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COVER STORY PAGE 26

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A RACE LIKE NO OTHER

THOUSANDS of lives could potentially be saved by a race scheduled to take place at Indianapolis Motor Speedway later this month.

The claim might sound extravagant, but there is method in my madness.

There are 1.3 million people killed in road traffic accidents every year, with research suggesting that the vast majority of them are caused by "human factors". Improvements in vehicle automation have the potential to save thousands of lives – and those advancements are precisely what the Indy Autonomous Challenge, the world's first such autonomous racecar competition at the famed IMS, hopes to inspire.

Many still think that Autonomous Vehicles (AVs) represent the future state of mobility. An anticipated $75 billion investment in the technology between 2019 and 2023 underlines that belief.

Nevertheless, there is no disguising the fact that the once confident march towards higher levels of autonomous technology has stalled. The Indy Autonomous Challenge, which features 10 full-size autonomous-enabled Indy Lights Dallaras, hopes to kick-start that progress.

It could be a recipe for carnage, of course. Without doubt, it is a big leap into the unknown. But what if it pays off?

The term 'Autonomous' used to conjure images of self-driving cars conveying us all safely to the office each morning while we worked on, oblivious to the journey, in the back seat! Increasingly, though, the reality is that many of us rely on automated technology – Advanced Driver-Assistance Systems, such as Lane Keeping Assist, Braking Assist, Blind Spot Indication, Adaptive Cruise Control and Parking Assist – without even knowing it.

Yet three prominent barriers currently hamper the further commercialization of AV technology.

The first is the solving of 'edge case' scenarios – problems or situations that occur only at an extreme operating parameter, such as avoiding unanticipated obstacles at high speeds while maintaining control.

Secondly, automated vehicles remain too expensive for scaled commercial deployment.

Perhaps more importantly still, we still don't really trust them. There is a need for the public to be engaged if the technology is to become accepted. A sizable fear factor remains.

Which is where the Indy Autonomous Challenge comes in. The sound and spectacle of full-size autonomous racecars – powered by ICEs rather than motors – mimicking human behaviour as they seek to overtake each other on such hallowed ground might capture the public's imagination. Into the bargain, it could well shape the AI experts, and the autonomous software, of the future.

Igniting passion in the academic world could make a difference to the applicability of autonomous tech in the real world.

Why am *I* telling you this, rather than William Kimberley, the editor? Unfortunately, William is out of action at the moment, so I will be holding the fort for him for a while. Don't worry, though: I won't give up the day job.

Mark Skewis
CONSULTANT EDITOR

AUTONOMOUS TECH ON THE RISE

The Brickyard gears up for this month's Indy Autonomous Challenge as DTM Electric makes historic Remote Run in Austria. By **Mark Skewis**

BELOW Students will program the autonomous-enabled Dallara AV-21, based on the constructor's Indy Lights car

THE Indy Autonomous Challenge (IAC), the world's first autonomous racecar competition at the famed Indianapolis Motor Speedway, is to spearhead an unprecedented push to advance autonomous technology.

The event, currently scheduled for October 23, commands a $1.5 million prize fund. It is viewed as the catalyst for discovering the next generation of software engineers in order to accelerate AV commercialization.

Other activities at IMS will include an Autonomous Innovation Summit, bringing together global thought leaders and experts from industry, academia and government to discuss the status of the autonomous technology industry and explore ways to accelerate and amplify the benefits of an autonomous mobility future. The summit will include leaders from Cisco, Bridgestone, Microsoft, Aptiv, Luminar, Dallara USA, ADLINK, AutonomouStuff/Hexagon, Schaeffler, Valvoline, Raytheon, Trucks VC, Draper, Elevate Ventures and many others.

In addition, a showcase of advanced technologies from competing university teams and IAC industry sponsors will be held on the IMS grounds. High school students from Indiana and beyond, interested in STEM (Science, Technology, Engineering and Math) are invited to attend the events. The Indiana Economic Development Corporation, Indiana Department of Education and the STARTedUP Foundation are leading the effort to coordinate high school student attendance.

The event is being hailed by Indiana Governor Eric Holcomb as: "an historic and exciting day for Indiana, which has taken the lead in hosting this first-of-its-kind technology demonstration for the best and brightest of university students from around the world."

"Through our work with the IAC, we also want to inspire the next generation of innovators and technologists," he added.

Paul Mitchell, president and CEO of Energy Systems Network (ESN), one of the primary organisers of the IAC, announced the official list of university teams participating in the IAC at IMS. "The Indy Autonomous Challenge began with more than 500 students registered from 41 universities," he said. "Today, we have 21 ▶

Driverless at 150 km/h over the Red Bull Ring

LAST month some of Europe's best racing drivers fought for podium places and championship points in the DTM with their GT3 cars at the Red Bull Ring in Spielberg. However, the secret star of the race weekend in Styria was a vehicle without a driver, which was used in the supporting programme of the motorsport series. The DTM Electric Demo Car was remote controlled by the AVL Driving Simulator from Graz.

Tim Heinemann (DTM Trophy Champion 2020) took his seat to steer the DTM Electric Demo Car, prepared by Schaeffler, around the Red Bull Ring from a distance of 82 kilometres. The simulator, developed by AVL, allowed the 23-year-old race driver to receive feedback on parameters such as the handling and stability of the vehicle – without being at the wheel himself or even in the cockpit.

The driving simulator runs based on the AVL VSM RACE (Vehicle Simulation Model) software, which represents the real race car in a virtual model.

"For AVL Racing, motorsport has been the platform for innovations and state-of-the-art technologies for more than 20 years. The know-how we generate through our involvement in various racing series around the world, is transferred to the development of production vehicles for future generations of mobility," said Ellen Lohr, Director of Motorsport at AVL.

"The DTM race weekend at the Red Bull Ring was the perfect opportunity to present the AVL Driving Simulator and the technologies integrated in it to a motorsport enthusiastic audience. At the same time, we were able to show that our technologies are already defining the mobility concepts of tomorrow."

On site in Graz, the entire project was implemented by Franz Reisenhofer and Ull Thaler, Simulation and Software Engineers at AVL Racing.

"This project is very special because we had our driving simulator in use in a completely new application. The difficulty was to give the driver in the simulator the feeling of the real vehicle by means of steering, pedals, as well as image and sound, in order to move the DTM Electric Demo Car at full race speed around the Red Bull Ring," said Lohr.

AVL technologies are already being used in the DTM's 'Balance of Performance (BoP) process as it transitions to a GT3-based series accommodating different vehicles. The DTM has harnessed the AVL VSM RACE driving dynamics software developed in-house, which works in simulation with purely virtual vehicle models as well as virtual drivers.

Benedikt Böhme, managing director of the DTM organisation ITR, said: "The DTM Electric Remote Run is the next step on the way towards a fully electrified high performance race series. The project is showing elements that in future could be used in a fully new, global, electrifying race series like we want to establish with DTM Electric alongside the proven DTM. Moreover, it shows the innovation power our platform has for developments aimed at mobility of the future."

Matthias Zink, board member Automotive Technologies, Schaeffler AG, said: "The operation in extreme conditions during the Remote Run is proof of the high maturity level of our technology and is a decisive step forward in the development towards series-production stage. The Space Drive system that has been implemented in the DTM Electric concept car is a key technology for autonomous driving, excellently proven with over a billion of kilometres completed on public roads."

BELOW The DTM Electric Remote Run demonstrated elements of autonomous driving that could also become a part of DTM Electric

universities from nine countries that have formed 10 teams that will participate in the final stage of the prize competition. These teams have overcome tremendous technology challenges to operate fully autonomous racecars and have done so despite the COVID-19 global pandemic challenges and inability to gather together as teams for most of the competition. We applaud them all and celebrate their collective achievements."

The final list of 10 teams, which have survived a number of qualifying simulation races, consists of:

- AI Racing Tech – University of Hawai'i, University of California San Diego
- Autonomous Tiger Racing – Auburn University
- Black & Gold Autonomous Racing – Purdue University, United States Military Academy at West Point
- Cavalier Autonomous Racing – University of Virginia
- EuroRacing – University of Modena and Reggio Emilia (Italy), University of Pisa (Italy), ETH Zürich (Switzerland), Polish Academy of Sciences (Poland)
- IUPUI-IITKGP-USB – Indiana University-Purdue University Indianapolis, Indian Institute of Technology Kharagpur (India), Universidad de San Buenaventura (Colombia)
- KAIST – Korea Advanced Institute of Science and Technology (South Korea)
- MIT-PITT-RW – Massachusetts Institute of Technology, University of Pittsburgh, Rochester Institute of Technology, University of Waterloo (Canada)
- PoliMOVE – Politecnico di Milano (Italy), University of Alabama
- TUM Autonomous Motorsport – Technische Universität München (Germany)

The inspiration for the Indy Autonomous Challenge can be traced back to the Defense Advanced Research Projects Agency (DARPA) Grand Challenge in 2004, which put forth a $1 million award and did much to create the modern automated vehicle industry. Moreover, given its heavy presence of university-affiliated teams, the DARPA Grand Challenge inspired an entire generation of students to pursue STEM.

The primary goal of the IAC is to advance technology that can speed the commercialisation of fully autonomous vehicles and deployments of advanced driver-assistance systems (ADAS). These enhancements will hopefully lead to increased safety and performance in all modes of racing and commercial transportation. RT

ABOVE Making split-second decisions on the racetrack will be an unprecedented test for AI

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Porsche and Siemens ramp up plans to produce nearly CO2-neutral fuel in Chile

PORSCHE and Siemens Energy have joined forces with a number of international companies to build an industrial plant for the production of nearly CO_2-neutral fuel (eFuel) in Punta Arenas, Chile.

The ground-breaking ceremony for this pioneering project took place last month in the presence of Chile's Energy Minister, Juan Carlos Jobet.

A pilot plant is initially being built north of Punta Arenas in Chilean Patagonia, which is expected to produce around 130,000 litres of eFuels in 2022. The capacity will then be expanded in two stages to around 55 million litres by 2024 and to around 550 million litres by 2026.

The necessary environmental permits have now been obtained by the Chilean project company Highly Innovative Fuels (HIF). Siemens Energy has also already started preparatory work for the next major commercial phase of the project.

"I'm pleased that we're making progress on this international lighthouse project for the hydrogen economy together with strong international partners from business and politics," said Armin Schnettler, EVP for New Energy Business at Siemens Energy. "With Haru Oni, we're bringing our power-to-X technologies to the global market. We're jointly developing and realising the world's first integrated and commercial large-scale plant for producing synthetic, climate-neutral fuels. In southern Chile, we're implementing one of the energy industry's most exciting projects for the future and driving forward the decarbonisation of the mobility sector."

ABOVE Construction has begun of the world's first integrated commercial plant for eFuels in Chile

BELOW Porsche will use the nearly CO_2-neutral eFuels in motorsport from 2022

Porsche initiated the demonstration project and will be using the eFuels in its own combustion engine vehicles. Michael Steiner, Member of the Executive Board for Research and Development at Porsche AG, said: "Porsche was founded with pioneering spirit. That's what drives us, we thrive on innovation. We also see ourselves as pioneers when it comes to renewable fuels, and we want to drive development forward. This fits in with our clear overall sustainability strategy. It means that Porsche as a whole can be net CO_2-neutral as early as 2030. Fuels produced with renewable energy can make a contribution to this.

"Our icon, the 911, is particularly suitable for the use of eFuels. But so are our much-loved historic vehicles, because around 70 percent of all Porsches ever built are still on the road today. Our tests with renewable fuels are going very successfully. eFuels will make it possible to reduce fossil CO_2-emissions in combustion engines by up to 90 per cent. Among other things, we'll be using the first fuel from Chile in our Porsche Mobil 1 Supercup race cars from 2022."

Ambitious targets

Chile has set itself ambitious targets as part of its National Green Hydrogen Strategy. It plans an electrolyser capacity of 5 gigawatts (GW) by 2025, rising to 25 GW by 2030. The aim is to produce the world's cheapest hydrogen and develop the country into a leading exporter of green hydrogen and its derivatives.

The Haru Oni project takes advantage of the perfect climatic conditions for wind energy in Magallanes province in southern Chile to produce the virtually CO_2-neutral fuel using low-cost green wind power. In the first step, electrolysers split water into oxygen and green hydrogen using wind power. CO_2 is then filtered from the air and combined with the green hydrogen to produce synthetic methanol, which in turn is converted into eFuel.

The pilot plant is scheduled to start production in mid-2022. In addition to Siemens Energy, Porsche and HIF, Enel, ExxonMobil, Gasco and ENAP are participating in the Haru Oni project. RT

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NEWS

RIGHT Laudenbach: excited by challenge

Enzinger passes Porsche Motorsport baton to Laudenbach

THOMAS LAUDENBACH has assumed the role of managing Porsche Motorsport. The accomplished German engineer takes over from Fritz Enzinger, who has led the racing department of the sports car manufacturer to countless successes since 2011.

"We cannot thank Fritz Enzinger enough for his enormously successful work over the past 10 years. He shaped an era at Porsche Motorsport that led us to incredible triumphs and title wins," commented Michael Steiner, Member of the Executive Board for Research and Development at Porsche AG.

"Motorsport has played a very special role in Porsche's corporate strategy. We've always used the racing platform as a test laboratory for the latest technologies. Thomas Laudenbach has everything it takes to successfully continue on this path. We look forward to the future of motorsport, in which we want to take an active role in shaping. The Mission R concept presented at the IAA MOBILITY showcases an exciting preview of what's to come."

Enzinger spearheaded the successful LMP1 programme with the 919 Hybrid. Between 2014 and 2017, he achieved three overall victories at the 24 Hours of Le Mans as well as winning a total of six world championship titles in three consecutive years.

Under his direction Porsche also tackled the ABB FIA Formula E World Championship, and won titles in the North America IMSA WeatherTech SportsCar Championship in the fiercely-contested GTLM class with the 911 RSR.

"Motorsport, like the entire automotive industry, is changing," said Enzinger. "Thanks to his experience and expertise, Thomas Laudenbach is exactly the right man to lead Porsche Motorsport into this future."

"I'm thrilled about the trust that's been placed in me and excited about the tasks ahead," commented Laudenbach. "We will adapt motorsport to the changed conditions in the automotive industry – from customer racing to factory involvement in the major racing series around the globe. We have our sights firmly set on claiming our 20th Le Mans victory, we want to win world championships – both in endurance racing and in Formula E. It's also important to continue developing our customer racing. With the Mission R concept study, we are showing how attractive this can look."

Born in Santiago de Chile, Laudenbach completed his mechanical engineering studies at the Karlsruhe Institute of Technology. His path initially led him to the DTM and to a service company that developed powertrain components for various European vehicle manufacturers. In the autumn of 1998, he joined Porsche AG. As Head of Powertrain Development, he was involved in racing and sports car projects such as the 918 Spyder, 911 RSR, 911 GT3 R and the 911 GT3 Cup until 2013.

As the leading developer of the 3.4-litre direct-injection V8 engine for the Porsche RS Spyder, Laudenbach also became acquainted with the North American motorsport scene, to which Porsche will now return with a new LMDh hybrid prototype. RT

Porsche presents vision of all-electric customer motorsport

PORSCHE has provided a spectacular glimpse into the automotive future with its Mission R concept car.

"We are taking the next big step forward in electric mobility. The concept study is our vision of all-electric customer motorsports," said Oliver Blume, Chairman of the Executive Board of Porsche AG. "The Mission R embodies everything that makes Porsche strong: performance, design and sustainability."

Since the start of the Porsche Carrera Cup Deutschland 31 years ago, the sports car manufacturer has produced and delivered more than 4,400 Cup cars from Weissach. A total of 30 one-make cup series are held worldwide each year. Porsche's Mission R provides an indication of what the future of one-make series with all-electric cars could look like.

The all-wheel drive car delivers just under 1,100 PS in qualifying mode and accelerates from zero to 100 km/h in less than 2.5 seconds. The electric racer achieves the same lap time performance as the current Porsche 911 GT3 Cup.

The car features newly-designed electric motors and battery cells – equipped with direct oil cooling. An electric motor with up to 320 kW (435 PS) powers the front axle, while a maximum of 480 kW (653 PS) is delivered to the rear. The manufacturer says with 900-volt technology, a 15-minute break from racing is all that is needed to charge the battery from five to 80 per cent SoC (state of charge). Charging can take place with up to 340 kW.

Mission R also features active aerodynamics and is largely made of natural fibre reinforced plastic (NFRP), the basic material of which is made from flax fibres obtained from farming. RT

PORSCHE'S MISSION R
See page 26

Remote connectivity solutions "a game-changer" for Mercedes

AS the "fastest laboratory in the world", Formula 1 is the perfect testing ground for the development of technologies for a climate-neutral future of mobility, Toto Wolff, Head of Mercedes-Benz Motorsport, told last month's IAA MOBILITY conference.

"There is a constant transfer of technology from the racing car to the road car," Wolff said.

The boss of Formula 1 champion Mercedes AMG Petronas underlined that his racing team's factories in the UK were already CO2-neutral thanks to green energy sources. In addition, the squad is working on reducing travel with new technologies.

"Sustainability and climate neutrality are of course very important topics in Formula 1 as well. If we can get it right, with all our travel, we could be a role model for other industries," said Wolff.

Software company Teamviewer has become an important partner for the F1 team's sustainability mission in the past year. "We have to reduce our mobility. That is good for the planet and good for people – especially in the professional sector," said Oliver Steil, CEO of the specialist for remote computer maintenance. He claimed that 37 megatons of CO2 – the equivalent of the emissions of about one million cars – have been saved by his company's technology. "There is a mastermind for every problem somewhere in the world. And we can match the expert remotely, without travel, with any client," Steil said.

Together with the Mercedes Formula 1 team, Teamviewer is working on fascinating remote access technologies. For example, it has been possible for the engine experts based in Great Britain to look into an engine problem at a race track somewhere in the world online and live. Further application examples are being worked on. According to Wolff, the partnership will enable his team to perform better and better: "A game-changer for us!" RT

ABOVE Teamviewer's remote connectivity solutions are focused on making Merc better, faster and greener

Mercedes acquires YASA

MERCEDES-BENZ has acquired electric motor company YASA, giving it access to the UK-based operation's axial flux motor technology and expertise.

YASA will operate as a wholly owned subsidiary of Mercedes-Benz, with its own brand, 250-strong team and premises: an HQ and production facility in Oxford, UK and innovation facility in Welshpool, Wales.

The company was founded in 2009 and regards its proprietary axial-flux electric motor technology as a step-change from the legacy radial technology on which most of the electric vehicle market still depends. Its motors won the Pikes Peak International Hillclimb in 2018 and it has been working with Mercedes-Benz since 2019.

"We've always been pioneers in next-generation electric drive technology. Now, as part of Mercedes-Benz, we're going to redefine the future of driving performance," said YASA CEO, Chris Harris. "We'll provide electric motors for Mercedes-Benz's AMG. EA electric-only platform, while acting as an innovation partner pioneering new electric drive technology for the wider Group and also continuing to supply our existing automotive supercar customers."

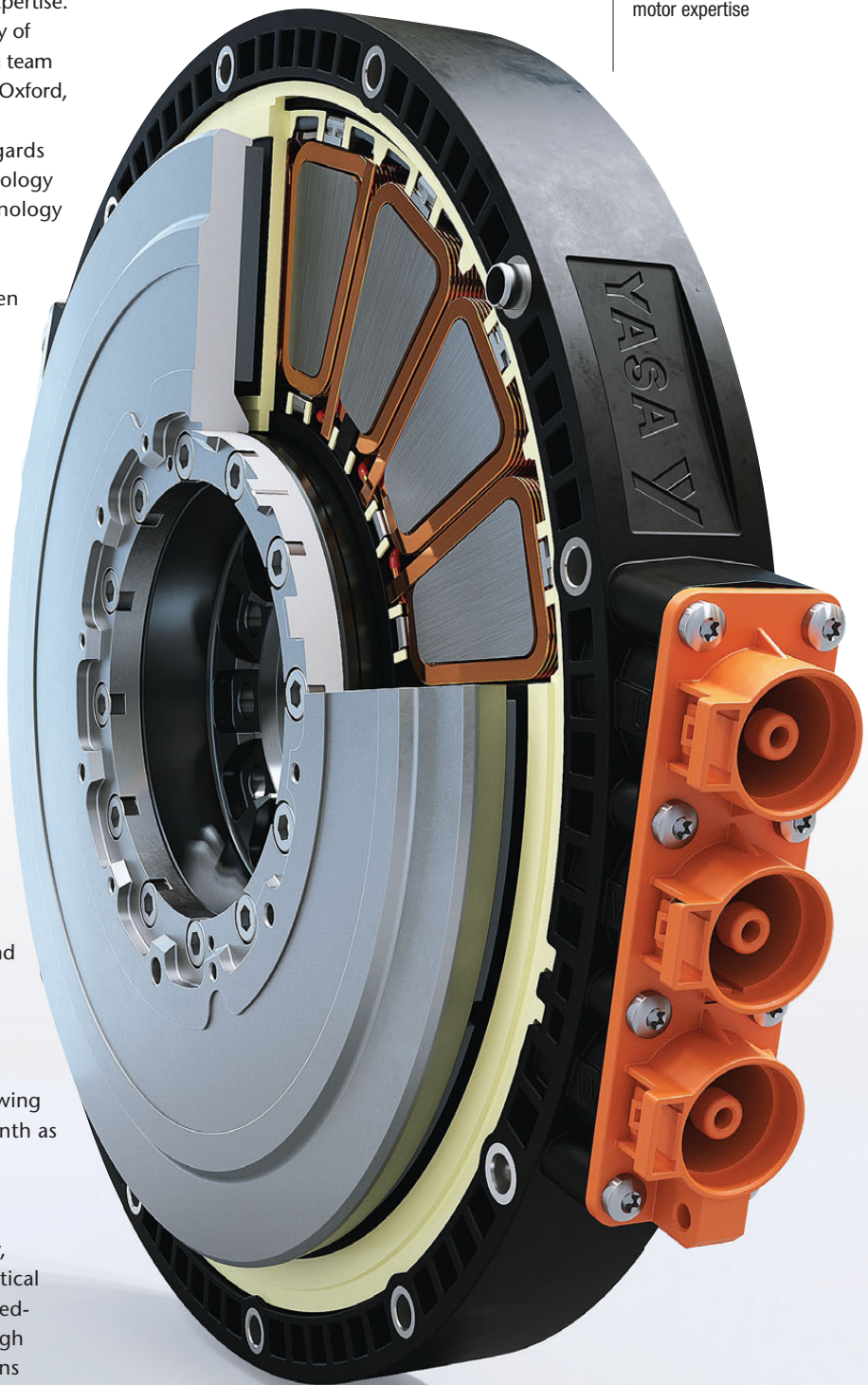
Higher power density

Philipp Schiemer, CEO of Mercedes-AMG and Head of the Top End Vehicle Group, said, "We warmly welcome YASA to Mercedes-Benz. YASA's impressive axial-flux technology allows future fully electric Mercedes-AMG performance cars to stay a step ahead of the competition. Thanks to electric motors with higher power density and continuous torque delivery we will redefine the future of driving performance."

Evolito, a new company spun out by YASA to commercialise its next-generation electric motor technology and IP for the rapidly-growing aerospace market, launched publicly last month as a privately-owned business.

Gareth Morris, Managing Director, Evolito, said: "Electrification in aerospace is some 10 years behind that of the automotive industry, but the market potential is huge. Electric Vertical Take-off and Landing, Electric Helicopter, Fixed-Wing and Urban Air Mobility aircraft need high power density, low weight electric powertrains with inherently high safety factors – a combination of attributes that are unique to our axial-flux electric motor and power electronics. By leveraging YASA's unique IP in the aerospace market, Evolito will fast-track the commercialisation of electric flight and transform mobility as we know it." RT

BELOW The deal gives Merc access to YASA's axial flux motor expertise



NASCAR takes "big swings" in Next Gen test

NASCAR emerged satisfied from its largest test yet of the Next Gen NASCAR that will race in 2022.

It assembled eight cars for a Goodyear test at Daytona International Speedway, intent on developing the tyres for next February's race and ensuring that speeds in single-car and multi-car runs were within its targets.

"We were really close to the speeds we're looking for," confirmed John Probst, NASCAR Senior Vice President, Racing Innovation, "but we only had eight cars in the draft. We wanted to make sure that we're conservative coming back here and need to have something in our back pocket should we get here and speeds are too high.

"Overnight we changed the taped spacer and made it smaller, to about 510 horsepower, and reduced the rear spoiler to seven inches. That had the desired effect; we did slow the cars down some. The feedback from the drivers was that it wasn't a radical change from one to the next, so we feel like we now have that data to evaluate coming back here."

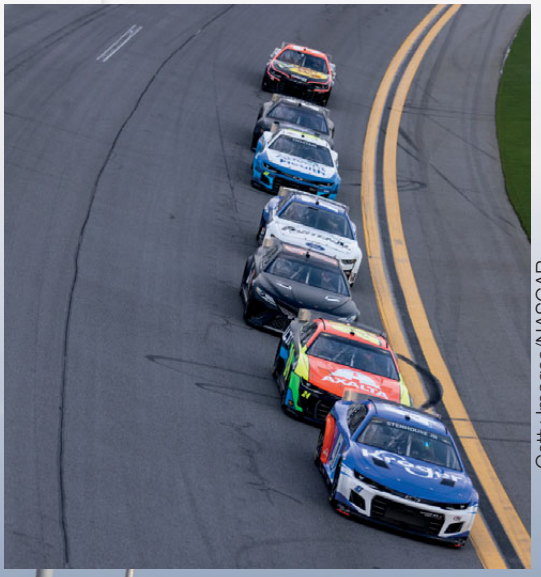
One issue identified was that of the heat within the car. "We have some ideas there," said Probst. "We used the afternoon to try some big swings at things and found some directions to go, so I feel like we made some really big gains there."

Another test at Daytona is likely to be scheduled for January, possibly with as many as 26 or more cars.

Driver reaction to the new car varied. Cole Custer admitted: "It's kind of like jumping into the unknown. There's so many things you don't know what it's going to be like. It's pretty much rethinking the whole way we race. We're going over things we never would have thought of to go over with our other car."

Denny Hamlin, by contrast, said: "It's a race car, it's got four tyres and a steering wheel. So from my standpoint it doesn't change greatly."

However, he did allow: "But still there are some nuances. Your vision is a little different. The shifting is going to be different, especially when you go into road courses. So you're going to want to get as many reps as you can to learn that." RT



Getty Images/NASCAR

BELOW & RIGHT
The Next Gen draft tests went well

GCK's hydrogen-powered Dakar challenger takes shape

GCK Motorsport has offered a first look at its ground-breaking 2024 hydrogen-powered e-Blast H2 cross-country racer.

Work behind the scenes has been ongoing with the wider group's (Green Corp Konnection) design office and engineering team supported by 21 experts from FEV, a leading global engineering provider, to design, build and integrate the fuel cell system into GCK Motorsport's current cross-country prototype. The team will present a first evolution of this vehicle at the 2022 Dakar Rally with the final car being ready for 2024.

The programme is part of GCK Motorsport's parent-company's global strategy: Green Corp Konnection uses cross-country as a lab for innovation to test its fuel cell system and powertrain in the toughest conditions before they can be integrated into vehicles in the context of its retrofit activity.

The newly-revealed visuals of the 2024 e-Blast H2 boast an all-new custom chassis design to house the proprietary GCK fuel cell and hydrogen tanks.

"The new visuals mark a key milestone in the journey to 2024 and the progress to a greener future in cross-country motorsport and beyond," said Guerlain Chicherit, President of Green Corp Konnection. "The innovations behind the e-Blast H2 are a driving force to help scale up the efforts of green technology across motorsport and industrial sectors alike. This is another piece in a very large puzzle, and I'm excited to see how the finished vehicle will look.

"This future vehicle perfectly reflects our project philosophy combining green technology, performance and design!" RT

Toyota to field new Hilux

TOYOTA GAZOO Racing will field an all-new Toyota GR DKR Hilux T1+ in January's Dakar Rally.

The prototype car, which conforms to the updated regulations for the T1 category, is currently undergoing testing – in a temporary raw carbon fibre finish – in preparation for an official reveal later this year.

The new Toyota GR DKR Hilux T1+ will share components with the race-proven Hilux that was first introduced in 2018, and won the race in 2019, but will feature a host of improvements including bigger running gear: tyres of 37 inches, up from 32 inches; together with a tread increase from 245 mm to 320 mm. The new car also has more suspension travel, with the previous limit of 280 mm now increased to 350 mm.

Under the hood, the car is now equipped with a 3.5-litre twin-turbo powered petrol V6 engine, sourced from the all-new Toyota Land Cruiser 300, as used in the striking new GR-S version of the iconic vehicle. In standard form, the engine produces 305 kW of power at 5,200 rpm and 650 Nm of torque from 2,000 rpm. However, in race trim those numbers are significantly higher.

BELOW The 2022 Dakar Hilux prototype (right) with its predecessor

"Our new GR DKR Hilux T1+ is progressing well, and we are confident that the new car will allow us to compete on a new level, come January," reported team principal Glyn Hall.

Dakar star Nasser Al-Attiyah said: "We won the race together in 2019, and now we have a new bullet coming. I am excited for our prospects, especially with the new GR DKR Hilux T1+, which is definitely faster and more capable than the previous car."

"The Dakar is one of the toughest races on the planet, but it suits our new Hilux perfectly," added Giniel de Villiers, another of the squad's drivers. "The new wheels, suspension travel and especially the move to the turbo-powered petrol engine from the Land Cruiser, is sure to make a big difference to our campaign. The engine is highly responsive, and allows us to push the new car to the limit." RT

BMW signs LMDh deal with Dallara

BMW M Motorsport has confirmed that it will use Dallara chassis for its endurance racing assault on IMSA's LMDh category.

LMDh cars will be based on LMP2 chassis developed for the category and feature a spec hybrid system. The German manufacturer is Dallara's second confirmed customer, along with Cadillac.

The contract for the programme, which will commence in 2023, was signed at the Dallara headquarters in Varano de Melegari.

"In Dallara, we are delighted to have found a partner for our LMDh project that shares our passion, professionalism and huge ambition in motorsport and, like us, is fully committed to the goal of writing a new success story in the history of BMW M Motorsport from 2023," said Markus Flasch, CEO of BMW M GmbH, during his trip to Italy. He took the opportunity, along with Mike Krack, Head of BMW M Motorsport, and Maurizio Leschiutta, head of the LMDh project, to check out the development and test capabilities that Dallara has to offer.

"After speaking to all the possible chassis partners, the decisive factor in our decision was that Dallara, with all its expertise and experience, was enthusiastic about working together with BMW M Motorsport," said Flasch. "The chemistry was there between us from the word go. We see our relationship as a real partnership in which we are fighting for a common goal of success at the racetrack."

Flasch, Krack and Leschiutta met in Varano de Melegari for discussions with the lead Dallara engineers and visited the key areas of the company, including the composite department, its own wind tunnel and the test track in Varano. The first test car will be built in Italy in a close collaboration between BMW M Motorsport engineers and a team of Dallara engineers assembled specifically for the BMW LMDh project. The rollout will take place next year at the Varano circuit.

"Dallara is perhaps the most successful race car manufacturer in the world and has already played a key role in virtually every relevant circuit racing series," said Leschiutta. "As well as the desire to work with us, several other criteria were of great importance when making our decision. Dallara is a company that covers the full range of requirements.

TOP & ABOVE The deal was inked at Dallara's Varano HQ

"Its expertise extends to the fields of chassis manufacturing, engineering, development, wind tunnel tests, and simulations. They are very strong when it comes to aerodynamics, which will be a key factor in the IMSA series. In order to ensure that our cars are ideally prepared from the outset and to lay the foundations for success at the racetrack, we are already working closely with Dallara at a very early stage of development."

"I'm honoured to have been selected by BMW M Motorsport and with great enthusiasm I'm looking forward to begin this new adventure," said Giampaolo Dallara, President of Dallara. "Back in 1977 I had the opportunity to work alongside BMW on designing the M1 as Lamborghini consulting. It was a great experience and a lot was learned. I hope to repeat the same adventure in LMDh. I firmly believe that we will do great things together."

Andrea Pontremoli, CEO and General Manager of Dallara, added: "Our partnership with BMW M Motorsport is the result of almost 50 years of work in the motorsport industry, engineering and race car development. It is a privilege to have been selected by BMW for their next and new challenge in the hybrid prototype racing world. The LMDh concept and the convergence between IMSA, ACO and FIA has no precedence in history and that will see our total commitment. We are looking forward to competing in this new and exciting chapter of global motorsport at its highest level." RT

Lotus reveals GT4 Emira

LOTUS has revealed an all-new competition-spec Emira GT4 contender.

Developed in collaboration with project partner RML Group, the race-ready concept is another milestone in the transformation which is taking place in every area of the Lotus business and brand.

The car features lightweight composite bodywork and Toyota's race-proven 3.5-litre V6 engine. The tech spec includes: a Harrop TVS 1900 supercharger; 6-speed Xtrac transmission; MoTeC dashboard with data-logging; Öhlins coil-over dampers; Alcon discs and callipers; Bosch Motorsport ABS; and Pirelli tyres.

Richard Selwin, Race Programme Manager, Lotus, commented: "The all-new Emira GT4 is an exciting next step following the hugely successful launch of the Emira road car. We have worked hard with the team at RML Group to ensure this next generation of Lotus GT car will deliver race-winning performance."

Simon Holloway, Commercial Director, RML Group, commented: "We are delighted to be collaborating with Lotus on the all-new Emira GT4 Concept. Both companies have a long and successful motorsport pedigree, and to bring that together at such an exciting time for Lotus is a welcome validation of our vision and values."

Gavan Kershaw, today the Director of Vehicle Attributes for Lotus but previously a GT championship-winning driver of Lotus race cars, has been involved in the development of the Emira GT4 from the start. He commented: "The all-new chassis on which the Emira has been developed is the perfect starting point for a high-performance race car."

The return to world motorsport is a key pillar of the company's transformation. Earlier this year Lotus Engineering, the consultancy division of the business, became technical partner to JBXE, the Extreme E race team led by F1 world champion Jenson Button.

Lotus aims to build a limited number of Emira GT4 race cars for the 2022 season, increasing production for 2023 in line with global demand.

RIGHT The resurgent Lotus motorsport division's Emira GT4

Audi ready to unleash new RS 3 LMS

AUDI is ramping up plans for customer sales of its second-generation Audi RS 3 LMS.

The brand sold a total of 180 units of its predecessor between 2016 and 2021 in North and South America, Europe, Asia and Australia. Audi Sport customer racing has not produced any other race car in such a high number within one model generation.

"This market launch has been long awaited by many customers," said Chris Reinke, Head of Audi Sport customer racing. "Our customers have clinched more than 300 race victories and 55 championship titles with the first-generation Audi RS 3 LMS to date. In the process, we have received valuable experience and wishes as feedback. Our new car is the sum of this feedback and the creativity of our engineers."

BELOW There are high hopes for the second-generation RS 3 LMS

In terms of safety, Audi Sport has once again gone above and beyond the regulations: the brand's own Protection Seat with six-point fixation; a roof hatch to facilitate recovery; and a pedal box that can be adjusted for different statures.

Audi Sport also offers a kit for endurance racing, including preassembled wiring for auxiliary headlights, a racing anti-lock braking system and a device for external refuelling. Front and rear windows made of polycarbonate as well as triangular safety nets to the right and left of the seat round off the range of options.

Deliveries of the second-generation Audi RS 3 LMS will start in the fourth quarter of 2021.

BTCC commits to more sustainable fuel

THE British Touring Car Championship has committed to using a more sustainable fuel from the 2022 season onwards.

The new fuel, selected after a tender process for the period 2022-2026, is designated Hiperflo R20. It has a total of 20% renewable components, comprising 15% second generation ethanol content and 5% of renewable hydrocarbons. It is considerably more sustainable than that which has recently been introduced to petrol station forecourts throughout the UK (E10).

ABOVE The BTCC has embarked on a more sustainable pathway

It is calculated by the manufacturer that this will give approximately an 18% reduction in greenhouse gases when compared to current pump fuel, significantly lowering the fuel's impact on the environment.

The successful tender was submitted by Haltermann Carless, which has been supplying the unbranded TOCA control fuel to the BTCC for some 26 years. A small batch of this new fuel was recently produced and distributed to all current BTCC engine builders, as well as the BTCC fuel system supplier ATL, for trial and test purposes. All tests and examinations of the new fuel have returned excellent results, with absolutely no adverse effects recorded to either engine performance or the fuel system.

The new fuel will be manufactured for the BTCC by Haltermann Carless at its refinery in Harwich, Essex, UK and distributed direct to the teams at each event by Vital Equipment Ltd.

The introduction of the new fuel next season will also coincide with the commencement of the BTCC's Hybrid era, as the series continues to lead the way in UK motorsport with regards to sustainable technology.

Alan Gow, BTCC Chief Executive, said: "As the premier motorsport series in the UK it is only right that the BTCC continues to navigate a more sustainable pathway."

Mike Jardine, Haltermann Carless Racing Fuels Division, said: "This is an exciting time for our company as we are working hard on the development and implementation of renewable and sustainable fuels in all areas of our business. Supplying our fuels to the pinnacle of British motorsport only adds to the credibility, pedigree and innovative nature of our products." RT

Formula E steps up fight against global warming

THE ABB FIA Formula E World Championship has become the first sport in the world to join the Science Based Targets initiative (SBTi) and the Business Ambition Pledge for 1.5°C commitment.

The SBTi is a partnership between the United Nations Global Compact, World Resources Institute (WRI), CDP and the World Wide Fund for Nature (WWF) and is the lead partner of the Business Ambition for 1.5°C campaign – an urgent call to action from a global coalition of UN agencies, business and industry leaders, mobilizing companies to set net-zero science-based targets in line with a 1.5°C future.

Formula E is the first and only sport to be certified net zero carbon since inception. The new commitment corresponds to cutting the championship's emissions by 45% by 2030.

Formula E has committed to new measures to meet its targets including reducing its absolute Scope 1&2 Greenhouse Gas (GHG) emissions (all energy used and purchased at its HQ and events) by 60% by 2030 and Scope 3 GHG emissions (all other emissions including freight, business travels, food and beverages etc) by 27.5% by 2030 from Season 5 (2019) baselines.

Jamie Reigle, Formula E CEO, said: "The ABB FIA Formula E World Championship exists to accelerate sustainable human progress through the power of electric racing.

"We are delighted to see a host of other sporting events and properties accelerate their own sustainability agendas to reach net zero faster. Formula E will continue to set the agenda for sport as a catalyst for change and showcase how we can all take tangible steps to reduce our combined carbon footprint."

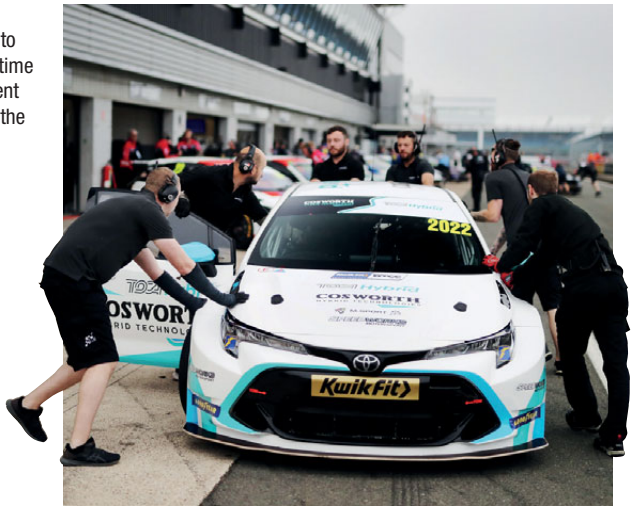
Season 8 of the ABB FIA Formula E World Championship is set to begin in January 2022 with a record 16-race season spanning 12 cities across four continents. RT

Fastest lap marks start of BTCC's hybrid era

A HYBRID-powered car took to the track in the UK's biggest motorsport championship for the first time at Silverstone last month, setting the fastest lap in the second of three races. The successful start of the British Touring Car Championship's hybrid era coincided with new research which revealed the importance of this development for the everyday motorist.

A study by Kwik Fit, title sponsor of the BTCC, found that motorists believe introducing hybrid power to the grid will have a positive impact – both for racing and in speeding up the shift to electric in road cars. Fifty-seven per cent of drivers believe that using hybrid or electric power in motor racing will help convince those who remain sceptical that these cars are credible alternatives to traditionally fuelled vehicles.

This rises to 65% among motorsport fans and a majority say these developments have a direct impact on their own views. Fifty-four per cent of racing fans say that seeing cars with hybrid or electric engines in racing makes them more likely to consider buying a low emission vehicle themselves.



RIGHT The objective was to replicate real-time BTCC race event conditions for the hybrid system

The BTCC will switch to hybrid power in all cars for the 2022 season and in advance of that, a TOCA Hybrid test vehicle took part in practice, qualifying and all three races at Silverstone, albeit starting from the pitlane. Participating in race conditions, with 2013 BTCC champion Andrew Jordan at the wheel, is a crucial part of the ongoing test and development programme ahead of next season's grid-wide adoption of the new technology.

Around one in six drivers (18%) say that a specific manufacturer's performance in motor racing influences their view of that car brand. However, showcasing technology in an entire race series can be influential for many more drivers. The Kwik Fit research found that some 58% of drivers believe that it's important to demonstrate that hybrid or electric power is suitable for racing as it shows the high performance and reliability of these engines.

Andy Lane, marketing director at Kwik Fit, said: "It's important that technological development remains a focus of racing, and that fans can see advances which are reflected in everyday motoring. Seven in 10 drivers think that technology in road cars often comes from racing innovations, and we believe that this is especially relevant to a series where motorists can easily relate to cars which are advanced versions of their own vehicles."

As well as the influence that introducing new technology into racing can have on the road, motorists believe that innovation is vital to the future of racing itself. The overwhelming majority of drivers, 73% (rising to 82% of motorsport fans), say that they expect there will be strict restrictions on racing in cars with petrol engines within the next 20 years and for motor racing to survive it will have to develop hybrid or electric replacements. Two thirds of drivers (67%) believe that it's important for motor racing to show that it is working to reduce emissions from their cars. RT

New landmark for Mission H24

THE Mission H24 programme returned to Spa-Francorchamps, the scene of its launch three years ago, for another important milestone on the journey to introduce electric-hydrogen-powered prototypes in the 24 Hours of Le Mans.

Back in 2018, Mission H24's first technology demonstrator car, the LMPH2G, turned its first laps in public at Spa. Now its successor, the H24, has also made its first outing in competition at the track, running in free practice for the Michelin Le Mans Cup among the other cars during the ELMS meeting.

The hydrogen programme, initiated by the Automobile Club de l'Ouest and GreenGT, suffered a year's hiatus due to the pandemic. Spa therefore presented a real mechanical and sporting test for the H24, its new prototype, which has covered only a few hundred kilometres in private practice.

ABOVE The electric-hydrogen H24 made an encouraging debut

Refuelled at the TotalEnergies mobile station on the pit lane, the H24 was able to complete 12 laps in the morning session, 13 laps in the afternoon. There was a constant improvement throughout each session (of almost two seconds, each time) and a huge gain in pace of almost seven seconds, compared to the GT3 cars, over its predecessor. RT

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SUSTAINABLE DEVELOPMENT

The world is currently moving very fast. To shape the future of motorsport it is essential that all people involved put their thoughts together and show that motorsport can be the enabler for new sustainable technical inventions. The World Motorsport Symposium offers the platform to be part of creating that future! It is great to see how the WMS has accelerated over the last few years and it was stunning to see that the ACO, FIA and F1 Liberty Media were using the platform to announce their new programmes and regulations!"

THOMAS KRAEMER, Director Motorsport Quality Management, Porsche Motorsport

Motorsport innovation drives our future. It's a unique environment that develops cutting edge technology and inspires next-gen talent. The powerful combination of science and sport can entertain, excite, engage and educate… These core principles shine through at the World Motorsport Symposium which provides an essential snapshot of the year's achievements balanced against exceptional future insights on the direction of every major motorsport category."

BRYN BALCOMBE,
Chief Strategy Officer, Roborace

In a changing world it is important to get unbiased thoughts from leading suppliers, manufacturers, engineers and trend-setters… The World Motorsport Symposium offers insight into different technologies from many different angles – it is a great initiative by RACE TECH to bring key people into the same room to share information and thoughts – this is extremely important for the continuing development of future energy for vehicles."

ANDERS HILDEBRAND,
Managing Director,
Anglo American Oil Company

POWER TECH | AERO TECH | DATA TECH | GREEN

The Davos of Motorsport Engineering & Technology

The Davos of Motorsport Engineering & Technology

"It was a pleasure to attend the WMS this year. As always, the quality of delegates and papers was excellent. This combined with the ever-professional running of the event made it a great success."

RICHARD BARDWELL, Director, SHARC
MARK GALLAGHER, Director, SHARC

"We really enjoyed the event and have thought a lot about it during the last few weeks. It is one of the best events of the year to strengthen our network and to be a part of shaping the future of the motorsport industry – very valuable!"

PETER WIRTZ, Customer Account,
Bosch Engineering GmbH Motorsport

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PORSCHE ON A MISSION

Porsche's all-electric GT racecar concept reveals a vision of what customer motorsports could look like in the future. **Anthony Peacock** reports

IT shouldn't come as a massive surprise but somehow it always does: the most prolific racing car manufacturer in the world is Porsche.

Since the German company quit its Le Mans programme with the 919 Hybrid at the end of 2017, it hasn't had a particular showcase – unless you count Formula E.

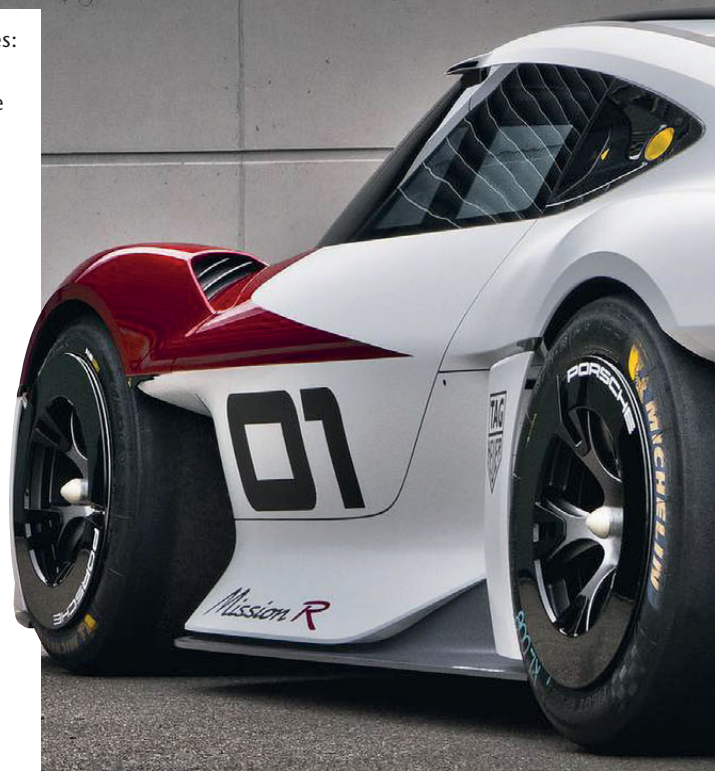
All that is about to change. Porsche has never relied on its factory programmes to make up the numbers anyway: instead, it's always been about customer racing. In other words, making money rather than spending it.

No wonder it has been so successful: Porsche is one of the world's most profitable car companies; growing in value by more than 100 million euros last year to 28.7 billion euros, with a profit of 4.2 billion euros and more than 272,000 cars delivered. By 2025, it aims to make 10 billion euros every year.

Head-turning

Those head-turning figures are reflected on the motorsport side too. The 911 Carrera Cup car, in all its variants, is the most mass-produced racing car in the world. First established in 1986 in Germany, there are now around 30 championships globally with 4,400 cars built over the years. Go to Zuffenhausen, the unprepossessing suburb of Stuttgart where Porsches are made, and the stunning Porsche Museum sprawls across the town centre, and the scale of the whole Porsche operation ▶

> *"We see sustainability as an opportunity"*



ABOVE A Drag Reduction System (DRS) on the nose section comprises three louvres in the air intakes on each side of the nose as well as an adjustable, two-section spoiler

ABOVE On the exterior, the Mission R's doors, front and rear wings, sills/side panels and rear centre section are made of natural fibre reinforced plastic (NFRP). The sustainable materials are based on agriculturally produced flax fibres

All photos: Porsche AG

becomes clear. If other car factories are like a self-sufficient village, this is more like a city.

So it's pretty clear that anything Porsche does is for a strong commercial reason. The level-headed Germans in charge do nothing on a whim.

That's why Porsche's Mission R is so vital: the 'R' in this case standing for 'racing'. The last time we saw anything similar was a project called Mission E in 2015. That went on to become the production Porsche Taycan, the all-electric road car on which the whole of the company's future is based. If Mission E was the template for Porsche's road cars, Mission R is the template for its racing cars to come.

The all-electric Mission R – which features two electric motors that can develop 1,000 horsepower in qualifying mode – bears more than a passing resemblance to the Taycan, looking a bit like a Taycan Coupé (were such a thing to exist) with the typical Porsche 911 styling cues around the rear. It's extremely compact: shorter than the current Cayman but considerably lower and wider. The company's head of style, Michael Mauer, responsible for penning those lines, drops a fascinating hint. "It's important that this car looks like a Porsche," he says. "Porsche isn't a company that creates concepts for no reason: all of them

> *"Porsche isn't a company that creates concepts for no reason: all of them have a high degree of feasibility"*

ABOVE The most important innovation of these permanently excited synchronous machines (PESMs) is the direct oil cooling of the stator

ABOVE Porsche aims to compete on all the classic long-distance endurance races using e-fuels. It is currently experimenting with Esso's renewable fuel

BELOW The Mission R is on a par with the performance level of the Porsche 911 GT3 Cup

have a high degree of feasibility. The Mission E turned into the Taycan and in fact all our racing cars are based on a production car. So stay tuned."

With Mission R firmly targeted at Porsche's backbone of customer racing, which in turn represents its most iconic models, is this a foretaste of the future of the legendary 911? As Mauer says, watch this space.

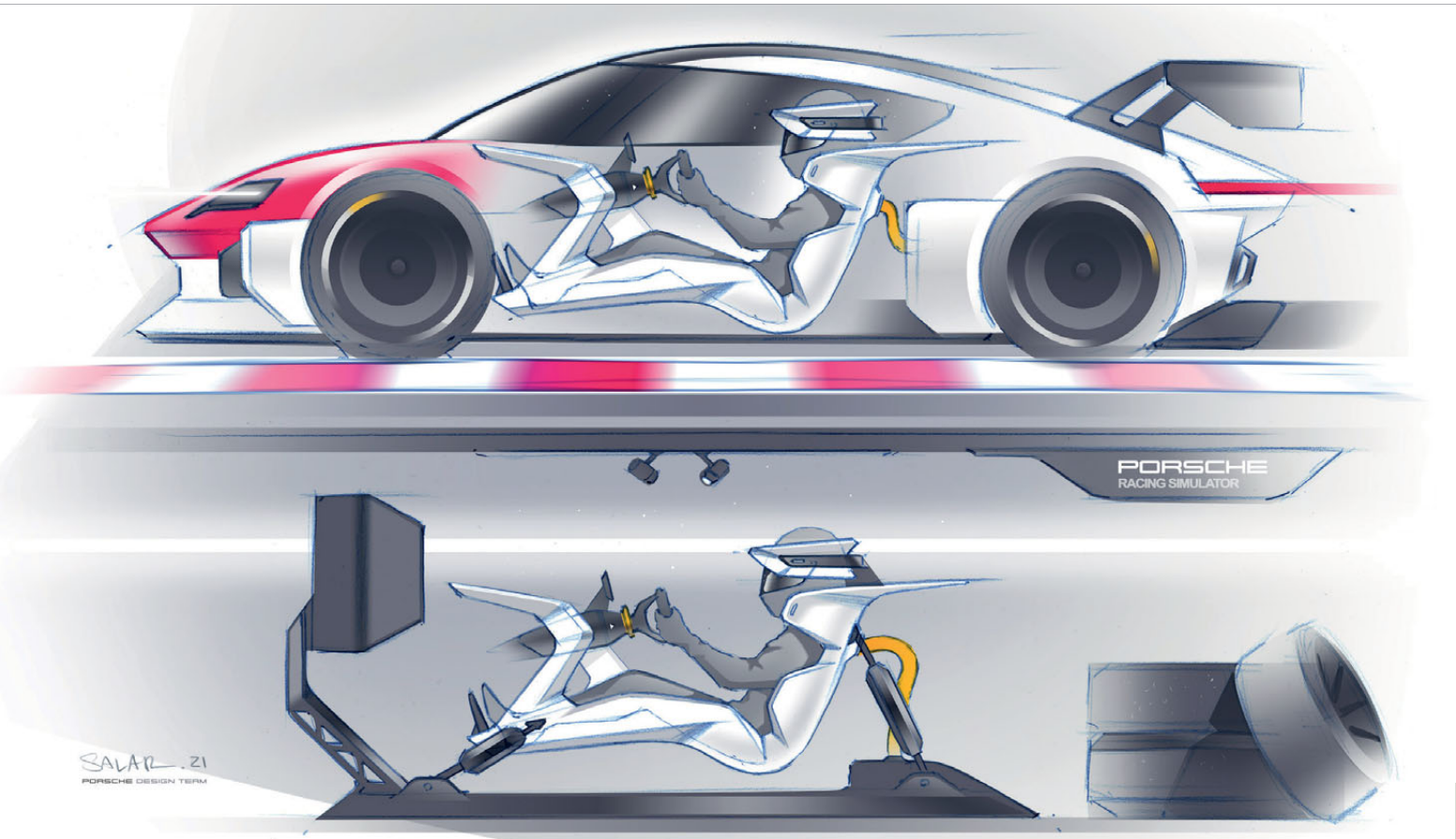
More digital, electric, connected

What's sure is that Mission R was created with the philosophy of being a Porsche first and foremost. Oliver Blume, chairman of Porsche's Executive Board, points out that motorsport is becoming more "sustainable, digital, electric, and connected."

More importantly, he adds: "We've been building sports cars for more than 70 years, yet the challenge remains the same: to combine our tradition and experience with fresh ideas and bold ways of thinking. So we see sustainability as an opportunity."

Here's the thing: despite the unquestionable worthiness of it, 'sustainability' has never been the most exciting word in the motorsport lexicon. Some may argue that it's even become somewhat irritating, as a well-worn platform for corporate virtue-signalling.

So it's refreshing to hear the unalloyed perspective of two-time Le Mans winner Timo Bernhard, who has done much of the test driving of the new Mission R, along with Lars Kern. ▶



Bernhard was described by former F1 star and Porsche factory driver Mark Webber as "a wily old fox": an old-school racing driver who's the outright lap record holder at the Nürburgring Nordschleife and has seen it all. Bernhard admits that for some people, electric motors will never have the same soul as internal combustion. But here's how he looks at Mission R: "To drive, this car is amazing. There's the instant power release combined with all-wheel drive and 1,000 horsepower. It's the sort of thing I only ever experienced before with the 919 Hybrid, which won Le Mans three times. And now we're talking about a customer car! It's definitely a car that makes your heart beat faster. The connection between test driver and the development team is very strong at Porsche, which is something I have always appreciated."

In summary, Mission R aims to give amateur racers the same performance and experience that has previously been the preserve of professionals. See it from that perspective – and hear it from someone like Bernhard – to change your view on electric racing.

Try this for size too: a top speed in excess of 300 kph and 0-100 kph in less than 2.5 seconds. It almost makes you wonder if putting such performance in the hands of everyday racers is really such a good idea…

Test bed for new technologies

Of course, as well as showcasing Porsche's passion for speed and motorsport – something that one of those very drivers, Hollywood star Patrick Dempsey, talked about at length during the Mission R launch – the car has a serious technical purpose as well, as a test bed for new technologies.

"The battery cell is the combustion chamber of tomorrow," is how Blume explains the company's one billion euro investment in decarbonisation over the

ABOVE Genuine racing and esports merge in Mission R. The monocoque-type driver cell is designed as a self-contained module and can be used in exactly the same form outside the vehicle as a simulator

BELOW This is a car designed to convert sceptics

> *"Mission R is the template for the racing cars to come"*

next 10 years, part of Porsche's aim to be carbon neutral by 2030: an unprecedented target in the automotive industry.

The company has entered into a partnership with Customcells to produce its own innovative batteries, using silicon as the anode material to significantly boost energy density, which will be operational by 2024.

"The development of high-performance batteries is how we link sustainability with the real feeling of driving a Porsche," explains Blume. "It's important to have the courage to try new things, and this is our vision of all-electric customer motorsport."

Other innovations include 900-volt Porsche Turbo Charging, which can charge the battery from five to 80 per cent in just 15 minutes. The car uses sustainable materials, such as natural fibre-reinforced plastics (made of flax fibres obtained from farming) and active aerodynamics to turn it into a veritable shape-shifter, capable of reacting instantly to changing race circumstances.

RIGHT The 800-volt technology of the three-time Le Mans winner, the 919 Hybrid, underpinned Porsche's Taycan at a time when 400 volts was normally used in electric cars. Mission R raises the bar a notch higher again with more than 900 volts

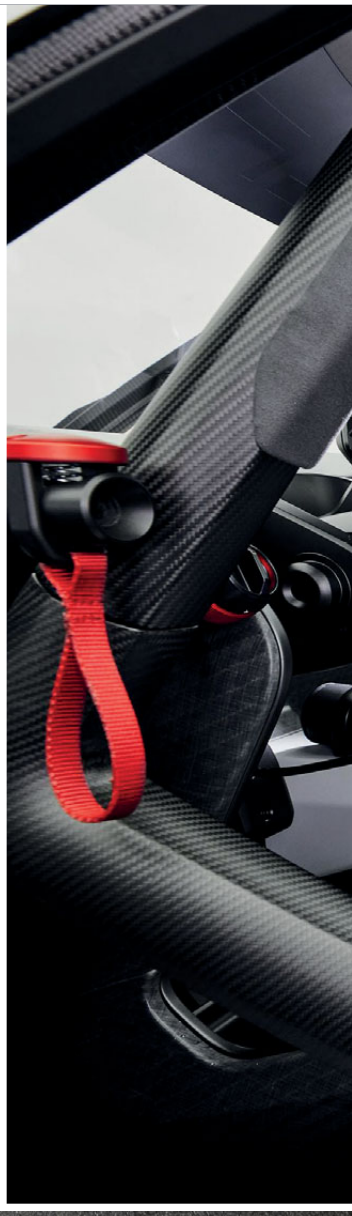
Perhaps most striking of all is the 'exoskeleton', combining the roll cage with a transparent roof skin: Blume's personal favourite detail of the entire car.

Interestingly, not all of Porsche's future development centres around electrification, as the company is also testing e-fuels in its traditional flat sixes: fuels that are made out of CO2 and hydrogen but create ▶

BELOW The concept features innovative e-motors, a high-end battery and 900 volts

RIGHT A new type of cage structure made of carbon fibre reinforced plastic (CFRP) is used to protect the driver

LEFT The steering wheel is equipped with biometric sensors, so that fans can feel connected to drivers in a unique way, monitoring all their parameters and inputs as they happen



completely clean combustion. In the short term, Porsche aims to compete on all the classic long-distance endurance races using e-fuels alone. This sounds perilously close to having your cake and eating it, but Porsche nonetheless remains committed to a future in electric racing, wherever that leads. "Porsche is a brand for people who follow their dreams," concludes Blume. "Motorsport is our DNA and the racetrack will always be our benchmark for future developments."

Just as it always has been, from those very first wins back in the 1950s on events such as the Targa Florio, when Porsche mainly raced in lower classes using prototypes that eventually found their way onto road cars. The Mission R may be the future. But in the end, that's simply an echo of Porsche's past.

A connected world

As Timo Bernhard acknowledges, people tend to fall into one of two camps: those either for or against modern 'digital' racing. Porsche wants to unite the two factions: to remove the element of tribal warfare. So the Mission R is a car designed to convert the sceptics. The transparent glass roof means that viewers will have

BELOW The 'exoskeleton' combines the roll cage with a transparent roof skin

LEFT Mission E, tested here by Mark Webber, became the template for Porsche's road cars. Mission R will be the inspiration for its future race cars

LEFT The power output from the two electric motors is transmitted to the front and rear wheels via straight-toothed input gearboxes and mechanical limited-slip differentials. To improve cost efficiency, the gearbox, electric motors and pulse-controlled inverters (PCI) on the front and rear axles are identical

a better perspective of the real driver at work, with the possibility of innovative drone footage and in-car camera angles.

The monocoque will also have a number of integrated cameras, some of which can be controlled by the driver, so that they can livestream their own real races and grow their following. Even the steering wheel is equipped with biometric sensors, so that fans can feel connected to drivers in a unique way, monitoring all their parameters and inputs as they happen.

These functions play an important role in terms of safety as well, with the transparent roof allowing greater visibility and perception, while there's an inbuilt collision warning system to reduce the risk of serious accidents. It's the functionality that you don't see on the Mission R that should allow not only improved safety, but a greater level of immersion in real racing than fans have ever seen before.

18+

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BRAKES MAY NEVER BE THE SAME AGAIN

Bosch Motorsport's new Electronic Brake System offers an affordable, user-friendly option for the rapidly-expanding electrified motorsport scene. **Chris Pickering** talks to the team behind its creation

FOR much of automotive history, braking systems have followed a straightforward mechanical concept. On early cars, you can physically see the rods or cables moving as they're used to transfer force from the pedal to the braking mechanism. Modern hydraulic disc setups are more complex in execution, but most are equally straightforward in concept.

When it comes to electric and hybrid vehicles, however, things become far more complicated. Instead of a direct correlation between the pedal pressure and the clamping force on the discs, the braking torque needs to be split between a conventional hydraulic system and the electrical braking.

As a general rule, the aim of any electrified powertrain is to recover as much energy as possible during braking. However, the amount of energy that a motor generator unit (MGU) can harvest varies with speed. It's also possible that the battery could be full or that an issue with the electrical system could reduce the effectiveness of the regenerative braking. In some cases, there may also be a limit on how much energy the car is allowed to recuperate on each lap. So, not only is there a split between the optimum level of regenerative braking and hydraulic braking required for any given pedal input, it's also one that keeps changing.

Balancing these demands is the job of brake-by-wire systems, such as Bosch Motorsport's Electronic Brake System (EBS). Inspired by the company's road car technology, it's pitched as a comparatively affordable and user-friendly option for the rapidly expanding electrified motorsport scene.

"We developed the EBS to maximise the efficiency of electric vehicles. You want to recuperate as much as possible, but the

RIGHT The men behind Bosch Motorsport's new EBS: motorsport engineer Michael Stams (left) and EBS Project Manager Florian Giura

braking torque from the electric motor varies. As such, there needs to be a device that controls the overall brake torque so you get optimum brake force distribution and consistent pedal feel," comments Bosch Motorsport motorsport engineer Michael Stams.

In a nutshell, the job of the EBS is to fill in any shortfall between total braking demand and the regenerative component using the hydraulic braking system. Deciding how much braking torque can and should be applied electrically is generally the job of a separate vehicle control module (VCM). Although

> *"The target was 1,000 bar per second and we can exceed that"*

the EBS doesn't have to carry out this high-level control in its current form, it still faces a formidable engineering challenge: it needs to react as quickly and accurately as possible while translating an electronic signal into a hydraulic pressure.

The hardware of the EBS system is based on series production parts. It consists of an onboard control unit, a valve block to control the fluid flow, a pressurised reservoir and an electric motor that drives a series of three internal pumps.

The reservoir is a key feature of the Bosch system – it stores pre-pressurised fluid in order to deliver the required flow rate and fluid pressure in the shortest possible time. This is crucial for motorsport applications, where response times are measured in milliseconds, explains Florian Giura, EBS Project Manager. "One of the requests we had from motorsport customers was to provide a very rapid pressure build up once the driver hits the pedal. The target was 1,000 bar per second, and we can exceed that. The reservoir holds fluid at 160 bar, which is more than the locking pressure on any racecar application that we've seen so far. We may only need to supply 80 bar, for example, but the important thing is to get there as quickly as possible."

The software inside the EBS system contains a PID controller. This includes pre-configured proportional and integral parameters that the Bosch engineers use to adapt it to each application, ensuring that the required pressure is reached as soon as possible without any overshoot.

"If you imagine that the pressure on the brake pedal rises linearly from 20 to 80 bar within 100 milliseconds and then remains constant, the control system has to react to that accordingly," notes Giura.

ABOVE Inspired by the company's road car technology, Bosch Motorsport's EBS responds to the market shift towards hybrids and EVs

EV or hybrid

The EBS system can be used on either axle, or two modules can be combined to work on both. Stams notes that the first motorsport application for the system was a pure electric car with two EBS modules ▶

onboard, but the principle is the same.

A typical hybrid application might see the EBS system controlling the rear brakes, while the front brakes are purely hydraulic. During normal operation, there is no direct connection between the brake pedal and the rear brakes. A sensor picks up the pressure that's being applied to the pedal; this information is then sent to the VCM where it's processed to calculate the desired brake torque from both the MGU and the EBS-controlled hydraulic system. "In this scenario, the pedal is always hydraulically connected to the front brakes and always isolated from the rears. That doesn't change, so you have a consistent pedal feel," notes Stams.

If power is lost to the system, it automatically opens a control valve that bypasses the EBS and connects the rear brake system directly to the pedal. A signal is also sent via CAN to the vehicle control unit (VCU) to cease all regeneration from the MGU. Other safety measures include internal and external pressure sensors for redundancy.

Another benefit of this bypass concept is that the brake hydraulics can be treated as a normal passive setup when it comes to repairs or maintenance; take the power off and it's the same as any other braking system.

> *"It needs to react as quickly and accurately as possible while translating an electronic signal into a hydraulic pressure"*

Production-based

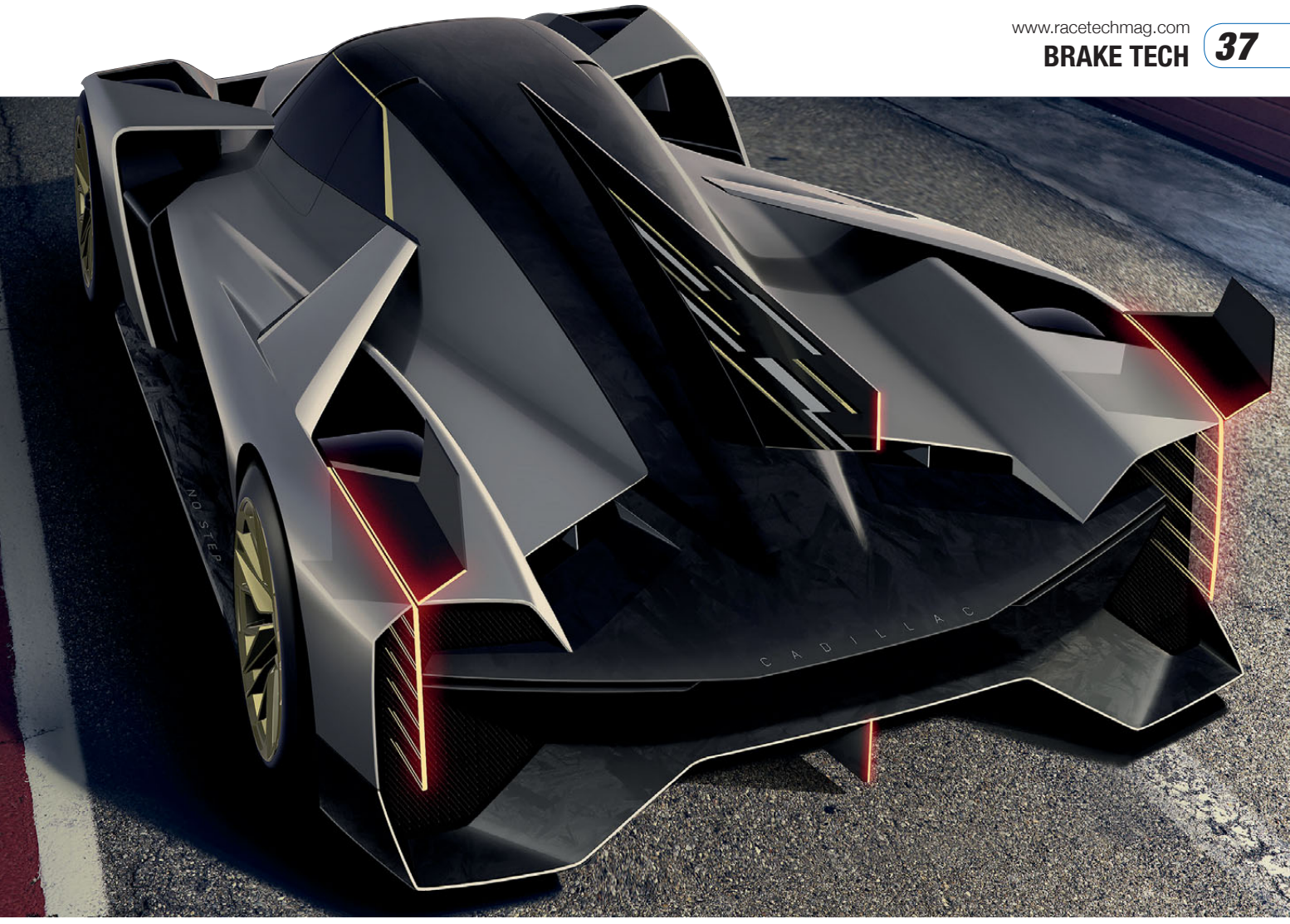
One of the advantages of Bosch Motorsport's production-based approach, according to Stams, is that the components are produced in comparatively high volumes and they have already been rigorously tested.

For motorsport applications, Bosch has focused on updating the control strategy and making the system easier to set up. Similarly, the company has set out to provide a simple and user-friendly diagnostic tool, based on experience gained from the development


Cadillac

RIGHT & BELOW
One of the first major applications for the Bosch Motorsport EBS will be the spec brake-by-wire system for the LMDh sports car category

Audi AG

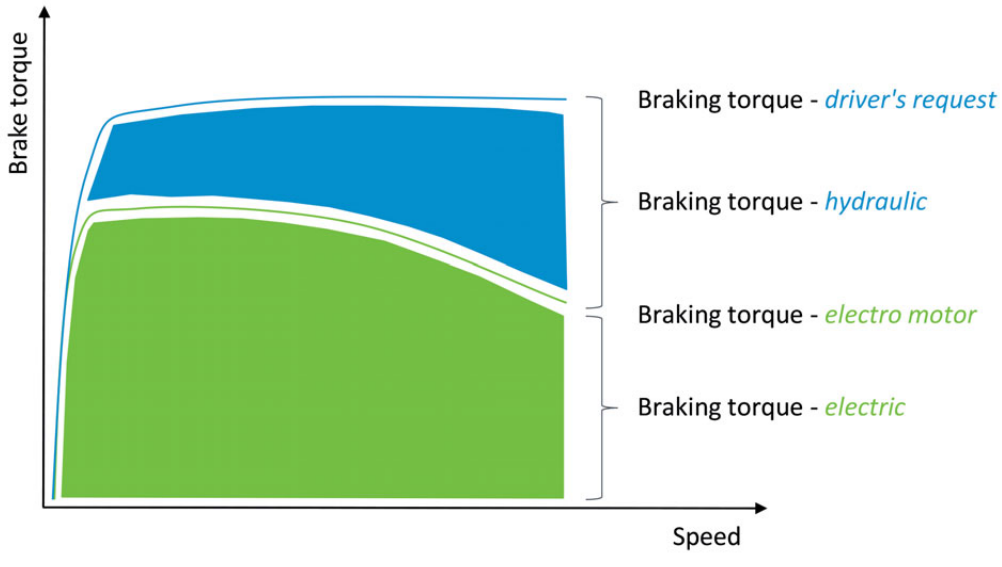


of its motorsport ABS system. The two features are now accessed by the same RaceABS software tool that's freely available to download from the company's website. This can be used to carry out diagnostic checks, to bleed the brakes and to modify vehicle parameters, such as weight, which are used by the EBS system.

"In motorsport, the time that the engineers have to adapt the system to a new use case is typically a lot shorter than it would be during road car development," comments Stams. "We have what we call a Cp value, which is the ratio between brake pressure and brake torque. For example, 1 bar on the pedal might equate to 30 Nm braking torque on the axle.

"This factor is usually calculated by models in series production cars. There, the cars are designed to always operate with the same pads and the same discs within a certain temperature range, so it's possible for the engineers to tune the system. For motorsport, we carry out the development for the application areas – there is no end user application tool for this aspect – but there are six pre-configured settings that the driver can choose from, which influence things like the system's dynamic response."

More fundamental changes, such as ▶



RIGHT The hydraulic brake torque at the electrically-driven axle must be controlled "by wire" to compensate for the varying brake torque from the e-motor

FIA

> *"The drivers like the dynamic response"*

adapting the EBS from one model in the manufacturer's range, require input from the engineers at Bosch Motorsport to re-calibrate the system, followed by track testing to ensure that the new settings are fully optimised. However, the underlying software has been designed to make this process quick and unobtrusive.

Affordable concept

The target market is predominantly customer racing, where the system has to be affordable and easy to use. Unlike Formula 1, where teams will typically develop their own bespoke systems to reduce the size and weight as far as possible, categories like GT racing and sports prototypes place more emphasis on the cost-to-performance ratio.

One of the first major applications for the Bosch Motorsport EBS will be the spec brake-by-wire system for the LMDh sports car category, and the company will also be supplying parts of the hybrid system, Stams reveals.

"We're looking forward to working with the LMDh category. A lot of manufacturers have announced their intentions to take part in that, so it should keep us busy for a while," he says. "We are already working on another project, which is a pure EV, and we're looking at LMH too."

Bosch has already looked into options to reduce the weight of the hardware, but this risks compromising the comparatively affordable ethos of the EBS. Instead, Stams and his colleagues plan to focus their attention on incorporating greater control into future versions of the EBS module.

"The hardware will most likely remain the same, but there is some potential to work on the software," he comments. "For example, the interface could be

Adrenal Media/WEC

ABOVE Bosch is supplying the MGU (motor generator unit) and inverter for the LMDh hybrid system. The cost-conscious approach to IMSA's new flagship series has proved a magnet for a stellar list of manufacturers

ABOVE LEFT With the launch of new series like the FIA's Electric GT World Championship, teams will need to contend with electronic brake systems yet keep costs under control

LEFT The fledgling Le Mans Hypercar category is one of the series Bosch is eyeing with its EBS

developed so it's not just pressure, but it could be a torque figure. We could take care of doing all the software development and the calculation, the brake temperature model and things like this, to put this into the EBS software.

"At the end of the day, it's possible that the EBS could be used to control the brake torque distribution for the whole of the car. This is an algorithm which is already available; basically we will need to adapt this to work inside the EBS."

One potential use case for this self-contained evolution of the EBS could be if a series organiser wanted to standardise parts and control development budgets. In this instance, incorporating as much control as possible into one device could be beneficial.

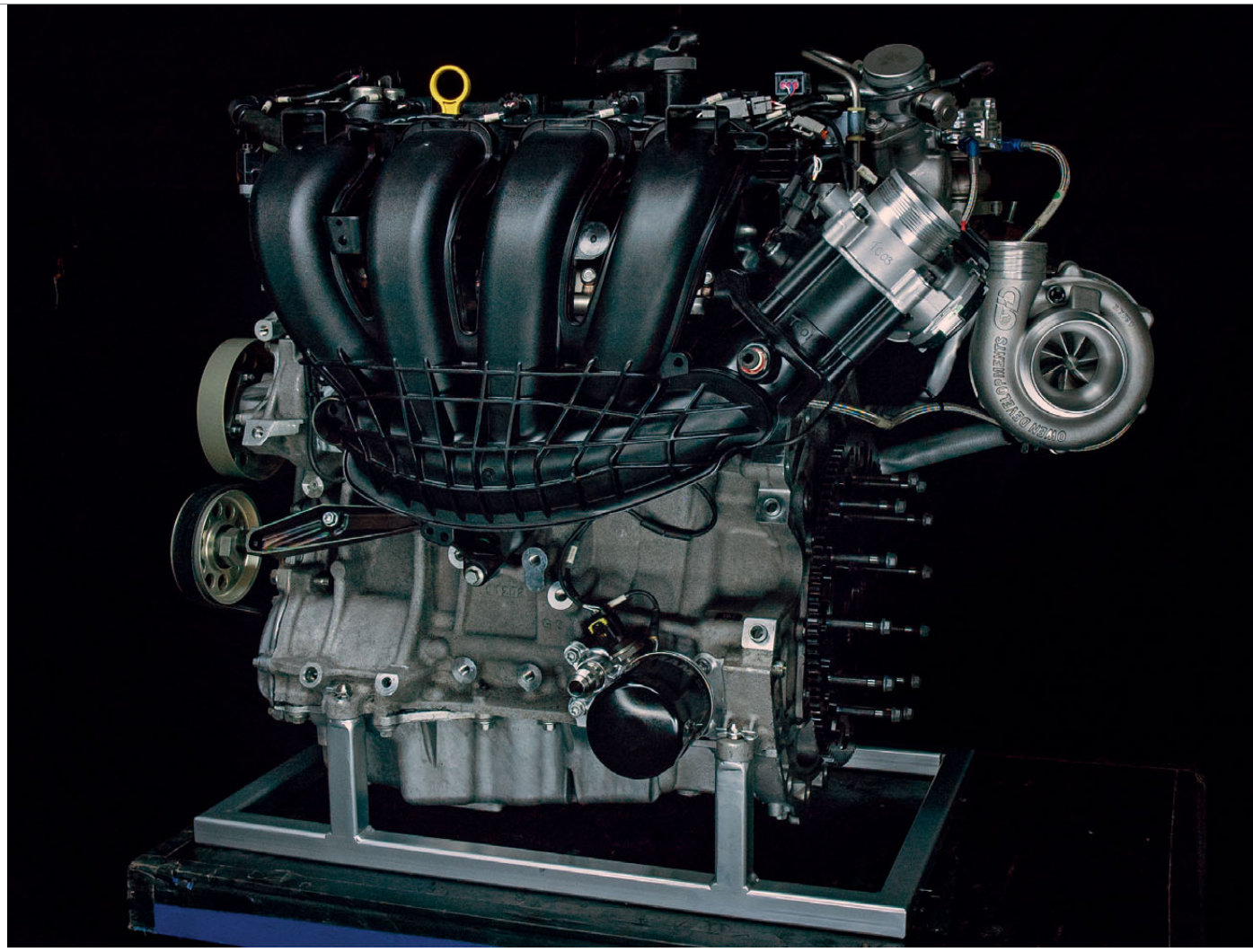
For now, the focus is on getting the first generation EBS system out to motorsport customers, and initial feedback has been very positive Giura explains: "Based on the track testing that we did with our own car, the drivers like the dynamic response. We also did a lot of hardware in the loop testing with our pilot customer, which meant that car could really race from day one onwards."

Systems like these may be a relatively new concept in motorsport. But as electric and hybrid powertrains become more commonplace, they will become an integral part of building and designing racecars. Brakes, it seems, may never be the same again. RT

RALLY SQUAD HELPS BTCC RACE INTO HYBRID ERA

Rally powerhouse M-Sport stunned rivals by winning the deal to supply the TOCA BTCC engine from 2022 onwards. With the unit now unleashed in its first races, Head of Engine Development Nigel Arnfield talks to **Chris Pickering**

Jakob Ebrey/BTCC



ABOVE The base engine is a two-litre four-cylinder direct injection (DI) unit fed by a single turbo, a setup typical of many road-going hot hatches

LEFT The 2022 TOCA engine made its race debut in the hybrid test car at Silverstone

IT'S been a decade since the British Touring Car Championship (BTCC) organisers TOCA introduced the Next Generation Touring Car (NGTC) format. With it came another new concept – the TOCA crate engine.

Unlike a spec series, those who wish to develop their own engines for the NGTC regulations are free to do so, providing it's based on a production unit from the original manufacturer's extended range. But the unbranded TOCA unit provides a competitive and cost-effective alternative for those who'd rather purchase an engine off the shelf.

Next year sees the start of a new hybrid era for the BTCC, and with it a new TOCA engine. Developed and manufactured by M-Sport, it follows the same production-based recipe as the other powerplants in the championship. Mirroring a typical setup in road-going hot hatches, the base engine is a 2-litre four-cylinder direct injection (DI) unit fed by a single turbo.

The hybrid system is a standard package from Cosworth. It features a lightweight electric motor generator unit (MGU) coupled to the standard Xtrac transmission unit and powered by a bespoke 60-volt battery from Delta. All teams will run the same system, which will be leased for £20,500 per car, per season.

The new engine marks something of a departure for M-Sport. Although the company has achieved considerable success with its own in-house powertrain projects, this will be the first time that it has acted as a third-party engine builder. It's no stranger to the production base engine, however, having worked with the same family of designs for well over a decade.

It was partly this familiarity that encouraged M-Sport's head of engine development, Nigel Arnfield, to pursue the TOCA tender, he recalls: "The tender process was the first time I'd actually seen the NGTC engine regulations. It's a good set of regulations to work to; they're well-structured and yet there's a refreshing amount of freedom in there compared to some of the other championships that we're involved with. It struck me that the engine we were working with already possessed a number of features that would make it a very good base unit for an NGTC engine."

Cost control was a key target, with the lease cost of the finished M-Sport/TOCA unit coming in around four per cent cheaper than its predecessor. To some extent this is a consequence of the NGTC regulations, which prohibit significant modifications to the block, cylinder head and crankshaft. As such, it's vital to choose a production engine that provides a suitable base with minimal modifications.

As a matter of course, Arnfield elected to use bespoke pistons and rods. "They're key components ▶

for durability, so it's not worth taking the risk to save a relatively small amount of money," he comments. "Plus, the piston design is quite important on DI engines as it forms the lower half of the combustion chamber."

Arnfield knew from previous experience that the production cylinder head design was a good starting point. "In general, we've found that when a production unit has been heavily optimised for efficiency and emissions, it tends to provide a very good baseline on the inlet port and combustion chamber design – particularly working to regulations like these where you can't modify the geometry," he notes. "The key to DI combustion is maximising in-cylinder motion, so having a high degree of tumble is at least as important as the flow coefficient. This engine provides both, with a comparatively large port area, as well as carefully-designed geometry."

One of the most crucial aspects of any NGTC engine is the inlet cam profile. As part of the homologation process for each engine, the TOCA officials independently measure the flow characteristics of the cylinder head, along with lift and duration of the cam. This data is used to calculate a boost pressure allowance for each engine, which is designed to equalise the mass air flow across all entries. It's not exactly performance balancing – the emphasis still rests on the individual engine builder to realise the unit's potential – but the idea is to ensure that they are all theoretically capable of producing the same power.

Quest for unfair advantage

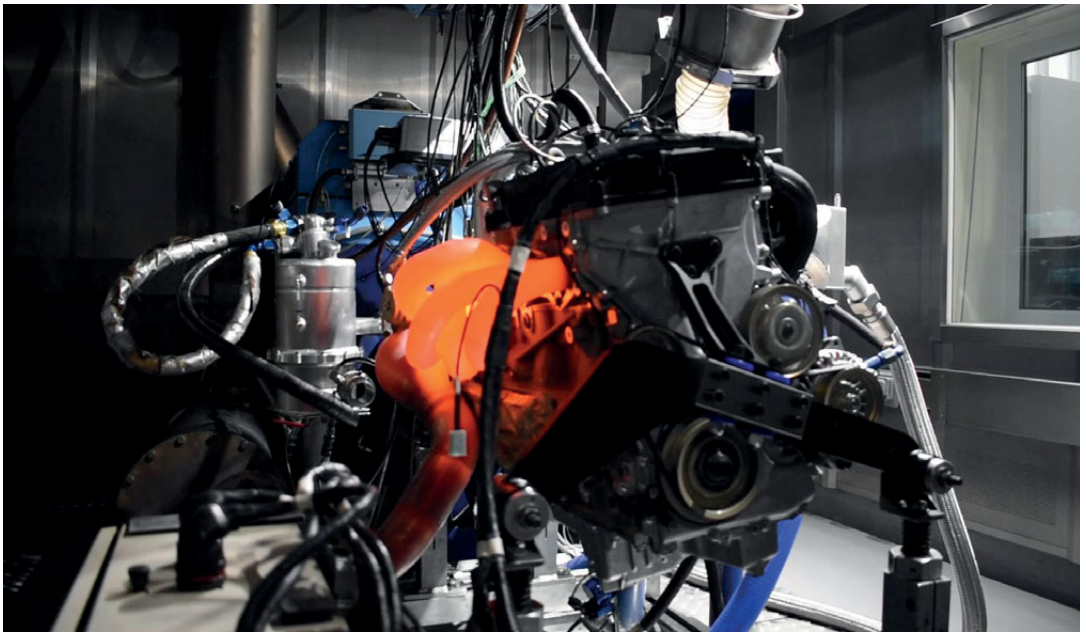
"It's a good calculation. I like the way that TOCA does it," comments Arnfield. "To be honest, it's pretty fair and it's pretty difficult for anyone to get an unfair advantage. The port geometry is fixed with the base engine, so it's really just a case of working with the camshaft profiles to get the optimum boost pressure.

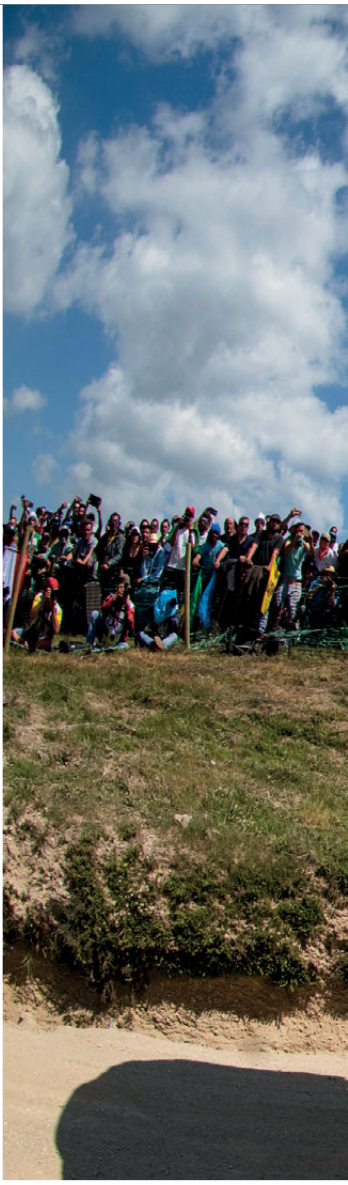
"What you're trying to do is provide the greatest possible airflow, without adversely affecting the TOCA calculation, that would result in a boost pressure reduction. We started with cam profiles that had originally been developed for a rally application but with reduced maximum lift. The profile development was a combined effort using an existing model of the cylinder head ports, and a mixture of calculation and empirical dyno testing."

M-Sport has retained the stock variable valve timing (VVT) system, which is employed in broadly the same way on the race engine. Further down the intake system, the standard production manifold has also been carried over. Likewise, the plenum chamber was tested and found to be more than strong enough to withstand the pressures produced by the touring car engine, so this too has been used.

Another advantage of this engine is that it's one of a relatively small number of affordable production engines that still comes with a separate exhaust manifold. Most have now switched to integrated manifolds cast into the head, which offer benefits for cold start performance and emissions reduction on the road car, but tend to compromise the engine's performance.

"One of the problems you get with an integral manifold is that the packaging constraints inevitably result in the runners from the outer cylinders being routed over the top of the head to meet the middle ports. That leads to a huge variation in length, which compromises the tuned lengths. Another issue is that internal manifolds reject a lot of ▶





LEFT The unit has already been subject to a duty cycle in excess of the entire 2019 BTCC season, replayed on M-Sport's dyno

ABOVE & RIGHT M-Sport has provided the engineering expertise behind the multiple championship-winning range of Ford rally cars as well as the Bentley Continental GT3

Red Bull/WRC

Bentley

heat into the cooling system," comments Arnfield.

From an NGTC perspective, the main advantage of having an external manifold is that it allows the engine builders to develop their own bespoke designs without falling foul of the TOCA regulations that prohibit modifications to the cylinder head. This means that the runner lengths can be individually tuned.

TOCA does have an engine with Integral Exhaust Manifold (IEM) actively competing in the championship, which is given a boost allowance to account for the constraints of the OEM parts. The same engine won the championship in 2016, proving that IEM designs can be successful, but many engine builders prefer the flexibility to design their own manifold.

Beyond power

The benefits of a well-optimised engine design can extend beyond its own performance – particularly in a series like the BTCC where it's hard to engineer a significant power advantage. One example of this is weight, Arnfield points out.

"I think the benefits that the engine can have on the car's centre of gravity are sometimes overlooked," he comments. "The engine sits relatively high up, so any mass you can save there that then has to be ballasted low down on the chassis is a really good gain. It's something we've worked very hard on during our rally programmes."

> *"The engine has to compete with other designs, both on-track and on the balance sheet"*

In total, the new TOCA engine will be approximately 25 kg lighter than its predecessor, and much of that is thanks to the weight saving measures employed on the standard production unit. These include improvement to the valve gear, timing chain and hydraulic tensioners, which have all had considerable mass savings from the previous generation of the production engine. Likewise, the VVT unit is said to have roughly halved in weight.

But while the base engine has got lighter and simpler in some respects, it also has to contend with an additional level of complexity in the form of the hybrid system. This is supplied as a bolt-on package ▶

Jakob Ebrey/BTCC

BELOW Consistent performance is a must for the new powerplant with more than half of the grid currently using the TOCA engine

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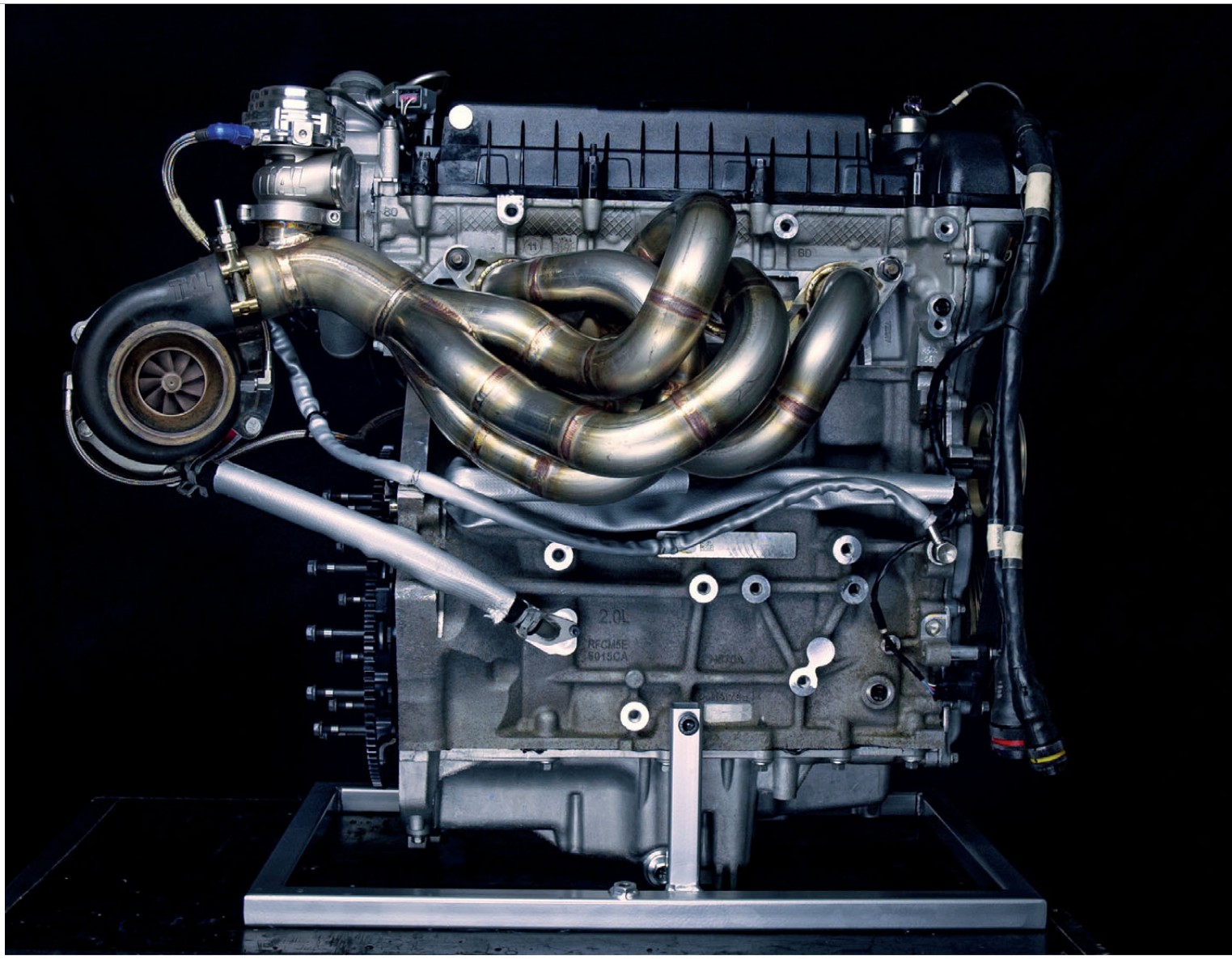


ABOVE Packaging constraints made 'move the turbo' a popular game during the design process

and controlled by a separate push-to-pass function in the standard Cosworth ECU, so it doesn't directly impact the engine. However, it still has a knock-on effect in the packaging and calibration.

Notably, it impacts the packaging when it comes to turbocharger position, Arnfield explains: "At first glance, it doesn't look like the turbo should be difficult to position, but the hybrid system does introduce a few additional constraints.

"You're trying to keep the headers as straight as possible into the turbine; you're trying to keep the turbo as low as possible for the centre of gravity benefit; and you're trying to keep the inlet path as straight as possible. That puts the optimum position right over the top of the gearbox, and the hybrid unit sits at the front of the gearbox in the front-wheel drive configuration, which means there are a few bits you need to avoid."

One of the first things that M-Sport did during the project was to acquire one of the standard RML front subframes to get an idea of the packaging constraints. The base engine is said to be slightly shorter than the current Swindon/TOCA unit. This provides a little extra space at the front of the engine (while the location of the back remains fixed by the transmission).

The company has designed its own bellhousing, which it will supply free of charge to teams using the new engine. Although not a critical factor in the performance, this was still an important part to get right, Arnfield notes. It incorporates two of the engine mounts, as well as the clutch release bearing and, on the front-wheel drive variant, the right-hand driveshaft.

The front engine mounting followed in the design process, by which point the fundamental position of the engine within the subframe had been defined. Next, the M-Sport engineers moved on to the exhaust manifold, which sits relatively close to the bulkhead on the front-wheel drive cars, presenting another packaging constraint. "We ended up moving the turbo a couple of millimetres or rotating it a couple of degrees every single day for weeks," Arnfield jokes.

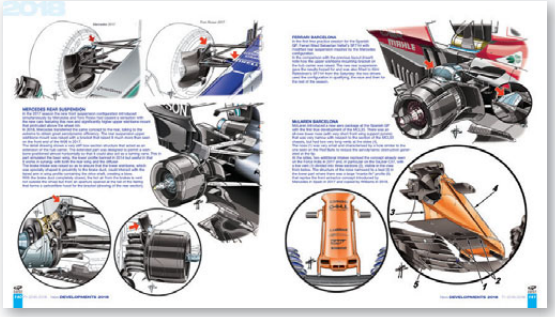
On the intake side, the throttle body sits well to the left of the engine, so Arnfield notes that some teams may find it beneficial to swap the inlet and outlet sides of the intercooler to give a better flow path.

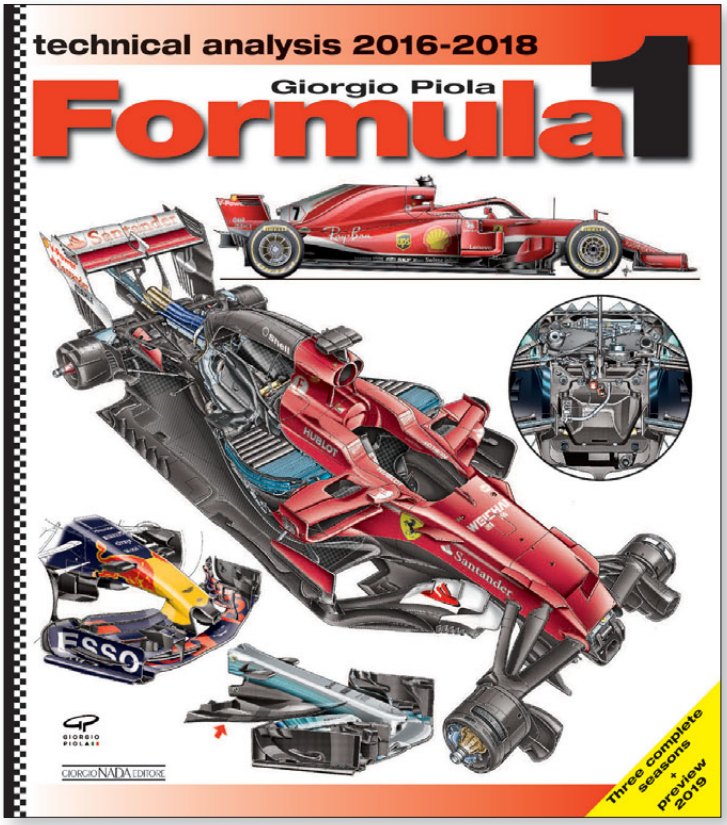
Overall, the engine looks much like a standard ▶

Giorgio Piola

NEW

FORMULA 1
2016-2018 Technical Analysis
(with 2019 preview)





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production unit. The front-end accessory drive has been redesigned to simplify things (in comparison to the OEM design, which includes extra items such as the production car's air conditioning pump). Even the alternator is no longer required with the hybrid unit fitted; M-Sport will be offering an alternative front-end drive for any teams that wish to test without it.

Another benefit of simplifying the belt routing and the number of idlers and pulleys is that it helps to reduce the engine's parasitic losses. "It's something that you have to bear in mind on any rotating part," notes Arnfield.

M-Sport's own test work on the engine began with developing a baseline calibration for the new Cosworth Antares ECU, which is another one of the mandatory changes for 2022. This required a new calibration to be built from the ground up, without any carry-over from the previous TOCA engine. Instead, M-Sport developed its own calibration for the BTCC engine, in parallel with another group within the company that's working on the same base engine for a different application.

"We started with the initial calibration. After that, the performance testing and development process began in earnest," comments Arnfield. "This work started with inlet cam profile development, exhaust cam optimisation, and further calibration development. A number of items were carried over from previous projects, using the same base engine."

In total, more than 200 power tests had been carried out by the time that the performance testing was complete. All of M-Sport's dyno testing was carried out without the hybrid system installed, but later track testing gave the engineers a chance to evaluate its impact. With a modest boost of around 40 hp, the system is not said to have had a significant impact on the engine's calibration, but small revisions have been introduced.

BELOW & LEFT The new 2022 customer TOCA engine has been run in the hybrid car throughout its 2021 testing programme

"From our point of view, the hybrid system doesn't introduce too many challenges into the calibration. With the cars set to run on electricity alone in the pitlane, we have to bump-start the engine before they join the track. Another thing that we had to work around is the additional load that system puts onto the engine, especially when it's idling. It was quite easy to stall the engine just by having a regen request, which is something we've had to work with. Out on the track, it

doesn't affect things that much."

Following the initial setup and performance development, the engine that had been used on the dyno up until that point was stripped and inspected. It was found to be in very good condition, showing no signs of stress whatsoever, even though it had been subjected to higher than normal loads.

Borescope inspection

A new engine was then assembled to carry out the durability testing. This second engine was run-in, and used for a further 20 power tests. Next, it was subject to a durability cycle that replayed the entire 2019 BTCC season on M-Sport's transient dyno.

"We were able to perform almost two entire weekends' worth of running in a single day," explains Arnfield. "The engine was power tested after every simulated race weekend and borescope inspected, plus the leak-downs were checked and recorded. After that, the same engine went on to do 2,800 km in the Speedworks development car [used for TOCA's private tests of the hybrid system] without any issue."

More than half the cars on the BTCC grid use the current Swindon/TOCA engine and it's likely that the new unit will see a similar uptake. With so many customers relying on the same engine, consistent performance is vital, but Arnfield says that's essentially guaranteed with modern manufacturing methods: "I think the concept of variability from one engine to another comes from inconsistencies of build or dyno results in the past. It's not something we really see these days. At World Rally Car level, for instance, every one of our engines comes off the dyno within a horsepower of each other – there's no variability to speak of between them."

But while uniformity is important across the TOCA units, M-Sport makes no bones about the fact that it has set out to create an engine that's as competitive as the rules allow. Ultimately, while the engine is likely to be viewed as the default choice for many teams, it still has to compete with other designs, both on-track and on the balance sheet.

> *"The benefits that the engine can have on the car's centre of gravity are sometimes overlooked"*

"We're still competing against other engine suppliers and that competitive spirit doesn't go away. We try to create an engine that's the most powerful that we can offer within the regulations, that's as light as possible, with the lowest centre of gravity and the lowest parasitic losses," comments Arnfield.

As this issue of Race Tech went to press, the M-Sport engine made its race debut at the BTCC's Silverstone round. The TOCA development car, driven by 2013 series champion Andrew Jordan, started from the pitlane to avoid compromising the race results.

In terms of championship points, the entry remained invisible but, conversely, it was important that the hybrid car be seen ahead of its introduction in 2022. The outing marked the dawn of an exciting new era for the series, not to mention another new chapter for the hugely successful NGTC concept.

Jakob Ebrey/BTCC

AUDI'S MOONSHOT

Just as NASA's engineers weren't sure what awaited them on the first moon landing, Audi's innovative Dakar prototype ventures into new territory. **Chris Pickering** reports

IMAGINE building a car to take on the Dakar Rally – a two-week marathon that covers 8,000 km and some of the toughest terrain on earth. Now imagine doing that with a cutting-edge powertrain concept that's never been tried in motorsport before.

That's the task facing Audi Sport with the RS Q e-tron, which is due to take to the sands of Saudi Arabia for next year's event.

Nobody would accuse the Audi engineers of lacking ambition. This, after all, is the organisation that brought diesel to Le Mans and utterly dominated endurance racing for the best part of a decade. The Ingolstadt engineers also have formidable partners in the form of Q Motorsport, headed up by Dakar legend Sven Quandt, whose X-Raid team has won the event six times in the last 10 years.

In essence, the RS Q e-tron is a range-extended electric vehicle. It uses motor generator units (MGUs) derived from Audi's recently-concluded Formula E programme to power the front and rear wheels. Beneath the cabin, in the middle of the car below the driver and co-driver, sits a bespoke 52 kWh lithium ion battery pack; meanwhile, behind the drivers but in front of the rear wheels, there's a 2-litre turbocharged four-cylinder engine taken from the company's previous generation DTM racer. This drives a third MGU as part of what Audi terms the car's Energy Converter, but there is no mechanical link between the combustion engine and the wheels, which are driven solely by the electric motors. ▶

BELOW The Audi RS Q e-tron is a trailblazer for the new era of alternative powertrains in cross-country rallying

Photos: Audi Motorsport / Michael Kunkel

This intriguing configuration began as the result of a brainstorming session, explains Andreas Roos, project manager responsible for the RS Q e-tron: "Even before the Dakar project started, we began looking at what a future powertrain might look like for motorsport. That's how we first came to the Energy Converter concept. This has the benefits of a fully electric drivetrain, but for long-distance racing you need a way of supplying energy to the battery. Running the Energy Converter at a fixed speed and load is far more efficient than a traditional combustion engine."

The plan is to operate on electricity alone as much as possible, with the Energy Converter only used to top up the battery when required. It's too early to put a percentage figure on the efficiency benefits, says Roos, although the brake specific fuel consumption is said to be less than 200 g/kWh, with the engine operating at a fixed speed somewhere between 4,500 rpm and 6,000 rpm.

ABOVE A cutaway view of Audi RS Q e-tron

That puts this gasoline unit roughly on a par with the most efficient road-going diesel engines. In Formula E form, Audi's MGU and inverter were said to offer a combined efficiency of more than 97 per cent in most conditions. It's fair to assume that the modified unit used on the RS Q e-tron would be in the same ballpark, even operating in more challenging conditions. As a result, the efficiency is likely to be a significant step up from a conventional gasoline powertrain, even ignoring the additional

RIGHT Andreas Roos is the project manager

BELOW The car looks huge from the outside but is tightly packed when the bodywork is removed

energy stored in the battery.

At this point, outside of laboratory conditions, it's hard to put a figure on exactly how far the car will go on battery power alone. Roos points out that the range will depend heavily on the terrain and the conditions, but the aim is to cover a substantial distance before the Energy Converter is called into action. This is likely to include the road sections used to connect the special stages, where the theoretical range should be into the hundreds of kilometres (for comparison, the road-going Audi e-tron GT quattro, which weighs somewhat more, offers an official WLTP range of 488 km from its 93.4 kWh battery). ▶

New class

What started off as a concept began to take shape once Audi approached the ASO – the promoter of the Dakar – to begin piecing together a set of regulations for its range-extended electric concept. More recently, the discussions have opened up to include the FIA, which will be adding the event to its forthcoming cross country world championship. Together, they are defining the new T1-E class that will encapsulate all alternative powertrains, although the exact details have yet to be defined.

"We have a lot of hybrid and fully electric experience here at Audi, as does the FIA. But now we have to combine that with the special circumstances that we have in the Dakar, so that aspect is completely new," comments Roos. "The exact details of the class are still being finalised."

The T1-E category caused some controversy when it was first announced. In order to make the most of the finite amount of energy carried in the battery, the regulations were drafted with a series of concessions for the alternative fuel cars. This met with resistance from several of the manufacturers in the existing T1 class, and a compromise was reached with the introduction of a new T1+ category for combustion-engined cars. This will extend most of the concessions planned for T1-E to the conventionally-powered four-wheel drive cars as well.

The new T1+ and T1-E will fall in between the current two-wheel drive (T1.2) and four-wheel drive (T1.4) regulations. They will use 37-inch tyres, as found on the current two-wheel drive buggies, in place of the 32-inch size found on the T1.4 cars, suspension travel will be 350 mm (compared to 280 mm for T1.4), while the minimum weight limit is likely to increase from 1,850 kg to around 2,000 kg. Neither of the new classes will be allowed to run a cockpit-controlled tyre deflation system, similar to those found on the buggies, so crews will still have to get out and manually adjust their tyre inflation.

"On paper, T1+ and T1-E should normally be on the same performance level. The power output between the two classes will be the final balancing factor," comments Roos. "We can't say at the moment how it will compare, but the

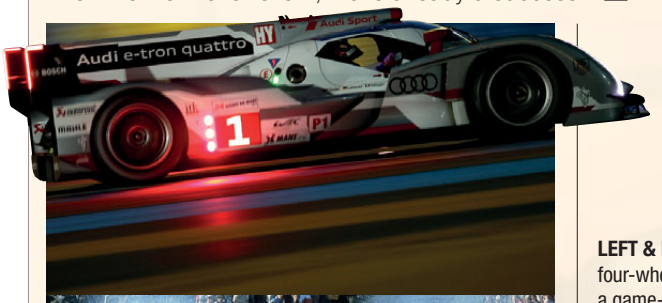
"One of the most complex cars I have ever seen"

"**AUDI** has always chosen new and bold paths in racing, but I think this is one of the most complex cars that I have ever seen," observes team principal Sven Quandt, whose Q Motorsport squad will run the Dakar entry in conjunction with Audi.

"The electric drivetrain means that a lot of different systems have to communicate with each other. Besides reliability, which is paramount in the Dakar Rally, that's our biggest challenge in the coming months."

It's a challenge the Audi squad relishes. "The quattro was a game-changer for the World Rally Championship. Audi was the first brand to win the Le Mans 24 Hours with an electrified drivetrain. Now, we want to usher in a new era at the Dakar Rally, while testing and further developing our e-tron technology under extreme conditions," says Julius Seebach, Managing Director of Audi Sport GmbH and responsible for motorsport at Audi.

Quandt compares Audi's Dakar project to the first moon landing: "Back then, the engineers didn't really know what was coming. It's similar with us. If we finish the first Dakar event, that's already a success." RT



LEFT & BELOW LEFT Audi's four-wheel drive quattro was a game-changer in rallying in the early eighties (below) and the manufacturer was the first to win the Le Mans 24 Hours with an electrified powertrain in 2012 (above). Now an electrified powertrain will take on the toughest rally of them all

BELOW Sven Quandt: just finishing will be a success

goal is for all the categories to be able to compete for the victory."

No manufacturer has ever won the Dakar on its first attempt, and Audi's radical powertrain concept faces a tougher challenge than most. However, Roos emphasises that they will be going to compete rather than simply to demonstrate the technology: "For sure, when we compete at Audi Sport we always want to win, we're not just there to take part. On the other hand, we don't expect to turn up to an event like the Dakar and win straight away. The first year will be a learning curve. "We'd like to prove the potential of our new concept with some good stage results, but we're mindful that the Dakar is one of the hardest events in motorsport. It's not about getting the concept to work for one or two days, it has to be competitive ▶

LEFT Motor generator units derived from Audi's Formula E programme will power the front and rear wheels

for 14 days, and with all the components that we have in the car there is more risk of a technical issue. Our focus at the moment is to get that reliability; then from the following year onwards we can push for a win."

This is a long-term programme, he adds, with the team already looking two or three years down the line. By that point, it's highly likely that others will have joined them. The rally organisers have already announced their intention to move all 'elite' drivers over to alternative fuels by 2026, but it's likely that the arrival of the T1-E category could tempt some manufacturers to make the move sooner than that.

When Race Tech previously spoke to Prodrive about its T1 (now T1+) Hunter there were hints that the company had already looked at an alternative powertrain concept. Similarly, while it's purely conjecture, it's not hard to imagine Toyota – with its recent success in the Dakar and its much-publicised history in hybrid powertrains – fielding an entry.

"It would be very interesting for us [to have competition]. We want to use the Dakar to show that this technology can work – and the more competition we have, the better platform it gives us to demonstrate that," comments Roos.

Bespoke battery

Creating an electrically-driven car for the Dakar is a unique challenge, but the team has applied fundamentally the same development approach as it would for any other project, Roos explains: "The conditions that the car will face on the Dakar are more challenging in some respects, but the philosophy is basically the same, whether it's Formula E, DTM or the Dakar. We've already worked a lot on energy management for LMP1 and Formula E, so that has been useful here. All the software development has been done in-house for these projects, so we can draw on that experience when it comes to brake-by-wire and the control of the MGU."

The key difference is the environment – not just in terms of the heat and dust encountered in the desert, but also the unpredictable nature of the terrain. With a circuit racing car, the engineers know the contours of the track down to millimetric accuracy and can prepare accordingly; driver-in-the-loop simulation has become an integral part of the process, allowing the prototype cars to be 'driven' in the virtual world before they ever turn a wheel in reality. But that's not feasible for the Dakar, where there's so little repeatability in the surface, Roos explains. ▶

BELOW Audi's RS Q e-tron is differentiated from conventional rivals by its futuristic look

ABOVE The alternative drive concept combines an electric drivetrain with a high-voltage battery and a highly efficient energy converter (TFSI) for the first time

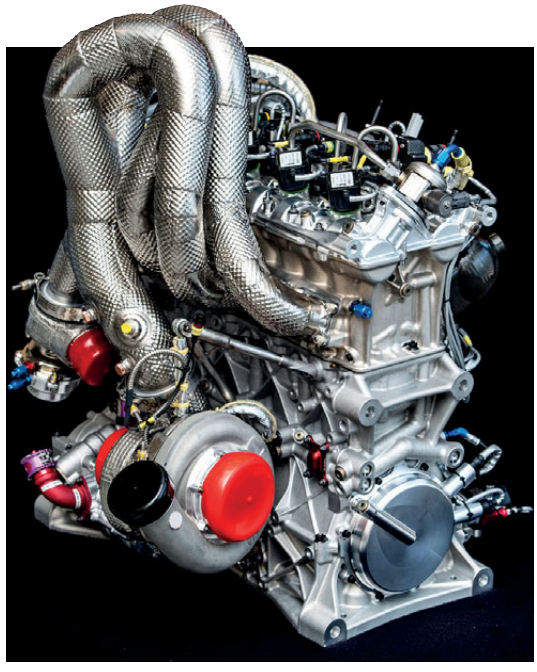
"Even an identical car following the same path five minutes later finds different conditions," he notes. "We looked at the data with our partner Q Motorsport to define things like the maximum and minimum temperatures, the longest amount of time you might spend at maximum throttle, and how the temperatures change when you're stuck in a dune. We've used these as part of our inputs for simulation and dyno work, but it's not as if there's a standard Dakar drive cycle that we can use."

Compared to most forms of conventional motorsport, the Dakar also offers far more technical freedom. Unlike Formula E, the opportunity to showcase a new drivetrain concept also gave Audi the chance to design its own battery pack.

Roos and his colleagues began by looking at where to fit the battery pack, and quickly concluded that it would be best located under the floor. This keeps the centre of gravity height low and places the battery safely within the perimeter of the spaceframe, protecting it in the event of an accident. Some initial simulation work helped to define the capacity of the battery and flesh out the design, which has resulted in a 370 kg pack, capable of charging at up to 220 kW, with a total system output of circa 300 kW (subject to confirmation of the rules).

Unlike circuit racing, rally raid doesn't tend to feature many heavy braking zones. The cars can be flat out for kilometres at a time over the dunes, which means there's little opportunity for regenerative braking, so the team aims to harvest it as effectively as possible when the opportunity does arise.

In theory, the car can charge itself while stationary using the combustion engine, but it's more efficient to use an external generator. The team is investigating ways to do this with renewable energy, rather then a diesel generator, but the remote locations and lack of permanent infrastructure make this challenging. Looking ▶



RIGHT The 2-litre turbocharged four-cylinder engine that dominated the DTM will drive a third MGU as part of the car's Energy Converter

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beyond Dakar 2022, options are also being evaluated for more sustainable fuels to power the onboard engine.

There are other challenges facing the engineers and support crews. A more complex car than the existing T1 machines inevitably means more spare parts and a bigger logistical operation. They also need facilities to support the charging back at the bivouac.

Things will be more complicated for the crews out on the stages too. Dakar vehicles always carry a selection of spare parts onboard. As with a traditional entry, the spares package for the RS Q e-tron is likely to focus on things like suspension components that can be damaged on rocks and other obstacles.

"We won't know what spares the crews are likely to need until we've done more testing, but it's likely to be the usual parts that can be damaged on the stages – it won't be possible to carry spare MGUs or anything like that," comments Roos. "We're also looking at the systems side. The crews will have some procedures that they can use to reset things in the software. For instance, they'll be able to reset some of the sensors and systems on the car."

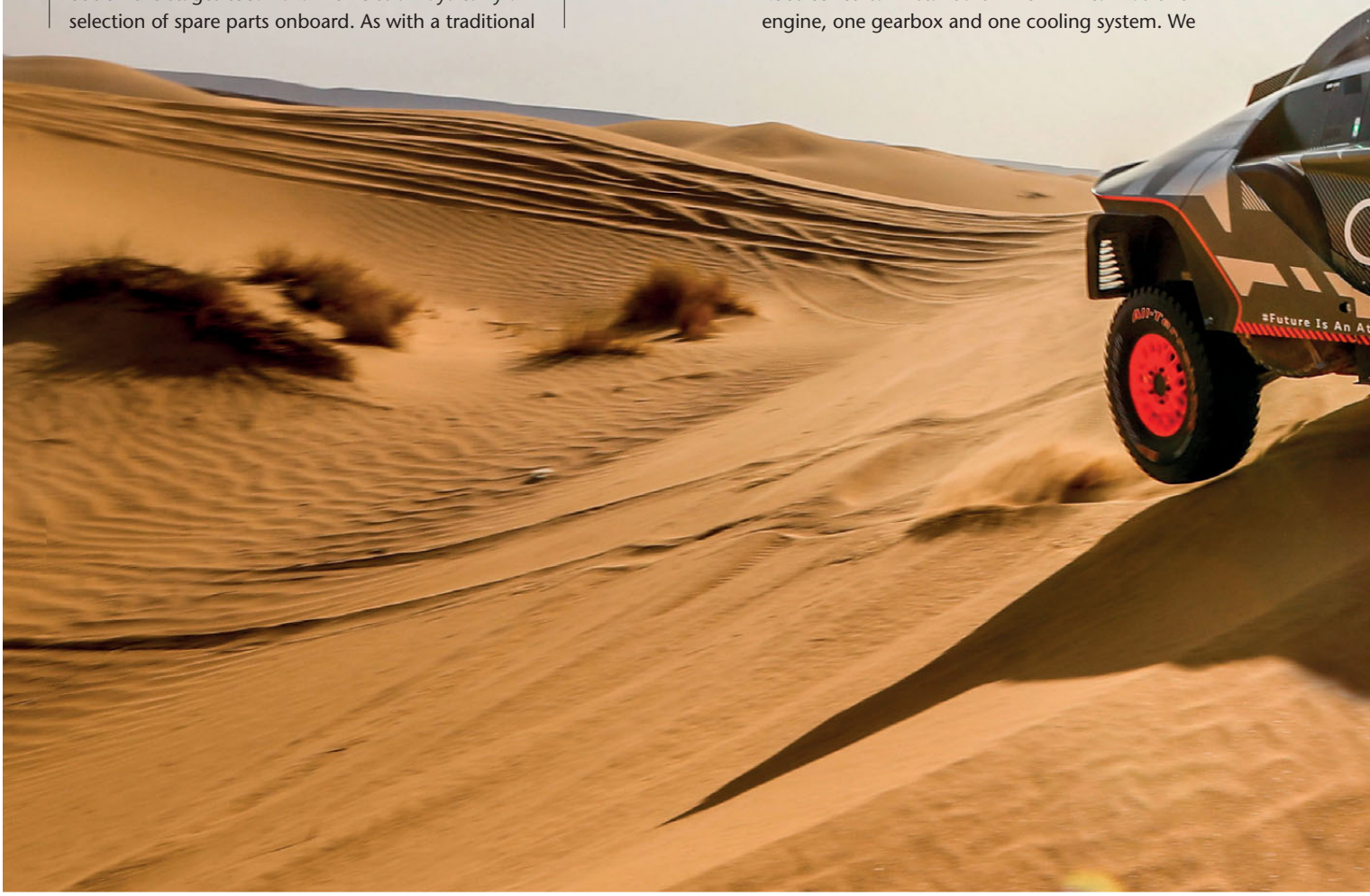
ABOVE Engineers gathered valuable data running in Germany and Spain but endurance tests in sweltering heat over the Morocco dunes presented the most extreme challenge yet

Tight timescale

Audi Sport has adapted existing technology for much of the powertrain, while Q Motorsport has brought a wealth of experience to the chassis side. But the real challenges come with packaging all of this technology together, and doing so in a relatively short timescale.

Sven Quandt has likened the project to the first moon landing in the way that it pitches the engineers into unknown territory. With the body panels off there's even a hint of lunar landing module to the car's appearance, such is the density of the packaging for the various electronics modules, pipes and cables.

"The packaging was a big mountain to climb," Roos concurs. "A standard T1 or T1+ car has one engine, one gearbox and one cooling system. We



have MGUs front and rear, both with their own gearboxes, a combustion engine and a third MGU in the middle, and then a battery, plus cooling systems for all those parts. Ultimately, you only have roughly the same size car to fit all that in. The car looks huge when you first see it, but when you take the bodywork off it looks really tightly packed."

The layout of the cooling system has been one of the toughest challenges, he notes. There are six cooling circuits in the car, including the air conditioning, which have to be packaged in a way that allows the air to flow around them. They also require additional fans for the very real possibility of the car becoming stuck in the dunes, where the system can be operating at full power with little or no air flow.

For Roos, the other challenge that stands out so far has been the timing: "It wasn't even 12 months from the point we got the go-ahead to the roll-out of the car, which is a very demanding schedule for a car of this complexity. All the different systems on the car have to talk to each other – including the battery – so it's a huge challenge in terms of systems engineering and software integration."

> *"We began looking at what a future powertrain might look like for motorsport. That's how we first came to the Energy Converter concept"*

The punishing schedule isn't about to let up, either. As soon as the development phase was complete, the team moved onto testing, with around six months to hone this fearsomely complex car before the Dakar.

Some of the conditions the test team encountered during almost two weeks of testing in Morocco were extreme. "The thermometer climbed to well over 40 degrees Celsius at times," says Quandt. "Sandstorms also hampered the testing. In addition, as expected, some new problems arose in the high temperatures, which repeatedly caused interruptions to the testing and needed to be solved before the next test."

"We expect much lower temperatures at the Dakar Rally," says Roos. "Nevertheless, we deliberately went to Morocco to test our concept under the most extreme conditions. Components such as the MGU, for example, were basically not developed for use in such high ambient temperatures, but the drivetrain and other components were also pushed to their limits or even beyond by the heat. The insights we gained in Morocco are invaluable, but they also show us that we still have a lot to do before the Dakar Rally and there is not much time left."

The high-voltage battery, which was developed specifically for the Dakar Rally, is also a major topic. "It's all about optimum temperature management and being able to call up the battery's maximum performance," says Roos. "This is where we are learning with every test. And that's exactly why we are going to the desert with an electrified drivetrain: We are gaining an incredible amount of experience that we are sharing with our colleagues from road car development."

But this is just the beginning. There will be thousands of kilometres more of testing to negotiate before the RS Q e-tron even reaches the start line in Ha'll on 1st January. Beyond that lies the toughest event in motorsport and maybe – just maybe – a place in the history books. RT

ABOVE The highly complex prototype underwent almost two weeks of testing in Morocco under the most extreme conditions

"When we say we treat the track as the extension of our laboratory, we mean it!"

Victory in the Le Mans 24 Hours with Toyota triggered celebrations that rippled across the globe. **Mark Skewis** speaks to Tomek Young, Global Motorsports Technical Manager, Lubricants Technology for ExxonMobil

Just playing devil's advocate here, but some fans might question how much difference lubricants really make in a 24-hour race?

"Lubricants do matter, they matter a lot! Modern motorsport at the highest level considers every detail. No stone is left unturned in pursuit of peak performance, so all of our racing lubricants matter. Engine oils are developed together with the key component of the car, the engine, and Mobil develops our formulations in-house. We design the composition to meet the engine's needs and then tweak it multiple times to achieve optimum performance.

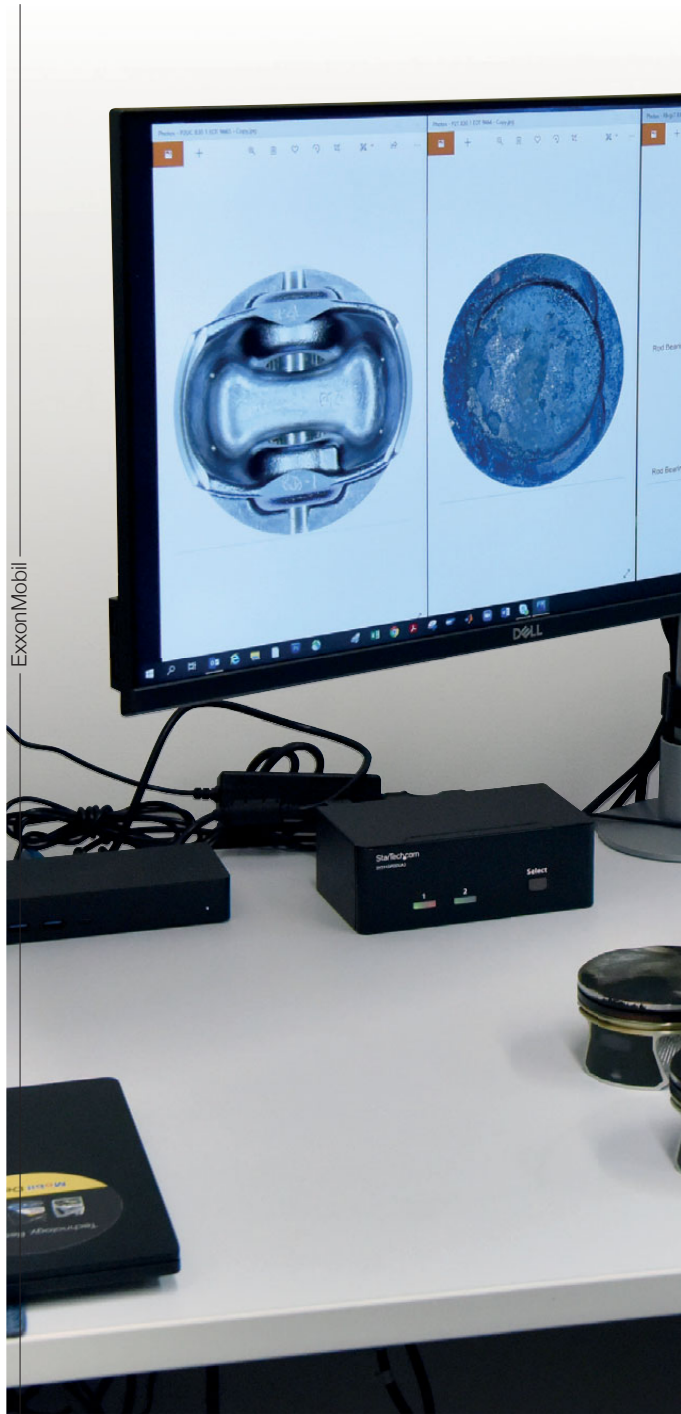
"When we say we treat the track as the extension of our laboratory, we mean it. Much development is done in stationary engines running on dynamometers, sophisticated instruments that simulate race conditions, but no amount of testing replaces validation in a 24-hour endurance event."

This was the first ever victory for a Hypercar at Le Mans. How has the transition from the LMP1 category to the new regulations affected your work?


Toyota GAZOO Racing

BELOW This might have been Toyota's fourth consecutive victory but it was also an historic achievement as the first ever win for a Hypercar at Le Mans

RIGHT Races aren't just won at the circuit: a technician evaluates pistons after a test at the Mobil 1 Engine Test Facility Metrology Lab in Clinton, New Jersey (USA)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> *Our engineers need to deal with the challenge of many types of alloys and composites that all move against each other and experience different relative velocities and pressures"*

"The Le Mans-winning Toyota GR010 HYBRID was the result of a dedicated, high-profile project that required incremental effort. While the WEC race cars are subject to Balance of Performance, maximizing power is always a priority. We design our formulations to offer performance over the widest possible operating envelope.

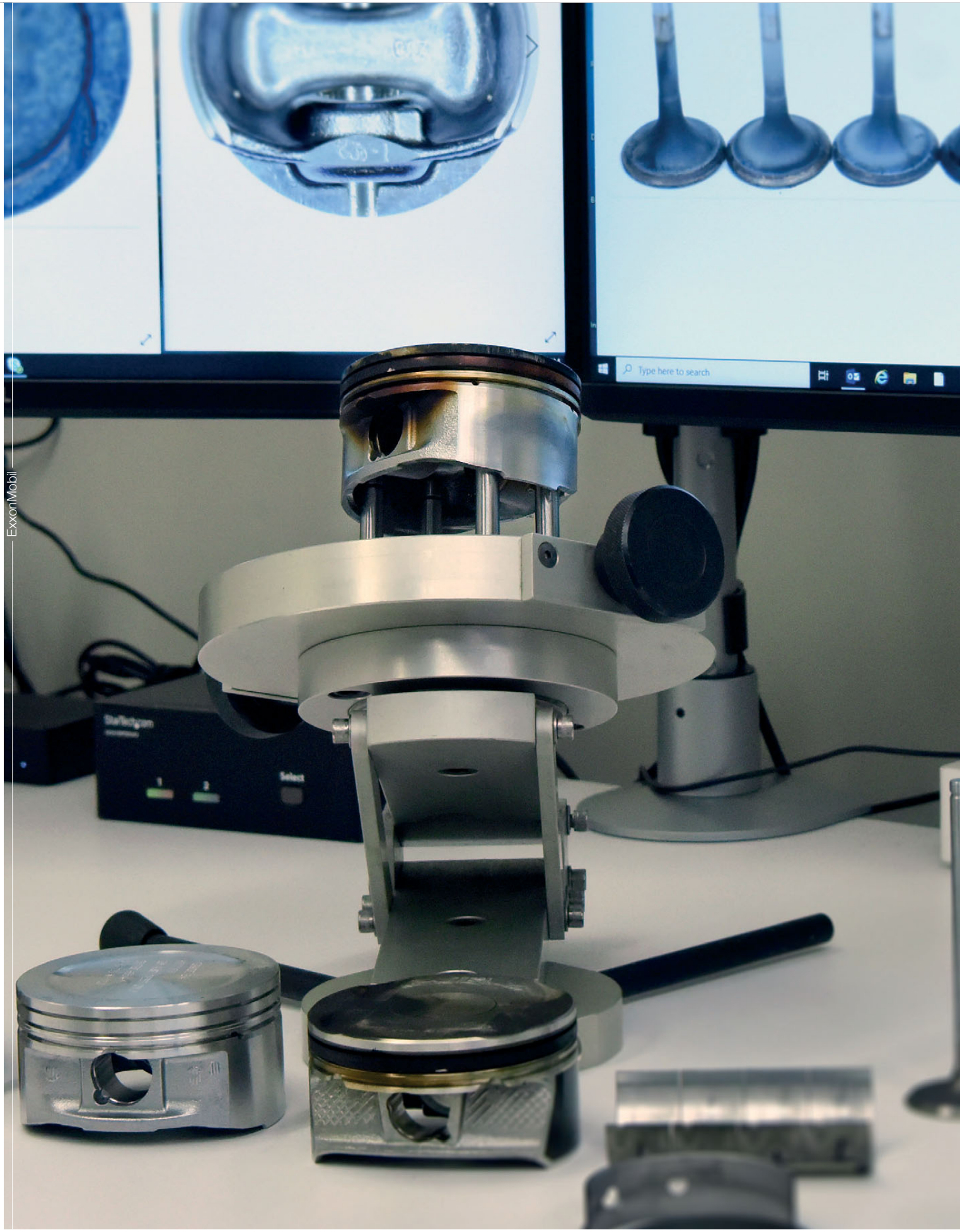
"We balance many priorities but our main one is engine durability, and this requirement is where the science comes into play. Our engineers need to deal with the challenge of many types of alloys and composites that all move against each other and experience different relative velocities and pressures.

"It would be easier if engine oil was equally supplied to all of the parts, but it is not. Sections such as the top ring only get a small amount and that small amount can burn and turn into harmful deposits."

People sometimes take success at Le Mans for granted when a big team is involved, but the reality is not that simple: what were the emotions amongst your team when the Toyota crossed the line?

"We were all so proud! Some of our staff were in France celebrating at the track and the rest of us immediately exchanged emails with our Toyota colleagues.

"Technical and logistics support ▶



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Toyota GAZOO Racing

ABOVE Toyota's winning GR010 HYBRID Hypercar covered 5055.2 kilometres at an average speed of 210.5 kph

LEFT Twenty-four hours of hard graft on the track are underpinned by months of painstaking work in the laboratory

in motorsports is very complex and we continuously have future generations of products under development. We are often completing final testing on one formulation whilst simultaneously working on a different concept that is new and hopefully better.

"We supply a team that races across the globe, and all of this occupies our minds, but it is our hearts that experience the incredible emotion that this great sport triggers. Our chemists and engineers are all fans and on each of our desks you will find an array of motorsports memorabilia, including used engine parts from catastrophically failed tests!"

I understand Mobil's F1 programme made a big push in evaluating chemicals not usually used in engines, so have your 'secret' chemicals from the cosmetic industry been used in sportscar racing?!

"This formulation is different from the Mobil 1 Racing engine oil that is used in Formula 1, but it is unique and special in its own way.

"One piece of information that I can share with you is that it does not fit into the industry standard viscosity classification which is the classification that anyone who attempted to select or buy their own oil was guided by. (I am speaking about the combination of letters and numbers, such as 0W-20 – a part of an SAE standard). This new oil combines properties of two different categories!"

How different, chemically, are your racing lubricants from your regular automotive offerings? Are we talking different worlds?

"An engine oil is comprised of many different base oils and additives to match the expected performance characteristics. Our racing line is mostly using the same functional groups of components that our regular offerings are made of. We have even recently introduced Mobil 1 products that are track to street on one oil for the racing enthusiast.

"However we do often test and employ new molecules for race specific formulations, such as the Toyota oil we are speaking about, featuring molecules that we have never used before. In this particular example of the Le Mans oil, we have found benefits of a new copolymer that forms nano-sized structures when in solution. We might later add it to our commercial products. Lubricant chemistry can be quite fascinating. I hope we can speak about it more in the future!"

Technically, what do you see as the challenges for motorsports lubricant development in the next few years?

"Each individual series makes its own decision, but we do see a general trend of hybridization and electrification. These new electrical components bring new requirements and this is an area that we have been working on for some time which is evident in the release of the Mobil EV lubricant line."

How has the COVID pandemic influenced your motorsport programme?

"The pandemic has had a profound impact on our industry and my company. Lubricants are everywhere and are universally present in all mechanical systems that have moving parts. We needed to quickly assure continuity of our operations whilst securing access to essential components and ensuring adequate supply for our customers. Our day-to-day racing jobs changed completely.

"As I previously mentioned the track is very much our proving ground, and we normally like to send technical representatives to our race events. At the beginning of 2020 nearly all of us became desk-bound, often at home, but we are fortunate to have computer systems that allow us to make blends and run experiments remotely.

"I want to recognise and thank my colleagues who travelled to races, dealt with the COVID-19 restrictions and were often not able to come home for extended periods of time. One person in my team travelled in a bubble and had to quarantine in hotels for weeks. All of this hard work and sacrifice ensured that our partners were supplied, and we are proud that each time you saw Mobil 1 on the livery, our custom product was in that car." RT


ExxonMobil

ABOVE With such fine margins at play, simulation (here with a piston skirt) plays a key role in fine-honing the properties of each lubricant

TARGET PRACTICE

Marc Cutler follows Nuno Costa, FIA Head of Competitor & Road User Safety, as he targets off-the-shelf safety products and puts them through the latest tests to ensure they are still worthy of FIA-approval

ON every piece of FIA-approved safety equipment there is a hologram affixed that ensures the product is genuine and complies with the latest safety standards. But how do competitors know that is always the case?

To ensure that every product complies to the strict homologation rules that are defined by FIA Standards, FIA Head of Competitor & Road User Safety Nuno Costa targets off-the-shelf safety products and puts them through a post-homologation process to ensure they remain as safe as when first tested.

Post-homologation tests compare the off-the-shelf product with the original that was tested during the homologation process. The latest of these was done with a Frontal Head Restraint (FHR) from Stand21 which included three tests: two non-destructive and a final one that applies force to the device until it fails.

"If we see during the post-homologation that something has changed outside of the permitted modifications, that is a fail,"explains Costa. "There are two types of post-homologation

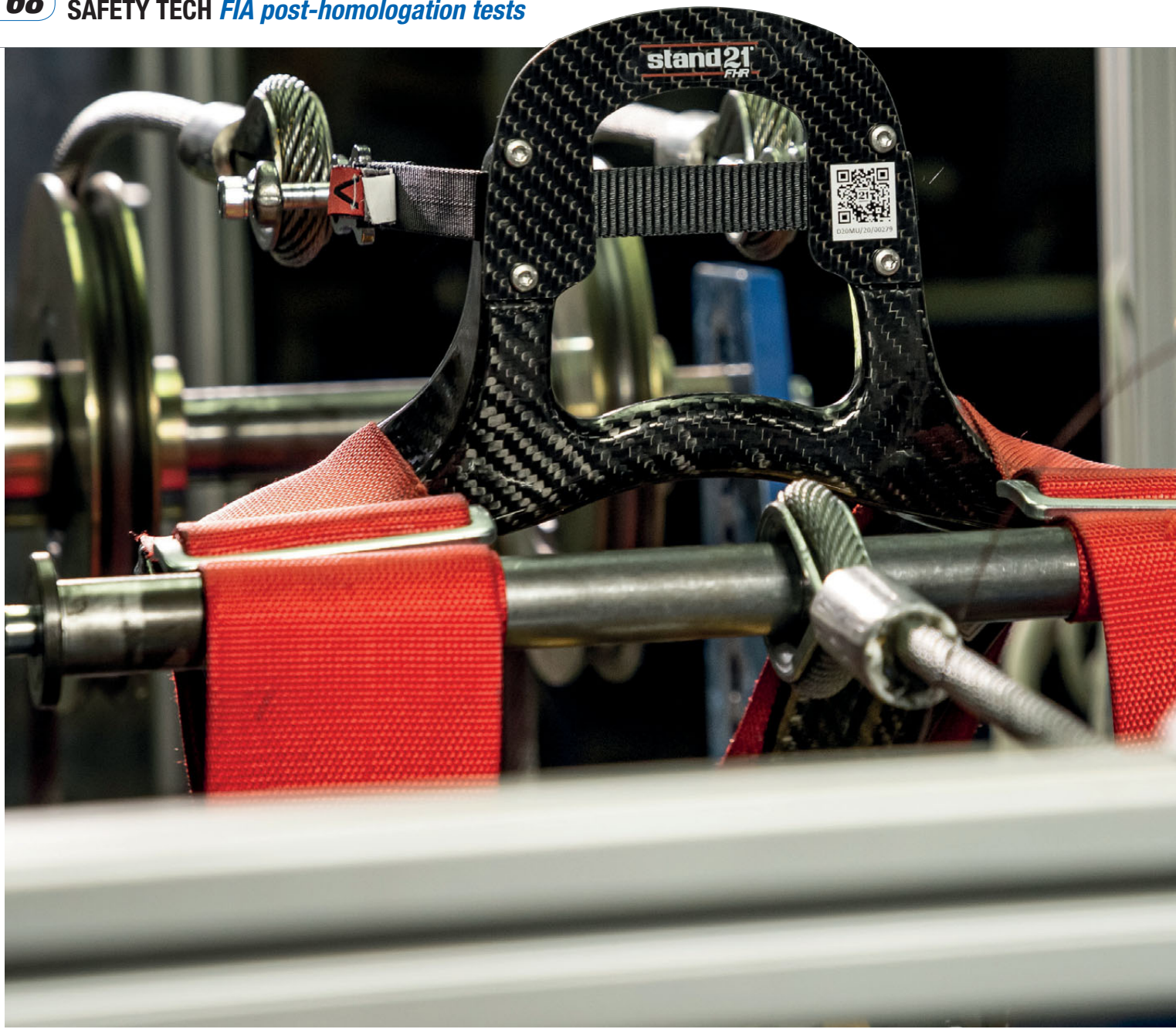
> *"Each product has a unique serial number on the FIA hologram"*

controls; first is a comparative check, which is to compare the product with the original approved; and the second which is basically to do a standard test or select some tests that are written in the FIA Standard.

For the FHR it's easy because we did all the tests we had in the standard. In some other cases it is not possible to do this because if you imagine a helmet, we need to run at least eight helmets per shell size depending on the standard to do the full homologation. In that case, what we typically do is buy one helmet and then we perform some tests and compare the results."

Once a product has passed or failed these tests, Costa goes through the process of informing the manufacturer appropriately. In the case of Stand21, its FHR passed the tests which means they will be sent a letter from the FIA to say the product was bought, ▶

BELOW Post-homologation tests compare the off-the-shelf product with the original



tested, and met the safety requirements along with the data to prove.

When there is a fail, the manufacturer will be given 20 days to inform the FIA if they want to repeat the test, whereby a second product is bought and another test date is scheduled. This will be attended by the FIA, manufacturer, a representative from the National Sporting Authority (ASN) of the manufacturer, and the test lab.

"If we identify a specific batch that has a problem or from a certain date of manufacturing, we only recall these products. We then test a product from a previous date to ensure the equipment is safe," explains Costa. "If this passes the tests, then we can still accept those products and we will recall the ones that do not meet the standard."

Quality control

In some cases, a manufacturer will come to the FIA to report a specific problem found during their quality control processes, which will result in both parties working together to find a solution to remove the products that are not safe anymore on the market.

ABOVE Stand21's Frontal Head Restraint (FHR) passed the test process

To make sure the manufacturer's quality control process is up to the standards required by the FIA, and in order for the manufacturers to be able to keep manufacturing the FIA-approved safety equipment, after five years they will need to submit to the FIA a dossier to demonstrate that the safety equipment is still up to the standard by going through a full new test defined by the FIA Standard for the product they are producing or by having a Quality Control system that meets the minimum requirements defined by FIA.

"What happens during these five years is they will do certain tests. If they identify there is a problem and a failure, they will inform the FIA and then we will start an investigation to try to understand why the problem happened and try to find a solution. These discussions normally they are straightforward and very easy, because they took the initiative and

> *When people create fake labels they will never be able to match the info we have”*

know that they have a problem.”

If the product still fails the tests, the FIA will start an investigation into why it happened and in the most extreme cases the homologation of the product is stopped, sales put on hold, and an announcement is made to say that it is no longer accepted in competition through FIA Technical Lists.

“Once we finish the homologation, then we strike through the product under the manufacturer in the homologation list, so the product is still listed but crossed out and FIA and ASN officials know that the product cannot be accepted anymore when the FIA regulation is in place,” says Costa. “We then have a note in the technical list which says: ‘For safety reasons, the homologation of the safety equipment is withdrawn with immediate effect’.

“If we only stop a certain batch, we will put the product homologation number along with the year/period in the list, enabling the FIA and ASN officials to know it’s a certain batch and all the others are allowed. We also issue a communication on the FIA website and send a letter to all the ASNs saying ‘this product is no longer valid’ because they don’t comply with the FIA Standard.”

The performance of safety equipment is directed related to a full package of: the minimum safety level and design requirements required in a standard, the administrative requirements such as quality control requirements and post homologation controls, and safety features to reduce the probability of fake products to be introduced in motorsport, such as holograms and product full traceability. ▶

BELOW The post-homologation process ensures that the product remains as safe as when it was first tested and approved

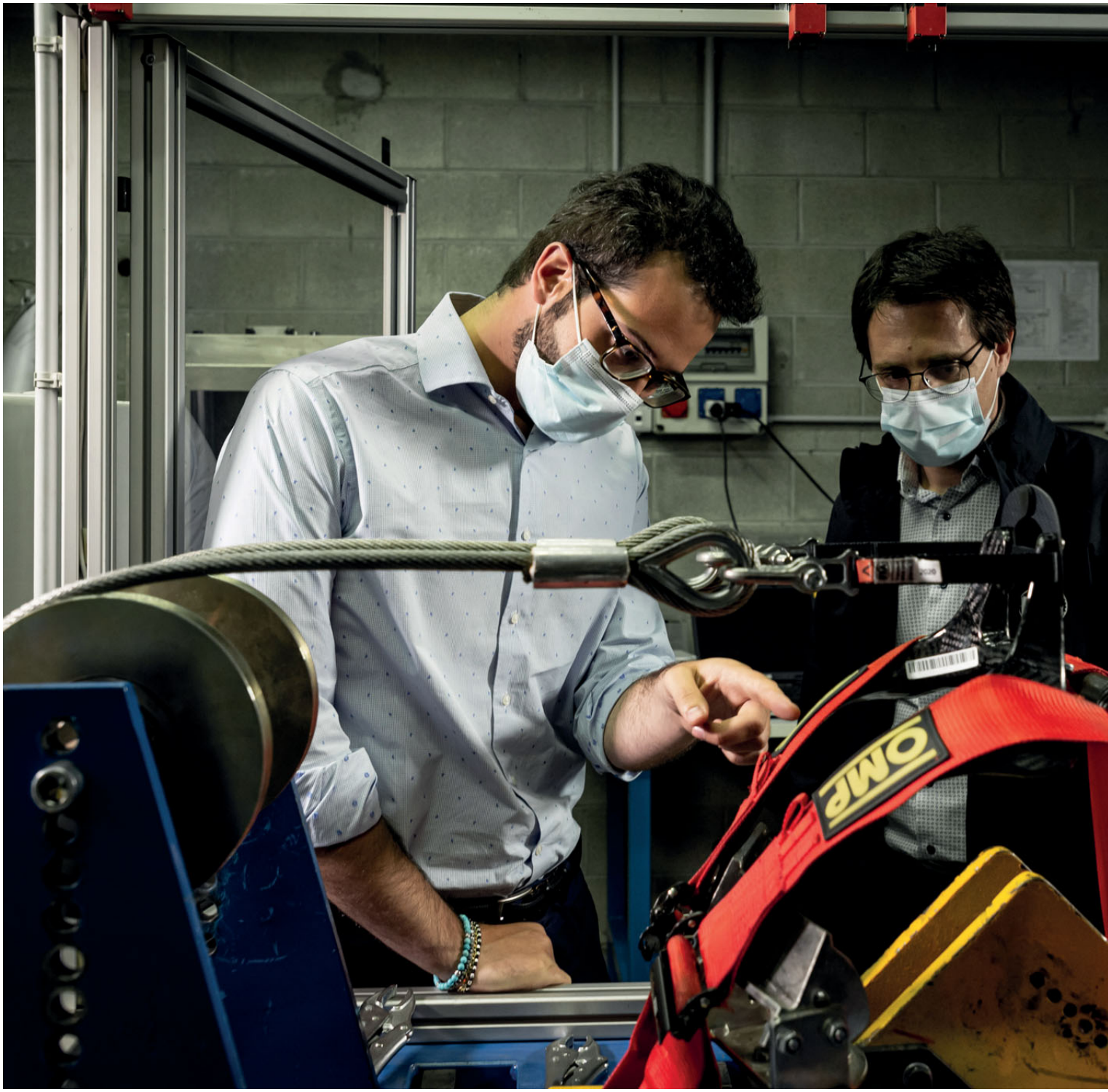
Seal of approval

Every piece of FIA-approved safety equipment contains a label that is composed of two parts: the label that is produced by the manufacturer which has their information, the necessary information for competitors and officials to identify the eligibility of the product for a certain competition, such as FIA Standard reference, manufacturer name, homologation number, etc; and the FIA hologram that contains a code for the FIA Standard and a unique serial number.

For example, for advanced racing seats the homologation number will say 'AS' for 'Advanced Seat' and then there are three digits for each model, and at the end there is the year homologation was assigned. So that would be 'AS.000.00' – every model has a unique homologation number.

"For each product they will have a unique serial number on the FIA hologram and for each unique serial number, we ask the manufacturers to have a complete traceability file," says Costa. "If there is a problem and we identify the batch, then we know for that batch the serial numbers have been assigned to that batch and then we can recall the specific serial numbers.

"It's a little bit like in the automotive



industry. If there is a problem with an airbag for a certain batch. They will know which airbag has been fitted in each car, then for each serial number of the car they know the customer, then they will contact them. We apply exactly the same concept."

While holograms can be copied and used to sell counterfeit products, the FIA Hologram has the same level of security as is used on bank notes to ensure that it is nearly impossible to replicate. If a good copy is made, a series of checks can be done by both the FIA and the hologram supplier to check if the hologram is genuine.

ABOVE & LEFT Costa puts safety equipment through the same tests required in FIA Standards

"There is the first check we can do which is looking at our database," says Costa. "When people create fake labels they will never be able to match the info we have in our database because only the FIA and the manufacturers have it. The other reason they might do it is to extend the validity date of the products – again if that happens we will be able to know through the database."

All of the holograms are produced by a supplier for the FIA, who then sell them onto the manufacturers. This is done to ensure that these are only used for products that have been approved and passed the homologation tests, so a manufacturer that only homologates seats will not be able to use the labels for additional products they sell such as helmets or FHRs.

"The hologram means that the initial product not only meets the FIA Standard but has been through several processes, the quality control that the manufacturers do, and all these random post-homologation tests that will give them the guarantee that the product meets the FIA Standard," says Costa.

"That's why we say that you should always look for the hologram." RT

This article is republished with permission from FIA's AUTO + Medical magazine

PORSCHE AHEAD OF THE CURVE – AGAIN!

Photos: Porsche AG

As Mission R offers a vision of the future of customer motorsport, **Sergio Rinland** examines Porsche's ability to keep on raising the bar

PORSCHE has carved itself a reputation for many qualities. One of them is being ahead of the curve – it always has been.

Ferdinand Porsche designed his first in-wheel front-wheel drive electric vehicle back in 1900, for Lohner-Werke. On the back of that followed the first four-wheel drive series hybrid electric vehicle, always with in-wheel motors.

In the 1930s Ferdinand Porsche was responsible for the fabulous Auto Union GP cars. These were the first racing cars with a mid-engine architecture, influenced by Porsche GmbH co-founder Adolf Rosenberger, as the story goes, inspired by the designs of another innovator of the time, Josef Ganz.

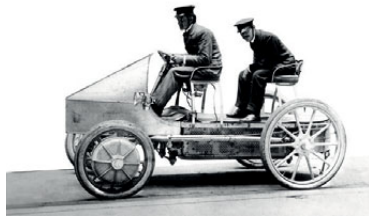
It took some development, though, to tame that concept with close to 500 HP, 750 kg and the narrow tyres of the time. By the D version in 1938, with a smaller engine and better weight distribution, it was a well-behaved beast.

After WWII, thanks to the financial and political efforts of Italian industrialist Piero Dusio, Ferdinand Porsche designed and built the Cisitalia Type 360 GP car. This car, also 'ahead of the curve', had many innovations apart from the same mid-engine architecture, such as a sequential longitudinal gearbox between the engine and rear axle (as with current F1 cars!) and four-wheel drive with front disconnect feature. As we said few issues ago, a jewel.

By the 1960s, Porsche was a well-established car manufacturer and racecar entrant in F1 and sports cars. It had achieved such domination by 1971 that it prompted the CSI (predecessor of FISA and the FIA) to change the rules. Without much success, I would say, because Porsche was winning everything in sportscar racing soon after.

The Porsche 917, that icon of a car, was later blamed for destroying sportscar racing in Europe and Can-Am in North America. Such was its domination, that nothing came close.

> *"Porsche designed his first electric vehicle back in 1900"*



ABOVE & BELOW Electromobility features prominently in Porsche's past (bottom left, Ferdinand Porsche had built his first electric car by 1900), present (bottom right, Formula E) and future (top, Mission R)

Much closer in time to the present day, 110 years after the creation of the Lohner-Porsche, Porsche was still pushing the boundaries. This time it almost made hybrid history when its 911 GT3 R Hybrid came close to winning the Nürburgring 24 Hours. The innovation this time was the flywheel KERS.

History was repeated with Porsche's three-time Le Mans-winning 919 Hybrid LMP1 car. Once again, the car's domination was such that by the time the manufacturer withdrew from the World Endurance Championship, in 2017, it had killed virtually all the opposition! ▶

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Mission R

This trip through memory lane brings us nicely to another first for Porsche: the Mission R, a purely electric racecar.

This is not the first electric racecar. For some years now we have had Formula E, in which Porsche itself is involved, but the Mission R is a showcase of innovative technologies applied to motorsport.

It is capable of similar lap times and range to Porsche's current 911 GT3 Cup cars, with a top speed of 300 kph and 0-100 in 2.5 seconds. This electric car can race on traditional circuits for 30 to 40 minutes, the typical duration of a Cup race, giving a similar quality of entertainment.

Thanks to the extensive use of composite materials (carbon fibre for the structural parts and natural fibres for body panels) and the latest Li-ion battery technology, the Mission R weighs 'only' 1,500 kg (twice as much as the pre-war Auto Union!) with an 82 kWh battery.

The roll-cage is innovative in the sense that it is all CFRP beams, creating what Porsche refers to as the 'exoskeleton'. It's worth highlighting here that the Halo, the life-saving Formula 1 'roll-cage', is made of metal, not composites. So it will be very interesting to see how the exoskeleton behaves in an accident compared with what we saw already in F1 with Romain Grosjean and Lewis Hamilton.

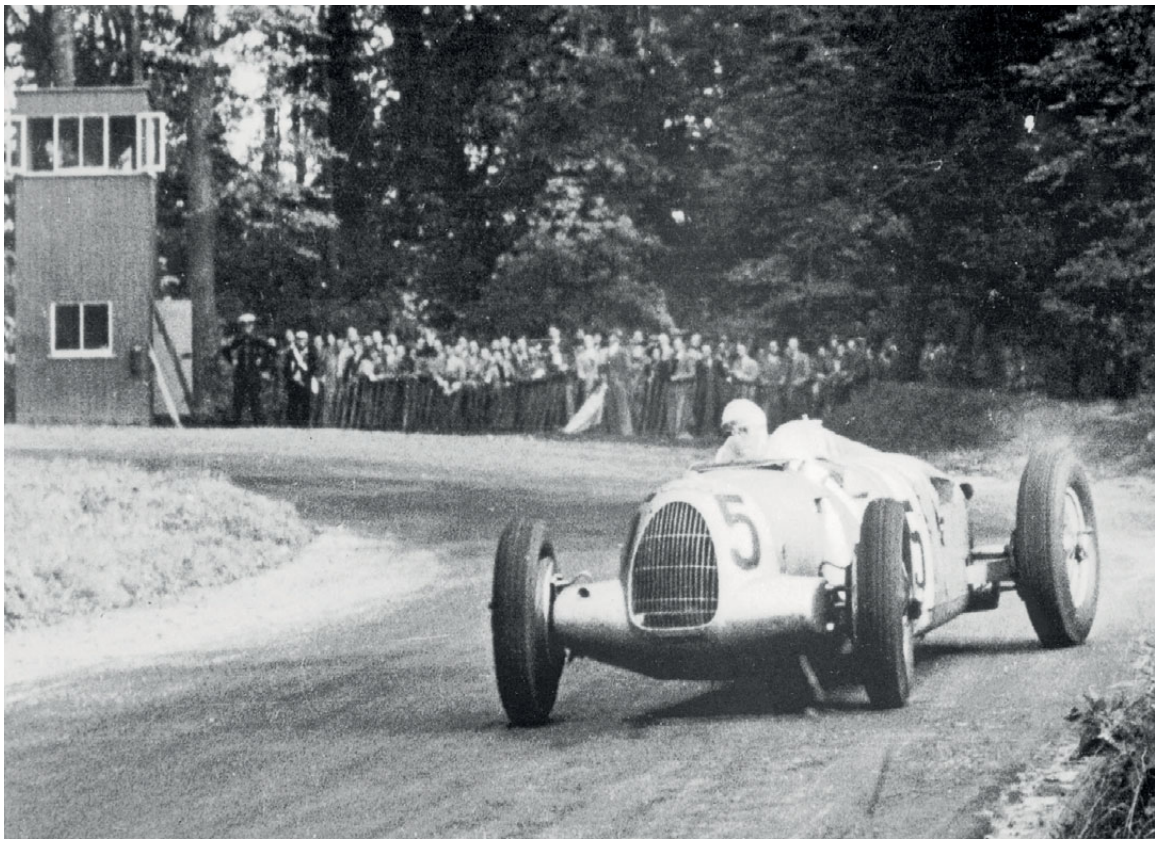
A novelty (I would not say 'innovation' here) is the concept of using the self-contained well-equipped monocoque-styled cabin as a simulator for the driver to train in between races and to participate in e-sports. A nice idea.

From the powertrain point of view, the Porsche Mission R can develop 800 kW in qualifying mode with 40% going to the front axle and 500 kW in racing trim, enough to propel this incredible machine to the same level of performance as its petrol counterpart. Same power to weight ratio as the Auto Union, but, thanks to more than 80 years of tyre and vehicle dynamics developments, they will not need a Tazio Nuvolari or a Bernd Rosemeyer to handle it!

Not all its aerodynamic features are to my liking. I would have preferred to see this car without a rear wing, relying solely on ground effect for downforce, as we saw recently when Peugeot unveiled its 9X8.

The Porsche Mission R has been developed to become the future Cup racer, not to compete in any multi-brand series, for which regulations still haven't been conceived. So, this time around, there is no danger of Porsche 'killing' another racing series due to its outstanding capabilities.

Instead, we hope to enjoy seeing the Mission R race for many years to come. In the process, it could inspire rule-makers, demonstrating what is possible when you think 'outside of the box', a Porsche tradition. RT



ABOVE Mission R demonstrates what is possible in the future of customer motorsport

LEFT Ferdinand Porsche designed the famous Auto Union 16-cylinder beasts (a Type C is tamed here by Bernd Rosemeyer at Donington Park in 1937). The cars were a precursor to today's Formula 1 design principles

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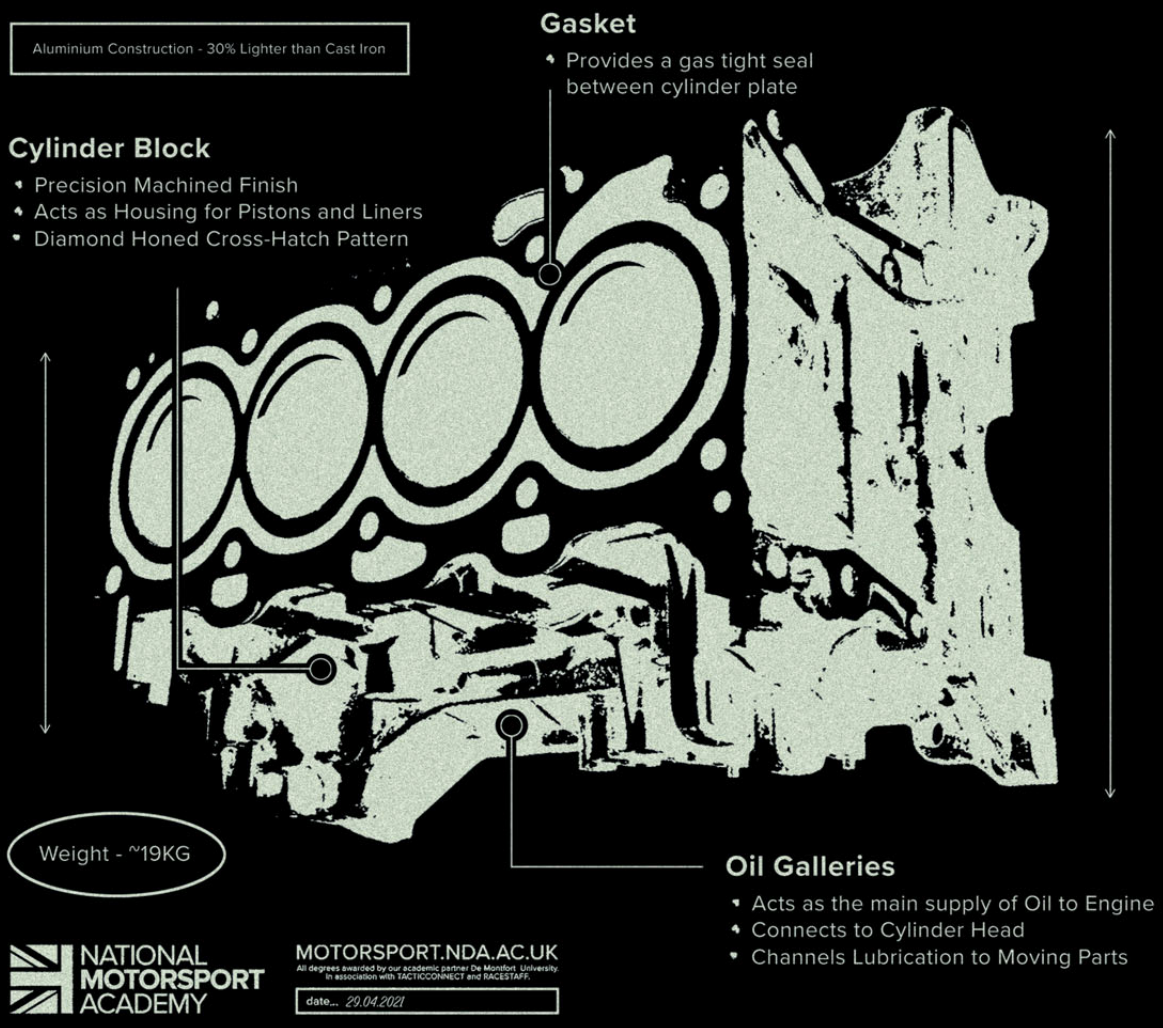

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