza. "Our solution is perfectly compatible with that vision because we can deliver energy very quickly."

VW ramps up commercial vehicle automation

The automaker will test prototype shuttles in Germany this summer, with an eye toward commercialising autonomous vans in 2025.
By Freddie Holmes

Volkswagen's commercial vehicles division has shed light on its plans to make fully autonomous vans for on-demand mobility and transportation services. Urban road trials will begin this year and deployment of production-ready models of the ID.BUZZ could hit the road as soon as 2025.

The initiative follows a Volkswagen Group board meeting late in February, which confirmed the budget for Volkswagen Commercial Vehicles' (VWCV) autonomous driving R&D programme. The company says that CVs are the "logical first choice" to apply the autonomous driving systems being developed by Argo AI, a Pittsburgh-based start-up in which both VW and Ford have invested. The two automakers confirmed rumours of a strategic partnership back in 2019, which will see the pair collaborate on electric and autonomous vehicle technologies.

VWCV's autonomous activities will kick off with a new round of field trials in Germany this summer, which will put Argo's self-driving system to use. The vehicles in question are based on the ID.BUZZ, a fully electric van designed squarely for autonomous MaaS use cases.

"It offers plenty of passenger space and has a versatile interior–ideal for a driverless people mover in the future," a spokesperson from VWCV's mobility and transport-as-a-service team told *Automotive World*. "Think of the MOIA vehicles in Hamburg, Germany, only with a more compact cabin and as an autonomous drive concept." The spokesperson confirmed that the ID.BUZZ has been developed purely by VWCV and is not part of the joint development project with Ford. A non-autonomous version is due to launch in 2022.

VWCV says it is the Volkswagen Group's 'lead brand' for automated mobility on demand. The ID.BUZZ will be the first of many special purpose vehicles (SPVs) built by VWCV. As the name would suggest, SPVs are purpose-built for the job at hand–be that ferrying passengers or transporting goods–rather than simply modifying a standard van.

> "The most powerful test facility is the real road with its endless and unpredictable challenges

Various automakers are developing flexible platforms that can be used to support multiple vehicle types. Kia is in the early stages of shaping a purpose-built vehicle (PBV)

Through MOIA, Volkswagen is already deeply invested in mobility-as-a-service

business in Singapore, for example, while its parent company Hyundai Motor is working with California start-up Canoo on 'fully scalable' skateboard platforms. Electric CV start-up Arrival has also touted this approach as a means of ensuring scalability and reduced R&D costs.

VWCV advised that the team is excited to get the first field tests under way. These will take place in built-up urban areas to replicate the kind of environment in which these vehicles will eventually operate. "Our R&D team focusses on metropolitan driving conditions," the spokesperson explained, because "the road situations with Europe are very diverse, more so than in the US or in China. Think of historic brick stone streets from the Middle Ages, with few signs, missing street lines and uneven road surfaces. Testing in various traffic situations is necessary to cope with those challenges."

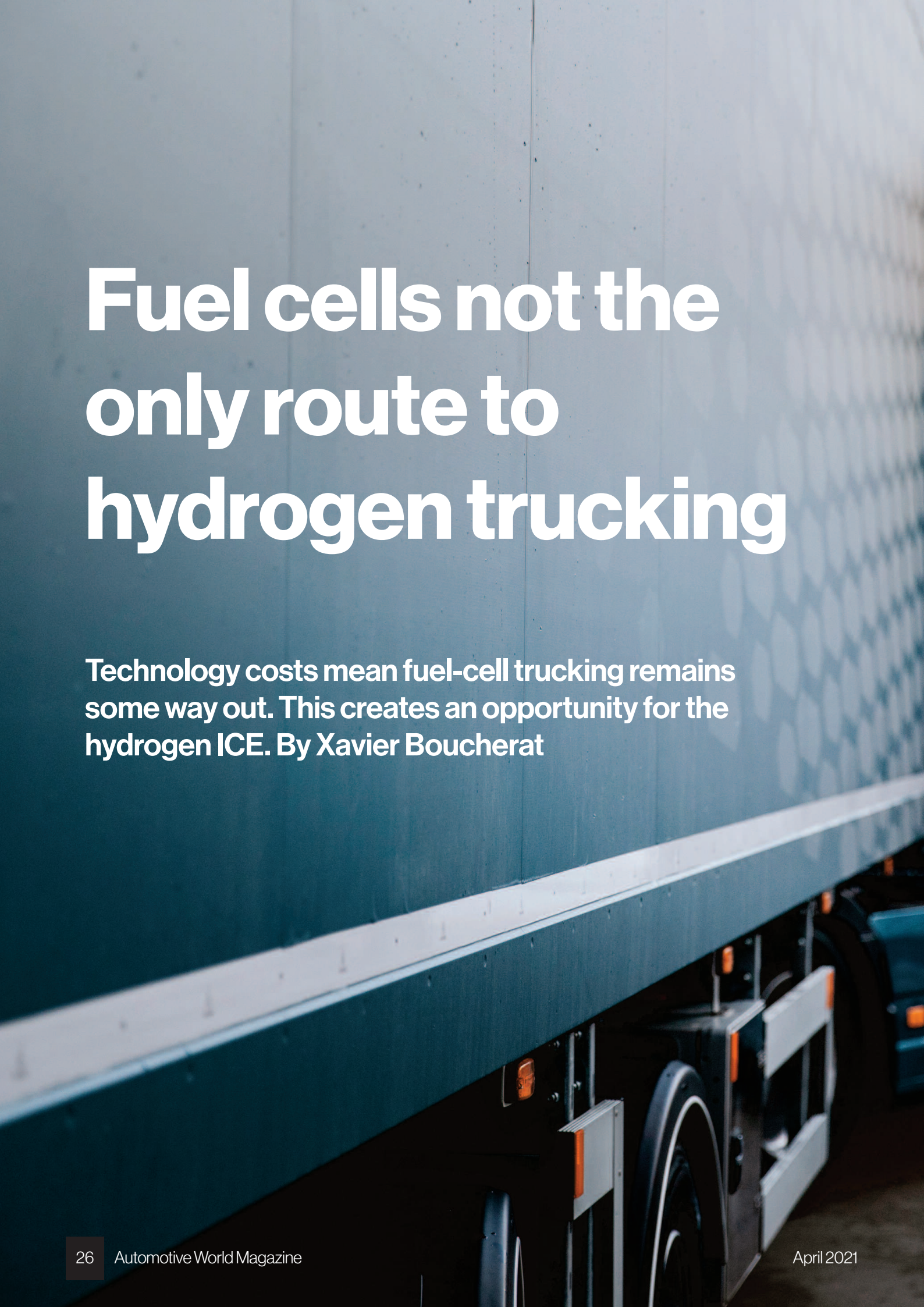
Road testing is critical for improving autonomous driving systems. Prototypes are also trained through simulation and on private tracks where scenarios can be repeated many times over in a safe environment, but there is no substitute for the real world. Field trials will also provide an opportunity to observe the practicalities of how a driverless service might run on a day-to-day basis. Ford has already tried and failed on the MaaS front as its human-driven Chariot service failed to attract enough riders, but the expectation is that driverless services could generate easy profits.

The ID.BUZZ shares similarities with the vans used in MOIA pilots

VWCV's spokesperson agrees that public road tests will be pivotal to the development of its autonomous ID.BUZZ and other autonomous SPVs in future. "The most powerful test facility is the real road with its endless and unpredictable challenges," he emphasised. "Our long-term use case at Volkswagen Commercial is mobility as a service."

Germany has emerged as a hot bed for autonomous driving within Europe, with various automakers, Tier 1s and tech start-ups already testing on public roads in cities such as Hamburg, Munich and Friedrichshafen. However, Germany's automotive association VDA warned in February that the government "is currently jeopardising Germany's potential lead in autonomous driving" by creating "extra work" for the industry. For example, a draft regulation published in February would make test vehicles subject to a full technical inspection every 90 days; VDA argues there are "no technical reasons" for this, and that it would hamper developers.

With approval from the Volkswagen Group supervisory board, the stage is set for VWCV to ramp up its autonomous driving activities. Driverless last-mile delivery services garnered significant interest during 2020, and so the move comes at an ideal time.



Fuel cells not the only route to hydrogen trucking

Technology costs mean fuel-cell trucking remains some way out. This creates an opportunity for the hydrogen ICE. By Xavier Boucherat

Recent research from FTI consulting suggests that whilst fuel-cell technology will eventually offer the trucking sector a greener means of propulsion at price parity with diesel, that day remains many years out. A successful scaling of costly fuel cell technology will depend on the widespread availability of green hydrogen–fuel produced via renewable means, delivering an environmental benefit. Discounting any major political interventions, FTI does not expect this will become competitive with grey hydrogen–fuel produced using fossil fuels–and battery electric vehicles (EV) by 2040.

Yet with numerous hydrogen infrastructure projects coming online and the increasing availability of 'blue' hydrogen–fuel produced in tandem with carbon capture technology–some are looking to the hydrogen-powered internal combustion engine (H2 ICE) to deliver near-term emissions reduction. Hydrogen is a readily combustible fuel, and H2 ICEs produce little in the way of CO2 or particulate matter (PM) emissions. However, like in a diesel truck, combustion still produces harmful oxides of nitrogen (NOx), and cannot be considered zero-emission, unlike fuel cell electric vehicles (FCEV).

Nevertheless, there is enthusiasm. In October 2020, Traton's Man Truck & Bus announced that 2021 trials of hydrogen technologies would include an H2 ICE, a solution it calls "more readily available and robust due to the well-known basic technology."

Engineering groups are also keen. "We must consider the relevant application scenario when making technology choices," said Stefan Pischinger, President and Chief Executive, FEV

Group, in October 2020. “This has prompted a significant step-up of the debate surrounding the hydrogen ICE as another sustainable drive form with vast potential for numerous areas.” Indeed, FEV believes H2 ICEs could prove more than an intermediary step: FCEV efficiency, they argue, deteriorates as the load of a vehicle increases. By contrast, H2 ICE efficiency may be poor at low loads, but increases with weight.

Mission profile is critical

AVL also believes the H2 ICE will be a major pillar of CO2 neutral goods transport. Speaking in a recent Mobex webinar, Bernhard Raser, Product Line Manager, ICE-based Powertrains for Truck and Bus, AVL, stressed the real possibility of competitive total cost of ownership (TCO), provided the application was suitable.

“In terms of TCO, the mission profile has a very high influence,” he said. “We are targeting vector-based long-haul applications. Compared with FCEVs, the H2 ICE has a clear disadvantage in terms of fuel consumption. However, in the near term, the much lower upfront costs of a combustion engine make the H2 ICE a more attractive solution in terms of TCO.” A whitepaper released by AVL and Westport Fuel Systems considered an investigation period of five years, and concluded that an H2 high pressure direct injection (HDPI) engine was the most cost-competitive, near-term pathway for reducing CO2 emissions in long-haul transportation.

> “The mission profile has a very high influence... in the near term, the much lower upfront costs of a combustion engine make the H2 ICE a more attractive solution in terms of TCO

Meanwhile, says Raser, the layouts and capabilities of FCEVs–which are ultimately electric vehicles–means they will hold definite advantages depending on the application. “For example,” he explains, “FCEVs can recuperate energy. And so if we have a dynamic mission profile featuring lots of stops and starts which can take advantage of this, then clearly FCEVs have advantages.”

“On the other hand, let’s consider a drive cycle like Munich to Milan to Munich,” he says. “This means drivers cross the alps twice a day, which takes some 45 minutes each time. The combustion engine is then going to have clear advantages, particularly in the summer where much of the heat built up by a combination of workload, weather and lack of airflow due to heavy traffic can be ejected via the exhaust gasses.”

Challenges remain: whilst hydrogen ICEs like that developed by AVL are approaching price parity with diesel engines, says Raser, one of the main cost considerations impeding adoption today is that of hydrogen storage. Hydrogen is the lightest element in the universe, and an estimated 2,700 times less energy dense than gasoline, meaning it must be stored at high pressure. Carbon fibre usage is therefore common.

Of course, the prospect of NOx, the carcinogenic pollutants at the centre of much of the EU's emissions standards for heavy-duty vehicles, will be of concern to truckmakers. Fritz Grabner, Business Development Manager at AVL, says the important thing for AVL is to ensure products can comply with incoming emissions standards.

> "Let's consider a drive cycle like Munich to Milan to Munich: this means drivers cross the alps twice a day, which takes some 45 minutes each time. The combustion engine is then going to have clear advantages

However, says Raser, what's clear is that Europe requires solutions. "The EU has to reduce fleet CO2 emissions by 15% in the next five years, and by 30% by the end of the decade," he explains. "A high share of improvements to existing diesel technology will help to cover that initial 15%, but it will also be encouraged by a certain penetration of CO2-free transport. This will include EVs and FCEVs, but within certain boundaries the H2 ICE as well." Compared with FCEVs, he adds, the H2 ICE's quick time to market could also pave the way to increased hydrogen infrastructure.

"We already see that during steady state and partial load operations, as well as long idling situations, there is virtually no NOx generation," he says. "However, to compete with current engines whilst retaining a proper torque build-up, we foresee NOx emissions under transient and full load conditions of roughly 10g per KWh." Ensuring this limit, he says, will enable a carry-over of existing aftertreatment technology, thus underlining perhaps the H2 ICE powertrain's biggest strength: the technology is mature, and already widely available.

StreetScooter: from dissolution to bidding war in one year

With electric delivery gaining ground rapidly, StreetScooter could prove a lucrative asset. By Megan Lampinen

The outlook for electric delivery has never been brighter. With the pandemic driving up e-commerce demand and cities taking decisive steps to address air quality, the pressure is on for more, and cleaner, delivery vehicles. The supply of trucks and vans that can not only meet the cargo space requirements of delivery companies but also the urban low- or zero-emission zone restrictions in cities is limited. That's why last year's announcement that StreetScooter was to be wound down came as such a surprise. But recent developments suggest there is a lifeline out there for the eco-friendly range after all.

many more to third parties. But after six years it had enough of the vehicle manufacturing game. At one point a sale to Chinese automaker Chery looked likely but talks fell through, and in March 2020 DHL announced that it would wind down vehicle production over the coming months.

Some industry watchers suggested the problem was less around the potential for electric delivery and more about the struggle to make money from vehicle manufacturing. James Hodgson, Smart Mobility Principal Analyst at global tech advisory ABI Research, noted at the time that it is "nearly impossible to make a profit

> "The market for electric delivery or electric commercial vehicles is still far away from being at that degree of maturity to start talking about profits

Demand remains strong

When logistics and delivery giant Deutsche Post DHL Group (DPDHL) couldn't find the sort of zero-emission delivery models the business required, it decided to develop its own, bringing in start-up StreetScooter initially to help with the design work and later acquiring the company outright. It went on to build up a fleet of thousands of electric vans, selling

when manufacturing cars" and that even industry incumbents are getting by on small margins with most of their models. "The profitability problem is further worsened by the level of investment that electric vehicles (EVs), in particular, require," he added.

Demand is there, though, for those that are willing to put in the effort and the finances. Amazon has placed an order for 100,000 custom electric delivery vehicles from Rivian as part of its goal of becoming carbon neutral by 2040. UPS has pledged to transition to

a zero-emission fleet and last year placed an order for 10,000 electric vans from Arrival. FedEx has just committed to an all-electric fleet by 2040, with an interim target to convert 50% of the fleet to EVs by 2025. Surely there is room for StreetScooter in this

founder Guenther Schuh was involved in the initial development work of the StreetScooter models. Then there is an unspecified American investor group previously involved in other electric transport deals.

Given the significant investments made by Amazon, UPS, and FedEx in electric last-mile delivery vehicles, DHL's planned wind down of StreetScooter last year seemed odd

push? "Given the significant investments made by Amazon, UPS, and FedEx in electric last-mile delivery vehicles, DHL's planned wind down of StreetScooter last year seemed odd," says Scott Shepard, Senior Research Analyst, Fleet Decarbonisation at Guidehouse Insights.

Interested parties

German media are now reporting that new investors are in a bidding war for StreetScooter. According to Manager Magazin, which cites those involved in the discussions, the group includes Chery once again, as well as another unspecified Chinese investor. There is also interest from entrepreneur Nazif Destani, who already holds a stake in Aachen-based electric car company e.GO through the Dutch investment company ND Group. Notably, e.GO

This revived interest comes as no surprise to Shepard. "That the company may now have fresh legs from new investors fits better with the broader state of the e-mobility industry, which has seen significant investment following a surge in SPAC (special purpose acquisition company) deals over the last nine months," he tells *Automotive World*.

For example, Hyzon Motors, a manufacturer of fuel cell commercial vehicles with plans for a heavy-duty and medium-duty truck along with a hydrogen-powered city bus and coach, signed a merger agreement with Decarbonization Plus Acquisition Corporation to form a SPAC in February 2021. That same month, California-based electric commercial vehicle company Xos teamed up with NextGen Acquisition Corp. for an initial public offering in a deal that values it at US$2bn.

Production of the DHL Deutsche Post StreetScooter in Aachen, Germany

Sector outlook

The amount of activity going on around electric delivery is notable, but that doesn't mean that it's a guaranteed money maker. The challenges of turning a profit, as highlighted by Hodgson, remain. "The market for electric delivery or electric commercial vehicles is still far away from being at that degree of maturity to start talking about profits," echoes Axel Schmidt, Senior Managing Director and Accenture's global industry group, lead automotive. "It is still an investment case and the race isn't over yet."

However, the arguments for fleets to go electric are growing ever more convincing. "Electric commercial vehicles can help commercial fleet owners and operators to gain an unprecedented advantage besides any potential regulatory requirements from governmental organisations," adds Schmidt. "Think about the increasing demand for cleaner transport. Furthermore, early adopters can benefit from reduced total cost of ownership due to the growing maturity of electric vehicles."

Already today there are electric vans that are cost competitive with diesel counterparts, and in many cases delivering significant savings. Accenture drafted a sample case in which it compared the total cost of ownership of a diesel van compared to that of an electric van. Total costs were £24,900 (US$34,400) for an EV compared to £25,900 for a diesel van. This was based specifically upon the UK market and a six-year operating life with 20,000km mileage per year. Savings come from factors such as low-cost overnight charging and relatively high surcharges for diesel engines due to the London congestion charge and ultra-low emission zones. "The efforts are worth it, not only due to the saving potential in terms of the operational costs," he notes. "49% of surveyed customers confirmed that a service provider with an EV fleet or low-emission fleet would appeal to them."

Moving forward, interest in electric delivery will only increase. "Looking at the unprecedented growth of e-commerce, especially in the light of COVID-19, and the demand for more sustainable delivery options, electric delivery is certainly a promising area at which automakers should look," says Schmidt. "This prediction gets underscored by the forecast for same-day delivery which is predicted to account for US$200bn in US online sales alone by 2025."

Whoever ends up with StreetScooter could find themselves with a very lucrative asset indeed.

Could truck platooning ease regulator autonomy concerns?

With opinions split on its real-world potential, platooning might offer regulators a solid starting point for more advanced autonomous vehicles. By Jack Hunsley

Autonomy and commercial vehicles seem a perfect match on paper. The tech could unlock huge safety and efficiency gains, which could ultimately save the industry time and money while protecting vulnerable road users. But not all automated technologies generate the same enthusiasm, and one that has seen less of the limelight in recent years is platooning.

concluded at the time—and a focus on higher-level autonomy development has seen platooning fall out of the headlines. However, enthusiasm continues in some pockets of the sector.

One player bullish on platooning is start-up Locomation and its success so far suggests its confidence may not be unwarranted. In 2020, it completed 14 trips in eight days along a 420-mile

> “Our approach is very attractive as it still maintains a great resemblance to how trucking operates today. There is still a human in charge and at the front

True potential or a pipedream?

A standard platooning setup wirelessly connects a single file of trucks to a lead vehicle. The lead vehicle’s driving inputs are then used to control those behind, allowing vehicles to travel far closer together than a human driver could safely do. In theory, this would improve aerodynamics, yield better fuel economy and reduce CO2 emissions.

However, a combination of Daimler’s dismissal of the tech in 2019—“Analysis currently shows no business case for customers driving platoons with new, highly aerodynamic trucks,” it

route from Portland, Oregon to Nampa, Idaho, using its Autonomous Relay Convoy (ARC) platooning technology. What was particularly impressive is that Locomation’s ARC platform had only been in development for 18-months at the time. According to Chief Executive Cetin Meriçli, the demo was the first to feature a traditional carrier using platooning tech within its freight network. The route, he added, had not been mapped or seen by Locomation before the run.

“Locomation’s human-guided autonomous convoying technology is currently being tested, validated, further developed, and improved on fully functional prototypes,” Meriçli told *Automotive World*. “We have

Two Locomation trucks, hauling Wilson Logistics trailers and freight, were deployed as an Autonomous Relay Convoy from Portland, Oregon to Nampa, Idaho

deployed our autonomous convoys on multiple successful customer pilots, operating on long haul routes, and delivering commercial loads."

Wilson Logistics–Locomation's carrier partner on the trial–was extremely optimistic about the safety and efficiency potential seen during the run. "The efficiency of being able to have two loads moving with two drivers is an economical game-changer which will also allow us to introduce serious improvements for the driver experience," Chief Executive Darrell Wilson told *Automotive World* in 2020. Wilson projects his company could yield "nearly 8% average fuel economy savings for each truck" using ARC tech, with Wilson Logistics having penned an agreement to deploy more than 124 ARC-equipped tractors across 11 ARC-compatible routes. "We fully believe that the further we automate the vehicles the safer operation we're going to have, so when we became aware of what Locomation was doing we were really excited," he added.

"Our technology is like a 'one-two' punch," said Meriçli. "On the one hand, we alleviate chronic driver shortage, improve both yield and resource utilisation substantially, and quadruple operating margins. On the other hand, our technology delivers two times the amount of cargo, twice as far and twice as fast. We are enabling our customers to offer a

> We fully believe that the further we automate the vehicles the safer operation we're going to have

premium service with predictable capacity that is just not possible today."

Another proponent is the US Army, which in 2018 awarded Robotic Research, a US-based autonomy developer which has also delivered an SAE Level 4 bus and unmanned logistics vehicles, a three-year US$49.7m contract which has since seen the developer provide nearly 100 unmanned platooning trucks. Robotic Research's main selling point is that its platooning tech can reverse autonomously, a key ability given the rough, rugged and often dangerous terrain in which military vehicles may be required to operate. "The capability solves the potentially life-threatening problem of an autonomous platoon of military vehicles being unable to navigate out of a dangerous situation," said Alberto Lacaze, President of Robotic Research. "This automated platooning capability will ultimately extend the reach of soldiers without putting them in harm's way."

Opinions, however, are split on just how efficient truck platooning can be in the real world. In addition to Wilson Logistics' findings, the European Manufacturer's Association (ACEA) believes platooning could cut the following truck's CO2 output by 16% and the lead vehicle's by 8%. Daimler, however, struggled to replicate the fuel efficiency potential it believed was on offer during its early real-world tests, even in "perfect platooning conditions." Problems with trucks disconnecting and reconnecting with the platoon further diminished results.

Regulation

However, regulators are growing more enthused with platooning tech. The most prominent example comes from another Locomation test run in October 2020, which saw its ARC technology make a 280-mile delivery run from Pittsburgh, Pennsylvania to Detroit, Michigan carrying groceries for three food bank initiatives. The demo was run as part of the Smart Belt Coalition, a collaboration involving 12 separate organisations, including five transport authorities. "Safety is our primary concern, and as smart mobility technologies mature, we believe these innovations will make our roads safer," said Ohio

Locomation completed several platooning runs in 2020

Governor Mike DeWine on the demo. "Deployments like this one will help to inform future projects."

The deployment followed a request for information submitted in March 2020 by the Ohio Department of Transportation (DoT) on the behalf of other Smart Belt Coalition stakeholders such as the Michigan and Pennsylvanian DoTs. "Michigan has been at the forefront of developing mobility technologies of the future, and this demonstration follows others completed here to foster more research focused on safer ways to move freight," added Paul Ajegba, Michigan Transportation Director.

Locomation believes the tech's continued use of human drivers is what appeals to autonomy-conscious regulators. "Our approach is very attractive as it still maintains a great resemblance to how trucking operates today. There is still a human in charge and at the front," said Meriçli. "We're pushing the envelope, but we are not completely leaving behind the currently familiar concept of truck operations yet. This is a great collective learning opportunity for the regulators, us, and all the other stakeholders."

It's not just in trucking where regulators are mulling platooning. The Port Authority of New York and New

Daimler switched focus from platooning to higher-level autonomy deployment in 2019

Jersey has previously considered applying the tech to its buses to ease congestion through the Lincoln Tunnel. “Today’s demand in the [Lincoln Tunnel’s Exclusive Bus Lane] far exceeds the bus capacity it can accommodate,” said Port Authority Chairman Kevin O’Toole in December 2019 after the Port Authority approved an 18-month US$4.8m programme to trial the tech. It hopes platooning could increase morning peak-hour bus capacity by 30% by allowing for an extra 200 buses. It estimates this would allow for an extra 10,000 passengers per day. “This demonstration programme will begin to explore how technology can maintain this lane as a reliable mass transit operation into the future,” O’Toole added.

Foot in the door

Moving forward, players like Locomation are confident that platooning development can continue at full throttle. “There are no key limiters of platooning deployment at the moment,” said Meriçli, whose company is focusing on expanding its product portfolio to include concepts such as dock-to-dock driverless deployments. “We still have work to do for wide-scale commercialisation of this technology but you will start seeing trucks with our technology on them in the next several quarters.”

Though some developers have distanced themselves from platooning, there’s no denying the technology’s reliance on human drivers could go some way to alleviating regulatory concerns. “The supportive regulatory landscape is creating tailwinds, and enormous market interest,” added Meriçli. “The remainder of 2021 is pretty packed with testing and validation, and customer pilots for us. We will continue to operate our fleet of autonomous convoys in different states along with our growing network of partner carriers, shippers, and third-party logistics companies. Our carrier partners are very excited and very eager to deploy our technology when the validation is done.”

The solid-state EV battery is taking shape

The much-discussed alternative to liquid electrolyte technology could soon take its first steps into the real world, but benefits will only arrive over time. By Xavier Boucherat

Nio is making increasing noise in the electric vehicle (EV) segment: the recent unveiling of its upcoming ET7 sedan puts it on track to compete directly not just with the Tesla Model S, but also the world's incumbent premium manufacturers. It could prove a canny move, but along with shining a light on the company's business plans, the unveil also underlined its technology ambitions. Chief among these was the offer of a 150kWh solid-state battery in vehicles by the end of 2022: the company claims this will enable a range of over 1,000km (621 miles).

Speaking in a recent interview for *Automotive World*, Hui Zhang, Vice President, Europe, said that solid-state was the industry's direction of movement, and could prove key in alleviating the concerns of consumers considering the jump from internal combustion engine to battery.

"Nio invests heavily in future technology," he said: "We believe that with the 1,000km range, the EV will have no shortcomings, and there will be no reason for the average driver to not choose an EV. If we consider the benchmark for gasoline cars, an Audi A6 has a 75-litre tank, with a range of roughly 950km. A 1,000km range means the EV gives nothing less." It is not clear which company is making Nio's battery, but in the past the company has signed agreements with cell giant CATL and another company called Prologium, both of which are pursuing solid-state battery development.

Nio has confirmed the battery will be compatible with existing models including the ES8 and ES6 SUVs, making upgrades possible for existing owners. This will also be relevant to customers who have opted not to buy their own vehicle's battery, but to lease on the company's battery-as-a-service (BaaS) programme, allowing users to select different grades of battery depending on their needs at the time. The new 150kWh battery, for example, could be swapped in for a drive to a holiday destination.

A range enabler

By now, a number of proponents have made the potential benefits of solid-state batteries well known. The removal of flammable liquid electrolytes in favour of solid electrolytes creates obvious safety benefits at a time when EV fires are still presenting issues. This allows for more charging cycles, improving longevity and potentially addressing concerns around low EV residual value, whilst also allowing drivers to safely take advantage of fast-charging opportunities. Meanwhile, the removal of components associated with liquid electrolytes also allows for a more compact cell arrangement within the battery pack.

Importantly, however, these qualities in themselves do not create higher energy densities of the kind which could vanquish range anxiety. Ken Rudisuela, Project Manager, Batteries at the Nickel Institute, says that rudimentary solid-state batteries use the same active cathode materials as conventional technologies. Over time, solid-state platforms will allow developers to take advantage of materials that enable higher energy densities.

Wolfgang Bernhart, Senior Partner, Roland Berger, agrees. "If a battery uses solid electrolytes with graphite anodes, the benefits are limited," he says. "One has to be careful when

considering announcements, and look closely at performance indicators... We will see solid-state batteries, but one should not assume that what arrives on the market will be revolutionary compared to what technology is available today for at least another six or seven years." Among the potential technology changes which solid-state could enable, said Bernhart, are sulphide and oxide-based electrolytes, lithium metal anodes and hybrid approaches.

Mid-2020s

A spokesperson for Solid Power, a solid-state battery developer, affirmed the idea of the solid-state battery as an opportunity to broaden battery design. "All solid-state battery technology can be thought of as a platform that enables emerging battery technologies," he said, "such as lithium metal anodes, ultra-high nickel-rich cathodes and more exotic conversion reaction cathodes."

The company expects to enter the "automotive qualification phase" in Q1 2022. The four-part qualification process will take as long as four years, preparing the technology for the harsh environment of an automobile. All going well, this means vehicle production could start in 2026. "From there, the rate of adoption and disruption will follow an S-curve... 5% adoption in 2030 with a market introduction in 2026 is well within reach," said the spokesperson. Solid-state, they added, will create cost reduction opportunities by boosting energy density and therefore reducing the number of cells needed, as well as through pack simplification.

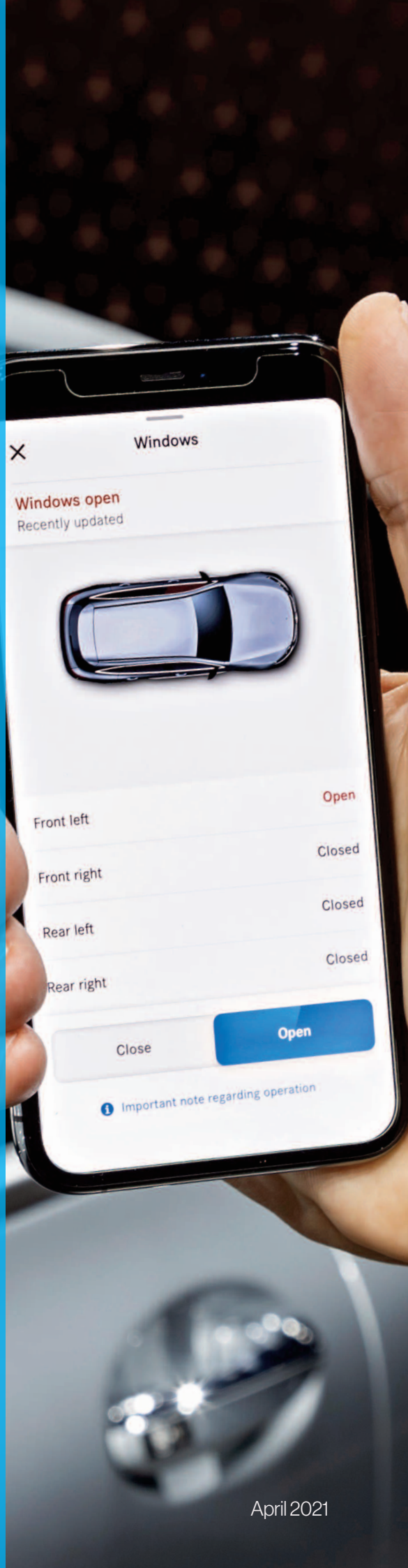
Rival QuantumScape recently announced it can now produce battery cells with multiple layers, which Chief Executive Jagdeep Singh has hailed as a major step towards scaling up production for the automotive industry and making a commercially viable product. The company counts VW among its major backers, with the automaker reportedly investing at least US$300m with the goal of producing solid-state equipped vehicles by 2024.

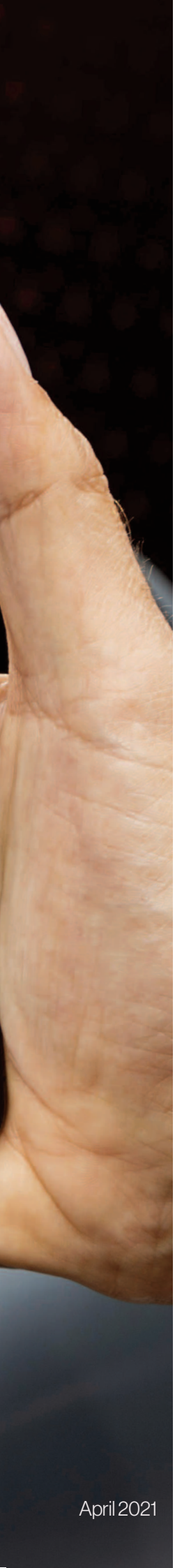
Amongst automakers, Toyota is said to lead on solid-state development, though the company has made very little in the way of official comments on the technology. A 2020 report from Nikkei said that a working prototype could arrive this year. Nissan is aiming for a more conservative 2028. Automakers are demonstrating clear interest, yet work remains largely secretive as developers determine how best to take advantage of the technology.

> "We believe that with the 1,000km range, the EV will have no shortcomings, and there will be no reason for the average driver to not choose an EV

Power in your pocket: what's the future of the car smartphone app?

A number of automakers have incorporated smartphone functionality into models, but could this be supplanted by voice technology and the cloud? By Xavier Boucherat





Smartphone apps have become a commonplace accessory for newer vehicles. Along with service scheduling and remote locking and unlocking, My BMW allows users to send their next location to the car ahead of a journey, prepping the navigation system. Tesla's app offers these plus software updates, charging data, Powerwall stats and climate control. Meanwhile, Daimler's 'ready to' app offers smart owners a packing assistant, which drivers can use to scan barcodes in locations such as furniture stores. The app will then tell them whether there's sufficient space in the trunk.

"Currently, most connected vehicle applications help to control basic functionalities," he says, "such as access, vehicle climate control, comfort and range management. In the future, they will become bearing points for the planning and payment of different types of travel, as well as a hub for individual brand experiences."

These apps, he suggests, will be hugely impactful in keeping a brand relevant for users when they aren't using a vehicle, particularly with vehicle attractiveness increasingly defined not by driving performance, but by software. The days of one-size-fits-all customer service, he says, are quickly fading, with personalisation and customisation coming to the forefront. Apps could help to create flexible, valuable services.

> "Many vehicles now offer support for Alexa skills, and so if you have an Amazon Echo device in your home, you can tell Alexa to warm up your car or whatever else is available. We're going to see the same thing happen with Google Assistant and other platforms

All these demonstrate the ways in which the connected vehicle is creating experiences beyond the cockpit. As Peter Fintl, Director Technology and Innovation at Capgemini, points out, this is no less than what customers have come to expect: many have become accustomed to flexible, easy-to-use, digitally enhanced services elsewhere. Automakers, he says, must make the car a part of the consumer's digital life, and dedicated phone apps will play a vital role.

However, he adds, this must not come at the expense of the in-vehicle experience: "Automakers should try to stay relevant for the digital customers not just by emulating functions and experience that are readily available on a customer's

BMW ConnectedDrive is a key part of the automaker's connected ecosystem

phone, but by bringing them to the 'middle console'. In the hunt for current and future data-driven revenues, automotive players are trying to occupy their position in the industry. Features from premium vehicles, such as rear seat passenger screens, will become the norm."

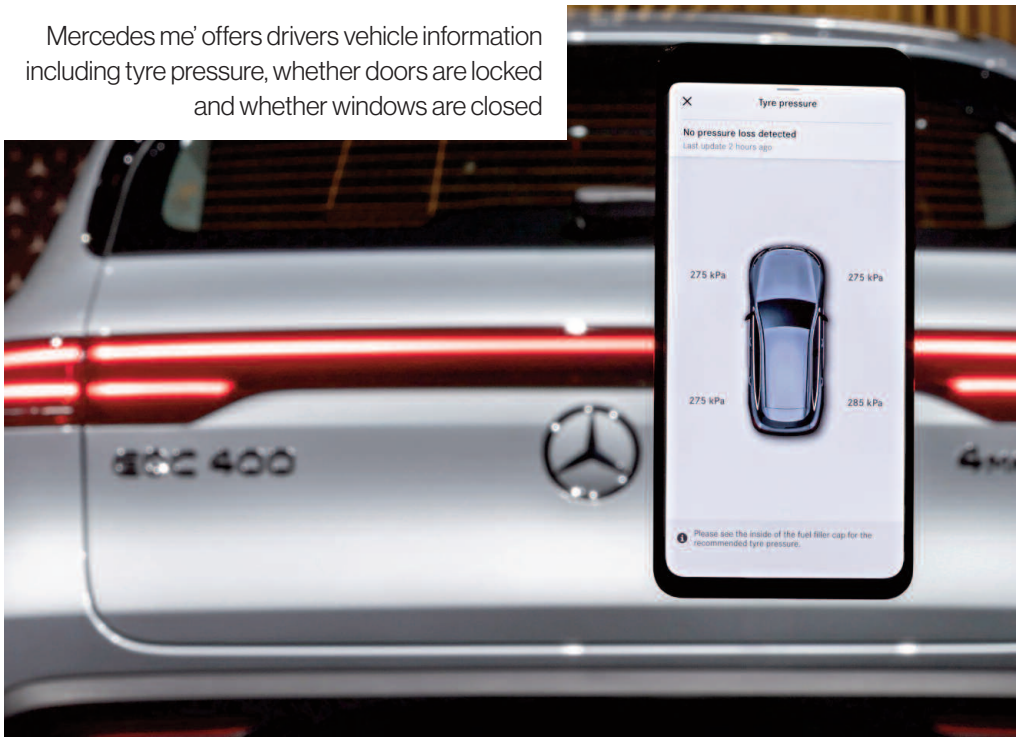
Additionally, automakers must not lock out those customers who use third party apps, such as Android Auto and Apple CarPlay. The smartphone developers' respective apps are hugely popular, enabling an easy means of integrating smartphone content including contacts, music and navigation with in-vehicle infotainment (IVI) systems. "The concept of 'bring your own device' is inevitable," says Fintl, "and so integration must be effortless. Consumers will expect a vehicle to integrate seamlessly into their digital ecosystem and their smartphone, and not the other way round."

> "The concept of 'bring your own device' is inevitable and so integration must be effortless

Reducing screentime

Yet logical as this all seems, the future of the smartphone app within automotive may not be so straightforward: that's according to Sam Abuelsamid, Principal Analyst, Guidehouse Insights. "Going forward, phone apps could prove less and less important, particularly when it comes to controlling functions in the vehicle," he says. The latter, he explains, is an area where automakers like to maintain control for security and reliability reasons.

Mercedes me' offers drivers vehicle information including tyre pressure, whether doors are locked and whether windows are closed



The increasing integration of platforms including Android Auto into vehicles is embedding third apps directly into the IVI. At the same time, voice-enabled digital assistants are becoming increasingly common, with advanced systems incorporating numerous voice-command platforms across different apps: the new Chrysler Pacifica, for example, can accept different wake up words to power different apps, including OEM-defined functions and external apps.

The combination of in-vehicle installation and easy control could mean that users no longer need to connect phones to the IVI to access certain features. But what about apps that can connect the vehicle to the user wherever they go, such as My BMW or Tesla's phone app? Again, says Abuelsamid, this may lose importance with the growth of cloud-based voice systems.

"Many vehicles now offer support for Alexa skills," he says, "and so if you have an Amazon Echo device in your home, you can tell Alexa to warm up your car or whatever else is available. We're going to see the same thing happen with Google Assistant and other platforms. The converse will also be true, with users able to control smart home functions from the car."

As time goes on, he suggests, the process of automating services and functions will only get easier. "Today, creating an Alexa skills or Google Assistant Routine remains a fairly convoluted process," he says, "but this will become simpler over time. Once that becomes more intuitive, more people are going to use them." The area which developers must address, he concludes, is taking friction out of systems which can send commands to different devices or apps: it is good that a single system can accept multiple wake up words, but ideally, there should be no wake up word, and a system can automatically determine where a command should be sent.

Geely and Volvo scrap merger plans for closer partnership

The partners have called off the merger but still hope to benefit by pooling resources on software, EV development and procurement. By Megan Lampinen

It's no secret that automakers are struggling to go it alone in today's industry, given the investment demands around CASE (connected, autonomous, shared and electric) mobility. The challenge has prompted numerous partnerships, joint ventures, acquisitions and mergers. For Geely and Volvo, the big question was whether their decade-long collaborative relationship would be taken to the next level in the form of a full merger. Zhejiang Geely Holding Group Company Limited currently holds about 40.94% interest in Geely Automobile and 97.8% in Volvo Cars.

"Today, we are a very successful growing company," Volvo Cars President and Chief Executive Hakan Samuelsson told media at an impromptu press event in late February 2010. "Ten years ago, we were not. We would never have achieved that without cooperation with Geely. We would never have achieved the position we have today in China without being part of the Geely group and we would not have a competitive smaller car programme without Geely. The partnership has been absolutely essential for the development of Volvo over the years."

Could more of a good thing be the answer? In February 2020, Geely Auto and Volvo Cars announced that they were considering combining their businesses "to create a strong global group, which would accelerate financial and technological synergies between the two companies." The idea was to create a player with the sort of scale and resources to become a leader in the rapidly evolving new mobility ecosystem. "A combination of the two companies would result in a strong global group," commented Geely Holding Chairman Li Shufu at the time.

> "Mergers and acquisitions can sometimes work as a distraction from other highly strategic and operational priorities. Corporate engineering is important but, in the long run, it's the company's ability to deliver value to the customer that will make the difference

> This brings all the benefits of a merger without the disadvantages that could entail
>
> *Håkan Samuelsson*
> *Volvo Cars*

A joint working group hammered out a proposal which was put to the boards for a detailed review, and a verdict has now been confirmed.

The golden decade as separate companies

In the end, Volvo and Geely concluded that their existing separate corporate structures will be preserved but that they will increase areas of collaboration. "The last decade of development at Geely was inseparable from the support of Volvo," said Gui Shengyue, Chief Executive and Executive Director of Geely Automobile. "If we could find a deeper and better collaborative solution then we could illustrate the synergy much better."

Daniel Donghui Li, Vice Chairman and Executive Director of Geely Automobile Holdings, went so far as to suggest that this new relationship "will open a new golden decade for the two, creating more powerful companies in rapidly changing field of automotive and mobility services."

Specifically, Geely and Volvo are looking into joint procurement to cut purchasing costs and expanding the use of shared modular architectures for electric vehicles (EVs). They aim to increase collaboration on both automated driving systems and electric drive technologies. In 2017, Volvo became the first mainstream vehicle manufacturer to commit to incorporating electrification across its line-up and has made it clear this is the brand's future. Samuelsson told media that the expanded partnership with Geely would mean that "customers will get better cars at a better cost. We will be faster at delivering what customers expect, and now they expect more electric cars–both plug-in hybrids and all electric."

At some point, Volvo and Geely could turn their attention to EV chargers, with Samuelsson adding, "We also need to work together to have a

Under the agreement, Lynk & Co will piggyback off Volvo's established distribution and service network

really good charging network." However, Geely wasn't quite ready to take this plan public, and An Conghui, President and Chief Executive of Geely Auto Group, Executive Director of Geely Automobile Holdings, was quick to interrupt Samuelsson at this point in the press conference. "The projects announced today are the projects that have already been clearly defined," he interjected. "We are working together to plan collaboration in more extensive areas, but we will discuss them later."

What he was willing to talk about was the global expansion plan for Geely's new Lynk & Co brand. Under the revised collaboration agreement, it will piggyback off Volvo's established distribution and service network. "Whenever you enter a new market, you have to invest heavily in the retail and service network," Conghui pointed out. "Harnessing the established Volvo network will empower Lynk & Co's global expansion." The brand's first deliveries to European customers are scheduled to begin in April this year.

Volvo and Geely may be keeping their corporate structures separate, but they are merging their powertrain operations into a new company. This unit will focus on next-generation hybrid systems and internal combustion engines (ICEs) for Volvo, Geely's brands and potentially external parties. Details such as its name and location will be announced later.

Merger pros and cons

The executives presented a united front in conveying the message that this expanded partnership was the best solution to the challenges faced by Geely Auto and Volvo Cars. As Samuelsson put it, "This brings all the benefits of a merger without the disadvantages that could entail." Exactly what these disadvantages are nobody was keen to delve into, though Shengyue brought up the risk of shareholding dilution.

Moody's analysts had been bullish on the potential of a merger, which they believed would yield increased scale

E-motors are a fundamental building block of EVs, which are at the heart of Volvo's strategy. Pictured: Volvo's e-motor lab in China

and greater geographic and brand diversification, as well as synergies in production costs and R&D spending. While Moody's concedes that this new plan will benefit both companies, it adds that "the magnitude of the benefits are likely to be less significant compared with the previous plan of a full merger."

However, Pedro Pacheco, Senior Director of Research for Automotive and Smart Mobility at Gartner, points to some very real benefits of avoiding a full merger. "Mergers and acquisitions can sometimes work as a distraction from other highly strategic and operational priorities," he tells *Automotive World*. "Corporate engineering is important but, in the long run, it's the company's ability to deliver value to the customer that will make the difference."

At the same time, this arrangement could leave Volvo and Geely more opportunities to approach capital markets separately to raise financing. When Samuelsson was pressed by media on the possibility of a standalone IPO, he did not rule it out: "As a standalone company with bold transformation, it's possible that we could approach the equity markets. It has always been an option. Today we have no decision about such an approach."

Ana Nicholls, Managing Editor of the Industry Briefing at The Economist Intelligence Unit, suggests that Volvo's electrification ambitions may

> Deciding against a full merger may be particularly important given that Volvo intends to reposition itself as a full-EV company...which may raise its market valuation further in a Tesla effect

have something to do with the decision to stick with the structure they have. Under the new agreement, Volvo will be hiving off its ICE business into the new joint company to focus on EVs. "Deciding against a full merger may be particularly important given that Volvo intends to reposition itself as a full-EV company, as General Motors and Ford are doing, which may raise its market valuation further in a Tesla effect," she explains.

There is also an argument that this more separate approach will benefit the individual brands. Volvo has spent decades establishing itself as a leading light in automotive safety while Geely is actively positioning itself as a brand that offers the latest technology. However, Nicholls suggests that "in practical terms, the two sides are increasingly sharing their areas of expertise, with Geely benefiting from Volvo safety equipment, while Volvo incorporates technology such as Geely's Coolray infotainment system that includes a 360-degree-view camera."

Nicholls also raises concerns around implications for the group's more minor brands. "Lotus has a strong enough positioning despite low sales, but Proton will have a hard time building a reputation outside Malaysia," she points out. "Whether the two need their joint Lynk & Co brand is also unclear."

For now, these and other strategic decisions will be decided either separately or as close collaborators.

Research breakthrough opens door to battery energy density improvements

Megan Lampinen examines new research around the understanding of oxygen-redox materials to increase cathode energy density of lithium-ion batteries

Battery performance could make or break the success of electric vehicles (EVs). Lithium-ion technology dominates the market today but is limited in terms of its energy storage capacity, which in turn limits the range of an EV. However, recent advances in the understanding of oxygen-redox promise significant progress on this front.

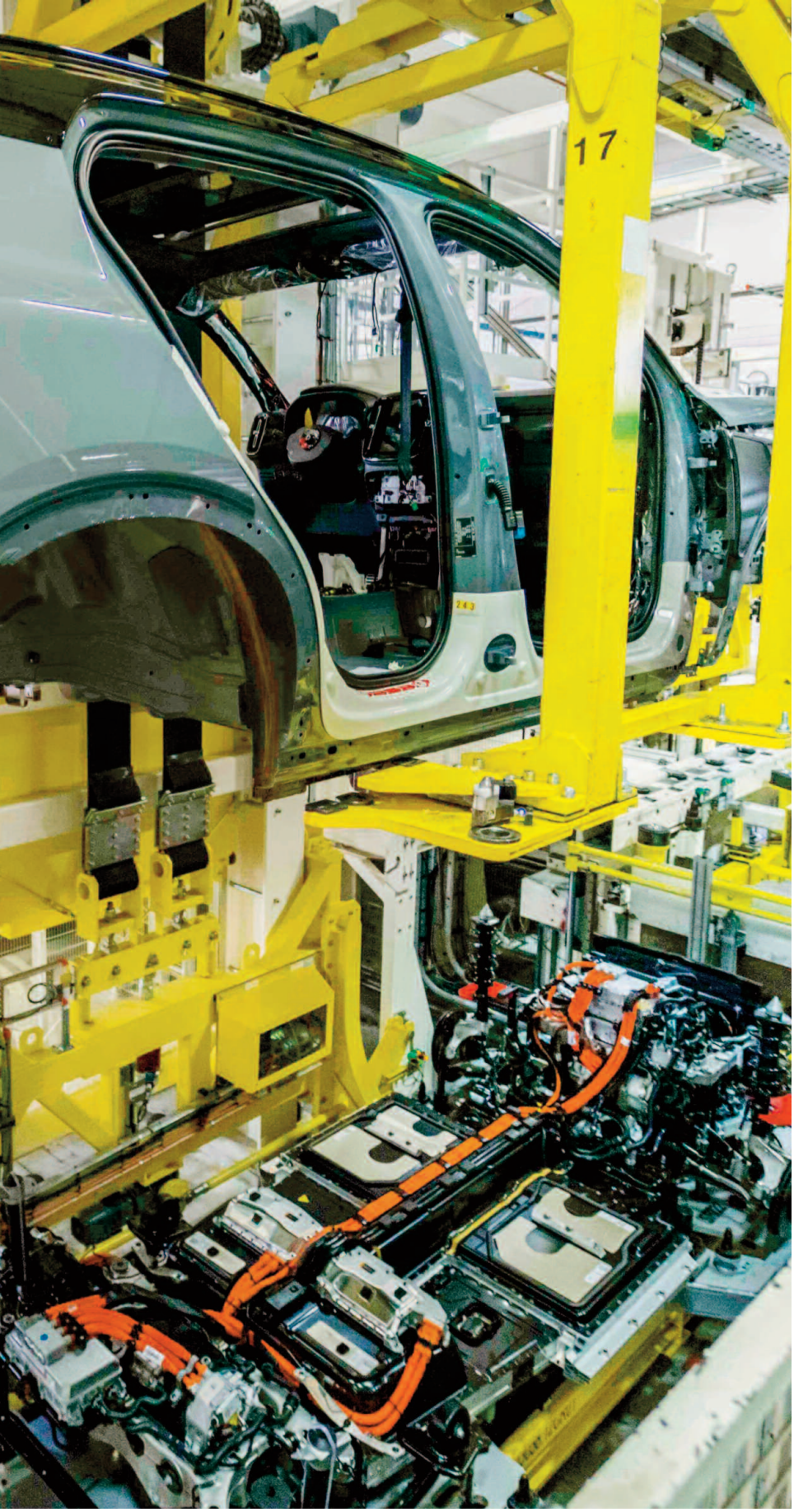
The cathode is made of a lithium metal oxide compound, typically an NMC (nickel, manganese and cobalt) material composition, and the charge is stored on those metal ions. Extending that charge storage to the oxygen will mean more charge overall can be stored. The challenge lies in the structural changes that oxygen-redox materials experience during their first charge. These

> “This particular scientific milestone unlocks and accelerates multiple new avenues of research in the quest towards battery materials that could increase the range of future EVs

“One of the key barriers to extending EV range is improving the energy storage of the lithium-ion cell,” says Professor Peter Bruce of the University of Oxford and Chief Scientist of the Faraday Institution. “That heavily depends on the amount of charge that can be stored in the cathode. One of the few ways of improving on today’s technology is to be able to store charge not just on the metal ions in the cathode but also on the oxygen.”

structural changes are mostly irreversible and result in a significant drop in the voltage available on subsequent discharge and future cycles.

Bruce and his team, part of the Faraday Institution CATMAT project, have advanced the understanding of the oxygen storage process, which should help identify how to make better materials.



A big deal

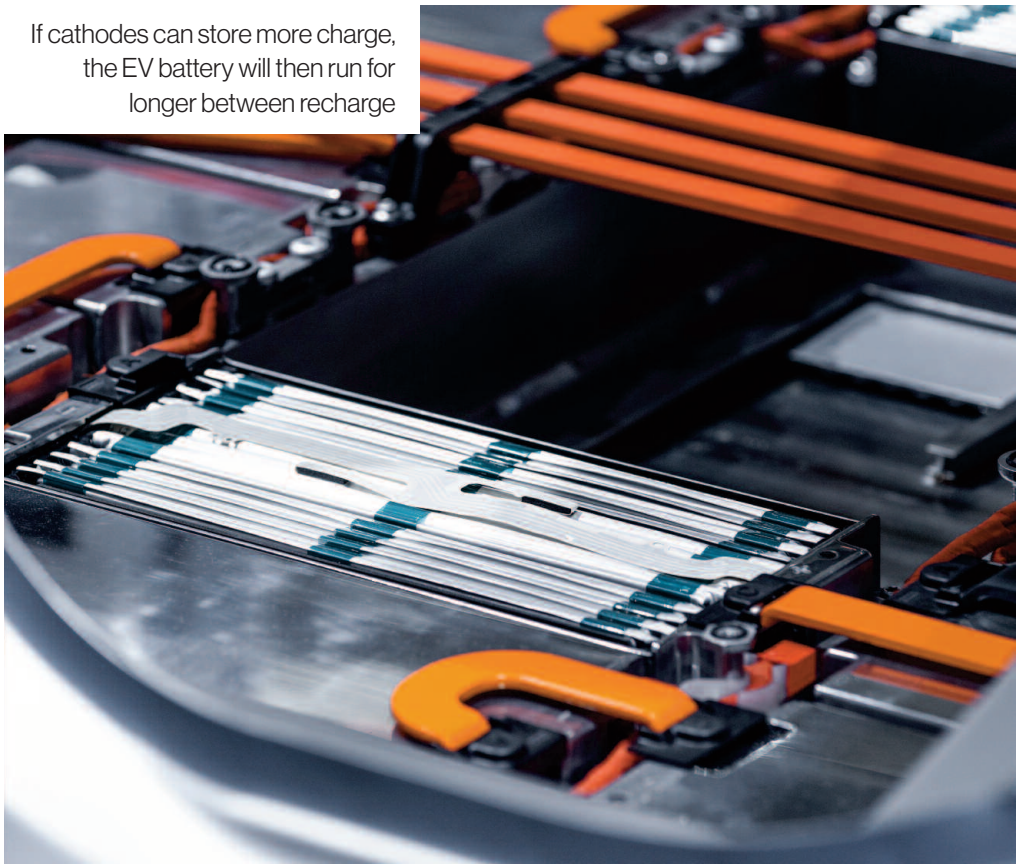
The team has successfully shown that when a battery is charged up with one of these materials that can involve the oxygen as well as the metal ions, oxygen is formed and becomes trapped in the material. That's not good, as the aim is to keep the oxygen as oxide ions and simply take electrons from them and put them back on, just as happens with the metal. In a paper published in Nature Energy, the team identify possible routes to suppress the formation of molecular oxygen and stabilise the structure.

The impact could be significant. Pam Thomas, Chief Executive of the Faraday Institution, explains that this particular scientific milestone "unlocks and accelerates multiple new avenues of research in the quest towards battery materials that could increase the range of future EVs."

Today's NMC materials typically offer around 200-220 milliamp hours of charge per gram. Bruce estimates that this could jump to around 275-300 milliamp hours per gram. "That's a big deal in terms of batteries," he tells *Automotive World*.

However, the work is just beginning. The industry still needs to produce materials that suppress the molecular oxygen formation and allow access to both oxygen redox and metal redox. "As well as examining routes to mitigate molecular oxygen formation, we are now looking into how this process of forming molecular oxygen affects the cyclability and voltage fade," explains Bruce. In these materials the voltage gradually changes over many cycles. He wants to explore whether the recent breakthrough in understanding can explain that.

If cathodes can store more charge, the EV battery will then run for longer between recharge



Closer to an electric future

The advances made by the Faraday team could accelerate the industry move towards an electric future. While there are many obstacles in the transition to mass market EV uptake–such as cost, charging infrastructure and model availability–range anxiety continues to hold back many consumers. “If cathodes can store more charge, the EV battery will then run for longer between recharge and that means longer driving range,” Bruce reiterates. “This is one of the limited number of ways of doing that.”

Armed with a greater understanding of the cell materials, researchers should now be able to develop better materials that will function in real cells in practical applications. The good news is the research environment to support this sort of work is improving.

“Often this sort of work is done by a senior professor and his or her group,” says Bruce. “We actually need teams of experts with different expertise to crack the problems of today.” This particular project is supported by the Faraday Institution, and according to Bruce, it offers a shining example of how to do things more effectively: “The unique thing about the Faraday Institution is that it is doing basic research in the lab with teams of experts that bring different skills and expertise to bear on these problems. We’re doing it at scale, in a way that’s not so common at the basic research level. We should be doing more of this approach if we want to crack these big global challenges, like electrification of transport.”

Augmented reality is space-saving and autonomy enabling

Placing HUD information on windscreens would allow automakers to reclaim the dashboard. By Jack Hunsley

Dashboards once housed physical dials to help drivers monitor things like fuel level and oil temperature. Now they can display satellite navigation data, lane positioning and even act as digital rear-view and side mirrors. Those developing these solutions believe there is an opportunity to push the boundaries even further.

Consumer electronics expert Panasonic is eager to leverage augmented reality (AR). It sees value in using practically every available surface in the vehicle as a canvas to transmit information from vehicle to human. "As we move to autonomous mobility, we're seeing activities around using every bit of real estate in the car," Andrew Poliak, Chief Technology Officer, Panasonic Automotive Systems America, told *Automotive World*. "Every piece of glass is a potential AR display."

Letting go

Poliak was speaking off the back of Panasonic's CES 2021 announcements, one of which was its AR heads-up display (HUD). The AR HUD combines advanced machine learning and optical technologies to increase the field of view for vehicle occupants. As Scott Kirchner, President of Panasonic Automotive and Executive Director of Panasonic Smart Mobility detailed in January, Panasonic sees the HUD market as "one of the fastest growing categories in mobility." Though moving information such as navigation data onto the windscreen could help human drivers, Panasonic is particularly enthused by AR's potential in autonomous vehicles.

Referring to his own experience with advanced driver assistance systems (ADAS), Kirchner believes AR could be key to easing occupant anxiety around assisted and autonomous mobility. "AR is very important for that transition from a human-driven to an autonomous-driven vehicle," he said. "It can reassure occupants that the car's sensors also recognise what they can see on the road." This can be achieved by using an AR display to manifest the automated driving algorithm's calculations. By colour-coding an obscured pedestrian trying to cross the road from behind a parked van, for instance, occupants can be reassured that the vehicle

> "AR is very important for that transition from a human-driven to an autonomous-driven vehicle

Augmented reality could reassure occupants that their AV has recognised any and every potential danger

is looking for any and every potential danger. “We can highlight things that would normally be recognised by a human driver,” Poliak added.

Other players, such as what3words, have recognised similar opportunities to ease anxiety. Its Chief Commercial Officer, Clare Jones, told *Automotive World* in 2019 that while there is not necessarily a functional benefit in including a visible map inside a Level 4 or 5 autonomous vehicle, developers may wish to include one anyway to show riders the vehicle’s planned immediate trajectory and route. “You can create an incredibly powerful machine that takes you from A to B, but if the human does not trust that the B is going to be the right place then you’re going to have a problem,” added Jones.

Space saver

AR also offers the ability to completely re-think dashboard packaging. Beaming information onto windscreens and side windows increases the surface area with which developers can play, and moving from a fixed central console would also allow developers to be more flexible in where, how and when information is shown. “Going into an autonomous mode opens up space for bigger HUDs,” said Poliak. “It can reduce costs by not having to put in a full instrument cluster. You could just have a centre display as redundancy.”

It could be a critical move for automakers, with Poliak noting how some of today’s dashboard display technology can occupy between six to 15 litres of space when mounted in-vehicle. An AR HUD would allow automakers to reclaim this area for whatever purposes they deem fit. “It’s very hard to include physical storage if you’re putting all these displays over those surfaces,” said Poliak, offering one example. “Going with an AR HUD gives the ability to change the interior and do some interesting and creative things to unlock great features for which customers are looking.”

Combining AR with technologies such as holograms or virtual reality (VR) could add even greater packaging flexibility. On the former, Panasonic is leveraging dynamic hologram developer Envisics’ expertise. Envisics provides hologram technology that

can adjust where information is shown in an AR display by allowing for multiple 'planes' of content. Information such as current speed or battery charge could be placed in the 'near plane', with navigation data or contextual ADAS information put in the 'far plane'.

Consumer interest

Panasonic already sees good consumer demand for cutting-edge HUD tech. "Once a consumer has had access to it, they want to have it again," Poliak notes.

The brands most likely to stand out are those which can offer a customised HUD experience. This can be achieved by either storing chosen user preferences or using AI to pre-empt what any given user may want from their HUD. "Automation will come from several different solutions such as using machine learning and neural processing in some of the units driving these AR HUDs," said Poliak. "You can add more 'smarts' into these systems." Though safety is a key benefit of these HUDs, players may wish to push comfort features in their quest to attract consumers. "If you wanted to be notified whenever you're within a mile of a Starbucks, for example, you could put that in too," Poliak added.

Whatever automakers opt to focus on, Poliak notes the importance of ensuring that technology-driven in-vehicle HMI functionality has a 'natural flow' to it. Clunky integration risks distracting, not informing, occupants. "You have to be careful not to throw everything onto the screen but to show what's important," he said. "Whether those alerts are safety-related, navigation-related and even points of interest for the driver, they should be limited to whatever the user is specifically looking for."

How and what information should be shown not only varies from occupant to occupant, but Panasonic also sees differences between regions. "You see different levels of information shown in displays in Asia, for instance, than in North America or Europe," said Poliak. "The way end users handle cognitive load across those regions is different."

Nio is another that has also noted this difference in the context of its virtual assistant Nomi. It has found that western consumers traditionally prefer their virtual assistants to remain strictly machine-like, while Asian consumers want a more personified experience. "Asian culture tends to be more receptive to animated and virtual characters compared to the rest of the world," Ted Li, Associate Vice President, Product Management Department & Senior Expert, Experience Manager at Nio, told *Automotive World* in 2020.

In the context of a Level 4 and 5 autonomous future where vehicles become more akin to living spaces rather than solely a means of transportation, AR could be a critical tech. Not only could clever integration allow developers to repurpose space inside the vehicle, but its ability to add visual context to real-world situations could also be vital in easing any lingering concerns over vehicle automation.

Dashboard displays will be the hub of the connected vehicle

‘Superscreens’ combined with connected intelligence can create an enjoyable and intuitive in-vehicle experience. By Jack Hunsley.

The dashboard is undergoing a revolution. Spearheaded by Tesla's tablet-like centre console, players both old and new are now working on bigger and better interfaces.

Most concepts focus on increasing the size of the centre console display and repurposing the space where physical dials are usually housed. More forward-looking concepts envisage a future where the entire dashboard, A-pillar to A-pillar, is one single seamless interface.

One such example is Mercedes-Benz' Hyperscreen. Unveiled at CES 2021, Mercedes promises its display will revolutionise the dashboard by blending digital and analogue design. Contrary to traditional centre console displays which have been constrained by the placement of physical buttons, knobs and air vents, the Hyperscreen will mould seamlessly around these components.

"We aimed for a complete instrument panel of glass and to position all interaction areas at the best possible position for the driver and the co-driver," Mercedes told *Automotive World*. "The MBUX (Mercedes-Benz User Experience) Hyperscreen is an example of the fusion of digital and analogue design. A huge, impressive screen unit sweeps across almost the entire width."

Intelligent interaction

The size of the screen has allowed Mercedes to think more deeply about how occupants interact with the various submenus accessible via traditional infotainment units. For example, the Hyperscreen features adaptive software which can conform to any given occupant's wants and whims, and makes personalised suggestions for infotainment, comfort and vehicle functions. This is achieved through a Netflix-style account system, where one vehicle can hold up to seven different profiles to allow driver and passengers to access their information and recommendations.

> "HMI is bi-directional; you need to understand the user at any given moment in any given situation

With consumer expectations rapidly rising, Mercedes believes this level of personalisation, accessibility and human-machine interface (HMI) design is quickly becoming the standard for in-vehicle infotainment. "Since the introduction of the infotainment system MBUX in the A-Class three years ago, our customers' expenses for digital content have tripled," the automaker detailed. "In 2019, we already achieved with the digital services revenue in the high three-digit million euro range, and this with a double-digit margin. With the introduction of the new C-Class at the end of February, all our vehicles are now equipped with MBUX."

Mercedes-Benz' Hyperscreen looks to merge digital and analogue design

The market is only set to grow. Mercedes hopes by 2025 that there will be around 20 million connected vehicles on the road compared to the seven million as of November 2020. In that context, it is aiming for a recurring €1bn (US$1.19bn) in earnings before interest and tax with its digital services by 2025.

Is bigger better?

Developers cannot assume increased screen size will automatically improve the infotainment experience, however. It is still vitally important that any information or interaction with the dashboard display informs occupants as oppose to distracts them.

In more advanced systems, there is scope to leverage artificial intelligence to cater alerts and warnings to any given occupant. "HMI is bi-directional; you need to understand the user at any given moment in any given situation," said Kelei Shen, Harman's Chief Technology Officer. "What is the state of that user? What's happening in their brain? How does that person typically react?"

Reading these cognitive signs could help a vehicle determine whether the driver is in an appropriate state to receive and react to dashboard warnings. If the system concludes the driver is overly stressed or fatigued, for instance, an ADAS-equipped or autonomous vehicle may conclude it is best placed to make the final driving decision itself rather than adding further stress to an already occupied driver.

This is not to say that increased displays sizes cannot play a critical safety role. In spreading displays across the entire dashboard developers could more accurately highlight potential dangers. For instance, a visual cue could be placed at the edge of a driver's vision should they attempt to turn when another road user is in their blind spot. Not only would this notification alert the driver that there is a potential danger, but the placement of the alert can direct the

driver's vision to exactly where the danger is present.

"The next frontier for a company like Harman is to build that truly great user experience," said Shen. Combining visual and audible cues could create a highly effective safety system. "Feeding information from all angles is one part," Shen added. "We also have to know the best way to communicate information to that specific user at that moment."

Virtual assistance

Virtual assistants are commonly integrated with these dashboard displays, as Mercedes has with its Hyperscreen. Its system can proactively display information or adjust vehicle settings for the user by leveraging artificial intelligence and previous data insights. Examples offered during CES included automatically raising the vehicle's chassis using GPS data to allow for greater ground clearance over speed bumps or bringing up contact details automatically if the driver makes a routine phone call on a specific day and time.

Such functionality is well suited to a future where vehicles become more akin to living spaces rather than solely a means of transportation. As the vehicle takes care of more driving tasks the dashboard display can become the hub of the vehicle, allowing occupants to verbally request a rundown of their latest work emails or receive recommendations on TV shows.

It's why Mercedes sees displays like its Hyperscreen becoming an integral part of the customer experience, acting as the starting point for practically every HMI interaction. "Displays have to support the passenger's experience," Mercedes-Benz told *Automotive World*.

"The amount, size and positioning of displays will strongly depend on the feature set which will be available for our customers. We will remain open to new technologies in the future; just as customer requirements have changed in recent years and new innovative technical solutions are available, so are new display concepts in vehicles, too. The focus is always on the customer in the vehicle and the customer experience."

Increased display size and in-vehicle intelligence will strain automotive computing power. Offering a wide range of display-based functionality can attract customers, but brands will struggle to retain this interest if applications do not run smoothly. "Not only do you have to integrate those displays but you also need enough computing power to support that along with the other interfaces from audio and connectivity inputs," Shen told *Automotive World*.

Clever computing prioritisation can ease this strain. Regarding Mercedes' Hyperscreen, for instance, should the passenger seat be unoccupied this section of the display becomes purely decorative, displaying Mercedes' signature star pattern instead. "If you use displays and interfaces right you can make things much better but if you use it incorrectly you can sometimes make things worse," added Shen. "In a driving environment, how can we make things smarter and as well as leveraging those physical interfaces? That is the next tier layer of the technology."

It will be several years before these systems become the norm in the industry. However, now automakers and suppliers have improved their internal computing expertise, the development of dashboard displays offers an interesting glimpse into automotive's connected future.

VW prepares for second wave of battery industrialisation

A strategy to diversify the sourcing of EV batteries and a new 'unified cell' concept will underpin the automaker's near-term plans. By Freddie Holmes

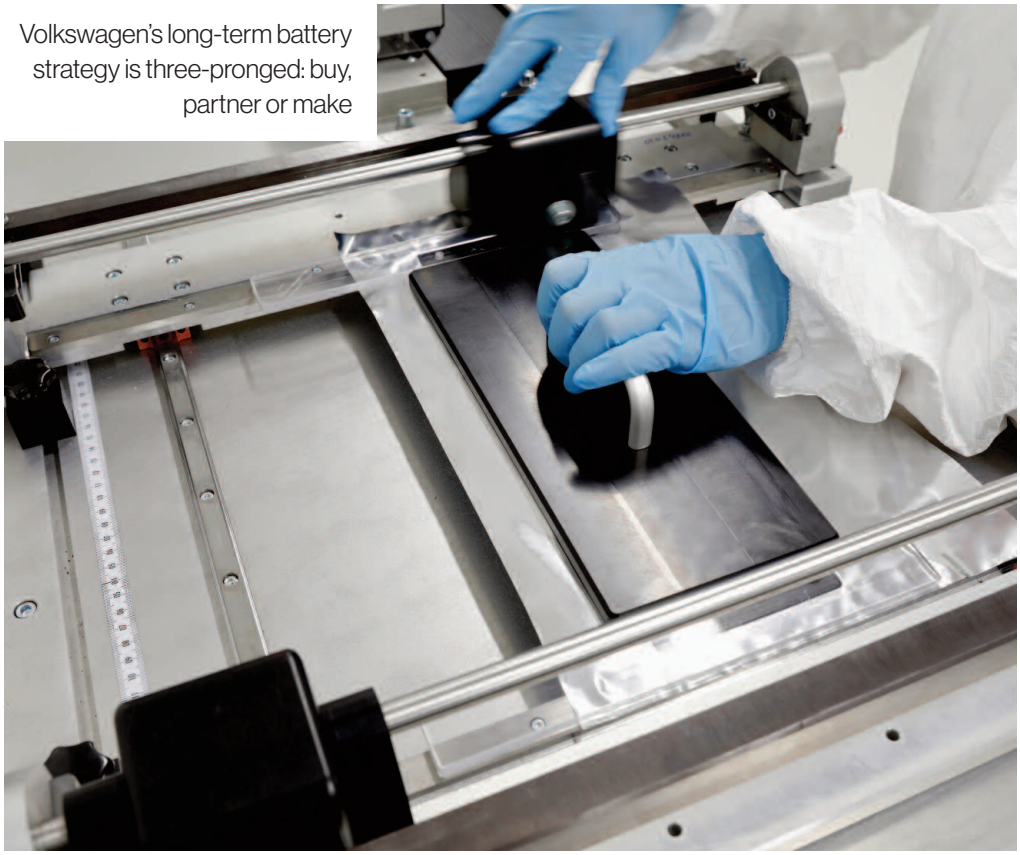
The Volkswagen Group has laid out plans to lead not only in electric vehicle (EV) manufacturing but also cell production. It aims to dramatically increase its battery capacity over the next decade both through strategic partnerships and own-brand gigafactories.

The announcement came as part of a two-hour webcast dubbed 'Volkswagen Power Day', which showcased the Group's roadmap for electrification in Europe, the US and China. Members of senior management from across the Group took to the stage in Wolfsburg or joined through a series of video links. It was a similar event to Tesla's Battery Day in September 2020, which revealed a new cell design for upcoming Tesla models and highlighted a push to increase manufacturing volume in China.

A key message was Volkswagen's ability to manufacture at scale, with Group Chairman Herbert Diess stressing the need for industrialised EV solutions to meet future demand. "In the EV world, size matters," added Tomas Schmall, Board Member, Technology at Volkswagen AG. "You need huge volumes spread over a wide portfolio."

EVs currently hold just a 6% global market share and the supply chain is already under pressure. As EV volumes grow, the challenge of sourcing batteries will only increase. But with more than ten million vehicles sold across the Volkswagen Group annually, the company knows how to scale. "Our goal is to secure pole position in the global scaling of batteries," Diess said during his opening remarks. "We know how to use platforms and synergies to transform a business successfully and unleash value."

Volkswagen's long-term battery strategy is three-pronged: buy, partner or make



> Faster is always better
>
> *Frank Blome*
> *Volkswagen Group Components*

The strategy that saw success in vehicle manufacturing will now be applied to battery technology. A key decision will be to focus on one standard battery design moving forward; this should begin series production in 2023 and cover 80% of all vehicles within the group by 2030. It is a "one size fits almost all" strategy, according to Diess. The remaining 20% may use different prismatic or cylindrical designs.

In entry-level EVs, this unified cell concept is expected to halve battery costs compared with today, making models more accessible to the average buyer. It is a fundamental change in strategy: the car is designed for the battery, not the other way around. The unified cell will use several chemistries for the cathode: entry-level EVs will use iron-phosphate (LFP); volume models will use a high concentration of manganese; niche solutions will use nickel-manganese-cobalt (NMC); and others will be solid state.

Experts within the battery sector have recognised a growing interest in LFP batteries. This has come as a surprise for some, with the chemistry widely seen as either outdated or better suited for heavy vehicles. "LFP won't give you major advances in range," says Peter Bruce, Chief Scientist at The Faraday Institution. "However, you do get that crucial benefit of reduced cost." Milan Thakore, a Senior Research Analyst within Wood Mackenzie, says LFP chemistry is becoming increasingly viable for entry-level EVs. "It will be very interesting to see how western automakers begin using LFP," he notes, "because we haven't seen that so far."

Frank Blome, Head of Battery Cell and System, Volkswagen Group Components, advised that solid state batteries are "the end game" in that they offer superior performance in terms of range, durability, charging speed and safety. Solid state cells could enable a zero to almost full charge in about 12 minutes, and as Blome puts it: "faster is always better."

Volkswagen holds a minor stake in QuantumScape, an early-stage company that has been researching the technology since 2010. The pair will build two joint-owned factories that will produce solid-state cells to be

used in vehicles across the Group. Volkswagen has previously stated aims to use solid-state technology in new vehicles from 2025. "We obviously cannot produce enough batteries to meet all of its demand, but it looks like it will take whatever we can produce," QuantumScape's Chief Executive told *Automotive World* in January.

batteries for its EVs in the short-term: a US$14bn order will see Northvolt supply Volkswagen through to 2030. The Volkswagen Group has a number of new EVs due to come on sale, including the Audi e-tron GT and Skoda Enyaq; the ID.4 SUV recently began deliveries in the US, and the ID.3 hatchback is already a top seller in Europe.

> "In-house production is only a step within the supply chain

Diess expects EVs to account for 60% of its sales in Europe by 2030, which will require an additional 240GWh in cell manufacturing capacity. The plan is to form up to six 40GWh gigafactories across the Continent, some of which will be run independently while others will operate through partnerships. This forms part of a three-pronged procurement strategy that will diversify the Group's supply chain and improve access to cells: buy, partner or make. "All options are on the table," advised Joerg Teichmann, Chief Purchasing Officer at Volkswagen Group Components.

Alongside QuantumScape, Volkswagen also has a partnership with Swedish battery company Northvolt that will co-develop next-generation cells. This partnership has secured Volkswagen vital access to

Volkswagen will not be entirely dependent on third party suppliers for batteries in the long run. The company wants to be more agile in its ability to ramp up volumes, and a move to increase its own capacity will reduce the risk of a supply shortage. By bringing production in house, it also has better control over design, cost and integration. Efforts will be led by the Volkswagen Powerhouse, a new division that will coordinate the vertical integration of battery manufacturing within the Group.

Ultimately, says Teichmann, finding the right balance between buying, partnering and making in-house will "decrease complexity, and increase implementation speed." He concluded that "in-house production is only a step within the supply chain."