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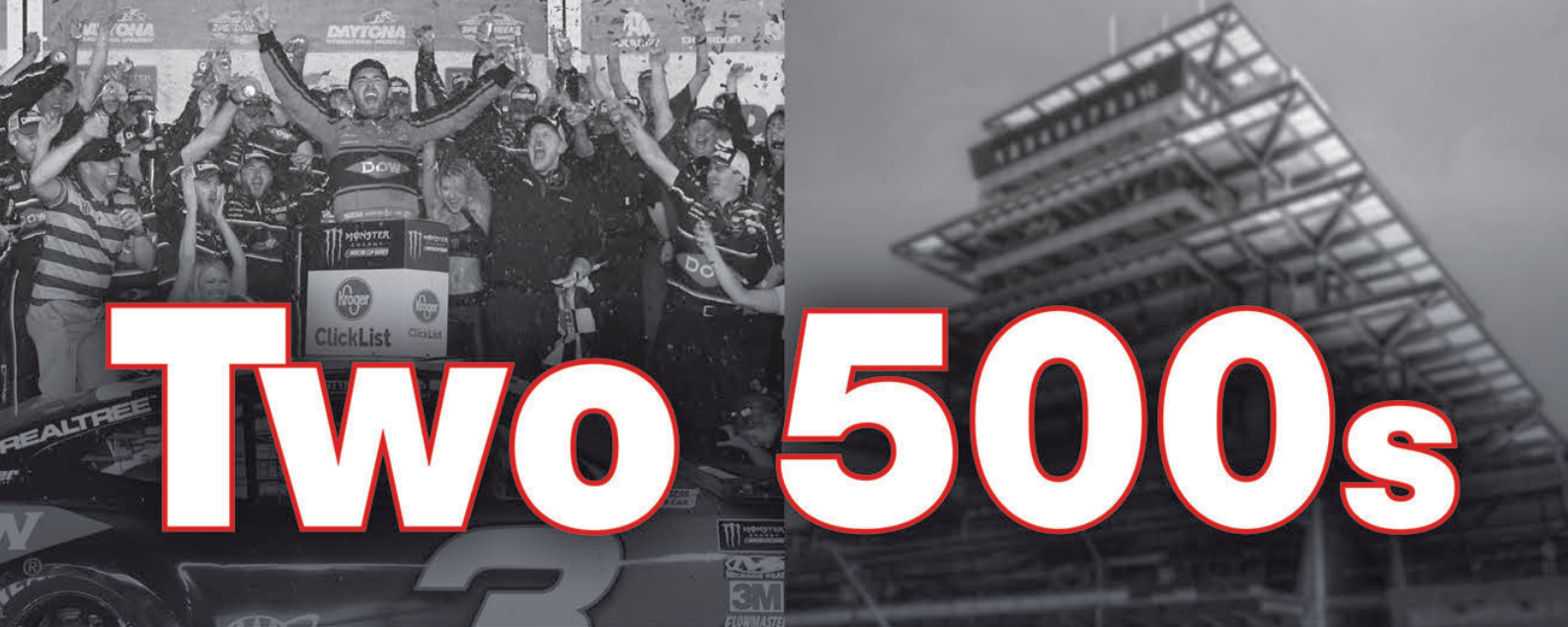
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Swimming against the stream (before I can't remember)

WE are a technology and engineering magazine that happens to focus on motorsport, but it doesn't mean that we don't look around the wider world to see what's happening and to pick up on trends. After all, at the end of the day, motorsport at the highest level is governed by sanctioning bodies that try to stay tuned to their respective automotive industries which in turn are governed by their respective governments. As we all know, electric vehicles are now the headline act, the carmakers responding to edicts and demands from governments and cities that are in the process of setting out deadlines to ban the internal combustion engine.

As is proved by this issue's front cover and main story, we follow Formula E with great interest while another article in this issue is on the proposed hydrogen fuel cell car that's been put forward by the Automobile Club de l'Ouest as an energy source of interest. However, enthusiastic as we are about these modern developments, it doesn't mean that we follow them wide-eyed and accept everything at face value, great though these initiatives are as they are a partial solution to future mobility needs.

Take the electric car. For sure, it will improve air quality in city centres when they become more universal, but they are far from being the complete answer, and don't let anyone, especially a politician, tell you otherwise.

I have just read an interesting report published by Bloomberg New Energy Finance that has carried out an assessment of electric cars and batteries that takes into account the manufacturing process and the energy required to power up the batteries. The report starts off by saying "Beneath the hoods of millions of the clean electric cars rolling onto the world's roads in the next few years will be a dirty battery." By 2021 capacity will exist to build batteries for more than 10 million cars running on 60 kilowatt-hour packs, says the report. Most supply will come from places like China, Thailand, Germany and Poland that rely on non-renewable sources like coal for electricity.

According to Berylls Strategy Advisors, the management consulting firm headquartered in Munich, which is quoted in the Bloomberg report, the average German car owner could drive a gas-guzzling vehicle for three and a half years, or more than 50,000 km before a Nissan Leaf with a 30 kWh battery would beat it on carbon-dioxide emissions in

a coal-heavy country - and that's one of the smallest batteries on the market: BMW's i3 has a 42 kWh battery, Mercedes's upcoming EQC crossover will have a 80 kWh battery, and Audi's e-tron will come in at 95 kWh. What the report doesn't address, about which I have asked questions before, is what happens at the end of the battery's life? Answer: that's a problem for future generations to sort out.

On a completely different note, I happened to catch Jackie Stewart, three times F1 World Champion, on the BBC news. As a teenager I had a big crush on his wife Helen and so was devastated to learn she has been suffering from dementia for two years. Stewart was on television not so much to talk about her but to raise awareness about dementia in general and the absolute need to address it. Today, 50 million people around the world suffer from the disease. Unless a cure is found, one in three people born today will get dementia in their lifetime. A new person develops dementia every three seconds. This crisis cannot continue. As the son of a mother who suffered it in her later life until passing away last year, I am personally very aware of the havoc and turmoil it can create in families.

Stewart was extolling the virtues of the can do, will do, supremely quick problem solving achieved by professional motorsport teams, particularly Formula 1, and wanted that mentality introduced into the medical industry to change mindsets. He referred to the time when he was actively racing and started a campaign to make motor racing safer. It was not liked at all and he had to fight hard in the early days to change entrenched mindsets, but he won through in the end. He now wants that to be applied to the medical profession.

"Coming from an industry where pioneering engineering is at its best, I believe that by investing in innovative and collaborative research we will accelerate the identification and development of drugs with the potential to transform lives."

He has set up a charity called Race Against Dementia www.raceagainstdementia.com to help raise money to fund research into dementia. Please help. **BT**

William Kimberley
EDITOR



UK Sports Prototype Cup to launch in 2019

William Kimberley

LONDON, UK: A new race series for lightweight sports prototype cars has been announced. The UK Sports Prototype Cup will launch in 2019 with a strongly promoted calendar at the most popular race circuits.

The inaugural calendar is planned to feature races at some of the UK's top circuits, including Brands Hatch, Silverstone, Donington Park, Oulton Park and Snetterton. The highlight of the provisional calendar is a support race to the European Le Mans Series at the demanding Autodromo Internacional Algarve close to the resort of Portimao, Portugal. The calendar will be announced later this year, but providing generous track time and a variety of race lengths will be key features of the Cup. This will include sprint races of around 25 minutes, and longer endurance style races featuring a compulsory pit-stop. These races will vary between 45 minutes and 1 hour and teams can choose to enter two drivers.

The Cup will be promoted by Pitbox91 who are developing a programme of events with the British Automobile Racing Club. Pitbox91 is a motorsport agency and director James Bailey has over 30 years of motorsport management experience within the British Touring Car Championship, FIA World Endurance Championship and Le Mans 24

hours. He also created the popular Dunlop Great and British Festivals and Race Academy, which were a feature of UK race calendars between 2006 and 2010.

The British Automobile Racing Club has over 100 years' experience in motorsport organisation. In addition to running the Dunlop MSA British Touring Car Championship, it also organises the prestigious FIA World Endurance Championship at its UK round at Silverstone.

The UK Sports Prototype Cup will feature 'races within the race'. "Rather than trying to balance the performance of a variety of different cars, any class of more than eight cars will be promoted as its own event with the Cup. The Cup will be launched with two such categories, The Revolution UK Trophy and the Trophy for Radical SR3 cars," said Bailey.

The Cup will run alongside other premium racing events such as the Britcar-promoted Dunlop Endurance Championship at UK circuits and the European Le Mans Series at Portimao.

The exciting new V6-powered Revolution (see separate story), which is being unveiled in early November, will have its own dedicated class within the UK Sports Prototype Cup. The LMP inspired, carbon tubbed, high downforce prototype has been under development for over a year and will

be one of the cornerstones of the new series.

"We believe the 440 bhp per tonne performance coupled with the quality, design and technology of the Revolution will quickly establish it as one of the leading premium prototype cars on the market. It's important for drivers and teams investing in the Revolution to know that they have strong race events to compete in together. We are delighted to promote the Revolution UK Trophy as a feature category with a commitment until at least 2023," said Bailey.

The UK Sports Prototype Cup will also feature a promoted class for the Radical SR3. With hundreds of the well-proven prototypes in existence, the dedicated category is expected to be a closely contested 'race within the race'.

Dunlop developed the original tyre for the Radical SR3 and will provide its expert service and technical support at each round of the UK Sports Prototype Cup for competitors in both the Revolution and Radical SR3 Trophy races.

"When we started planning the UK Sports Prototype Cup, we had considerable interest from teams and drivers who own Radical SR3 cars. They told us that the service level of Dunlop's experienced Le Mans technical team and the welcoming 'family atmosphere' we aim to create were attractive selling points for them" said Bailey.

The UK Sports Prototype Cup will also be a qualifying event for the Sunoco 240 Challenge. Drivers meeting the Sunoco 240 Challenge criteria and entering a full season have the opportunity to compete for a place in a GT4 car in the 240-minute endurance race on the Friday before the Rolex 24 At Daytona. **RT**



ABOVE The UK Sports Prototype Cup and Revolution Racecars have a five year agreement to have a 'Revolution UK Trophy' as a promoted feature race within the Cup



ABOVE The soon-to-be revealed Revolution that will offer LMP technology at a low cost point

Come the Revolution

William Kimberley

LONDON, UK: Some details of new British sports racing car have been released prior to its official unveiling in November. The brainchild of Phil Abbott, one of the co-founders of Radical Sportscars, the all-new two-seater track and race car is a lightweight, 675 kg sportscar that packs a 300 bhp punch from its dry sump Ford 3.7-litre V6 engine.

It has been conceived, designed, developed and built by racers for racers. It's the first truly affordable, sub £100k sports racer with a carbon tub and cutting-edge technology bringing what Revolution Racecars, the constructors, claim is LMP technology and safety to the masses. It is also easy to maintain, cost-effective to run with accessible handling and performance so that it can be enjoyed and exploited by all levels of driver, from those wishing to enjoy track days through to those on a career path to Le Mans.

Others involved in the project include Simon Cox, one of the top car designers in the UK with credits that include head of design at Infiniti and GM, and Pete Watts whose CV includes being head of composites at BAR F1, with Bentley on the LMP1 programme, working on the Bugatti Veyron as a design engineer and a prototype engineer at McLaren Automotive.

Proven reliability is a key component within this package, its performance matched with some of the lowest running costs with 10,000 km or 100 hours between rebuilds. Fitted with a unique exhaust system and fine engine tuning, it also comes with ultra-sharp throttle response and a brilliant soundtrack. It is mated to a 3MO 6-speed gearbox utilising WRC technology to again provide reliability and ease of use.

"Race car technology has advanced immeasurably over the last couple of decades along with the tools available to design and develop them, and it's now possible to bring these advancements to a larger market," said

Abbott. "I began again with a blank sheet of paper that I first gave to Simon."

The long period of CFD development that followed ensured that not only does this car produce more downforce than anything else in its price bracket, but also remains balanced in all situations as drivability has always been one of the concept priorities.

The carbon tub is being manufactured in Germany by DD-Compound utilising a carbon infusion process developed by Dominik Dierkes, which matches the initial brief of utilising latest techniques to ensure efficient production with the highest levels of quality and safety.

Inside the carbon tub there is plenty of space for two, with class-leading width and elbow room making it easy to operate both solo and with a passenger aboard. Formula 1-style controls, with everything operated from the steering wheel adds to the experience, with an inbuilt display that is ergonomically easy to operate with a Life ECU controlling all the electronics. **RT**



ABOVE Nine-time FIA World Rally Champion Sebastien Loeb's season with Peugeot in World Rallycross has come to an abrupt halt

Peugeot withdraws from World Rallycross

Hal Ridge

PARIS, France: In a somewhat surprise announcement, Peugeot has said it is withdrawing its works World Rallycross Championship effort at the end of the current season. It was one of the first manufacturers to put its weight behind an electrified future for rallycross. At the same time, at the announcement at the Paris Motor Show, the company said that it was going ahead with its development of a new range of electrified sports vehicles from 2020.

Having been present in World RX since the series' inception in 2014 by partnering 14-time European rallycross champion Kenneth Hansen's Hansen Motorsport squad, Peugeot Sport took over the programme for 2018 and introduced a brand-new Peugeot 208 WRX Supercar mid-way through the year, at the Swedish round.

Peugeot's World RX interest was also aimed at the future however, and the proposed transition to electric cars initially planned for 2020. However, when it was confirmed that the planned switch to electric cars had been postponed a year to 2021, partly taken following Audi's decision to cease competing

in rallycross, and with it any plans for electric rallycross, Peugeot has decided to leave the championship as well.

"The decision to stop WRX appears as very brutal, but my mission as a CEO is to make decisions at the right moment to ensure the sustainability of the company and the employees," said Peugeot CEO Jean-Philippe Imparato, "and the actual context pushed us to react quickly. Last October, during the Paris Motor Show, the European institutions decided to tighten up the regulation in Europe with a 40% reduction in CO2 emissions in 2030, on the basis of the 95g already fixed for 2020. We have no other choice to be compliant with the new thresholds if we don't want to disappear by inertia. The uncertainty of a future EWRX championship is not compatible with the calendar of our electrified offensive, which is starting now! That's why we are withdrawing from WRX."

Despite Peugeot only achieving a single win in its maiden works rallycross campaign, Imparato says results in the current series have had nothing to do with the decision. "This announcement is not linked with our results in the competition or our pilots.

I want to congratulate and thank all the Hansen family and team for the exceptional talent, fighting spirit, determination and for the Swedish kindness they shared with us. For Sebastien [Loeb] it's too early to say, but he remains a pilot for PSA Motorsport so we will think about the future with him." Peugeot says it will now restructure and develop low-emission, high-performance sports vehicles together with Peugeot Sport.

Paul Bellamy, senior vice president, motorsports at series organiser IMG says World RX will continue to push towards an electric switch in 2021. "We are on the verge of an exciting new era for motorsport," he said. "Electric cars are increasingly important to all areas of mobility, and rallycross is the perfect platform to demonstrate the incredible performance capabilities of electric cars in a fun, competitive and cost-effective environment.

"A huge amount has been accomplished in a relatively short time since the first formal meeting in June 2017. A completely new type of rallycross car has been conceived and defined, and so it is worth waiting a little longer to secure the best possible field of competitors. We believe that fans new and old will love what will be a thrilling addition to their favourite events.

"We will continue with our rapid expansion plans for World RX and are in continuous discussions with a number of manufacturers as we move towards an electric series in 2021." **RT**



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F1 MD Ross Brawn hints at future data restriction for teams

William Kimberley

AUSTIN, TX: In a world increasingly driven by data, perhaps spearheaded by Formula 1, Ross Brawn, Formula 1 managing director, has put forward the suggestion that perhaps teams should have only limited access to its data.

He made this remark after the US GP in Austin where it had rained most of practice, the teams getting just one hour of dry running before qualifying on Saturday leading to the teams slightly up in the air when it came to tyre life and strategy. As a result, it led to qualifying and a race that was more unpredictable than usual and three drivers from three different teams fighting

for victory as the race entered its final phase.

What this illustrated to Brawn is that if the teams do not have access to all the data at their disposal, then there could be a case for limiting it in the future for the sake of better racing. He underlined this by saying that it should become part of F1's deliberations over how to make racing better.

"The three drivers on the podium crossed the line within the same three seconds. They all ran different tyre strategies, through choice in the case of Räikkönen and Hamilton and by necessity for Verstappen who started from the penultimate row of the grid," observed Brawn. "That's unusual in Formula 1, where the level of sophistication in terms

of simulation and strategy is so high that one doesn't usually get such a variance, especially when it involves the top three teams.

"This was probably down to the fact that no one had been able to run dry weather tyres on Friday as the track was wet throughout the three hours of practice. That meant the teams had less data than usual on which to base their race plans, and thus the margin for error increased.

"To use a football metaphor, when two teams play perfectly, a nil-all draw is the logical conclusion. In Formula 1, when the simulations are all worked out to the smallest detail, then they all converge towards the same best possible strategy.

"So does less data produce a better show? It's definitely more uncertain and therefore another topic for discussion when looking at ways to make our sport even more exciting." **RT**

World Endurance hypercar budgets slashed

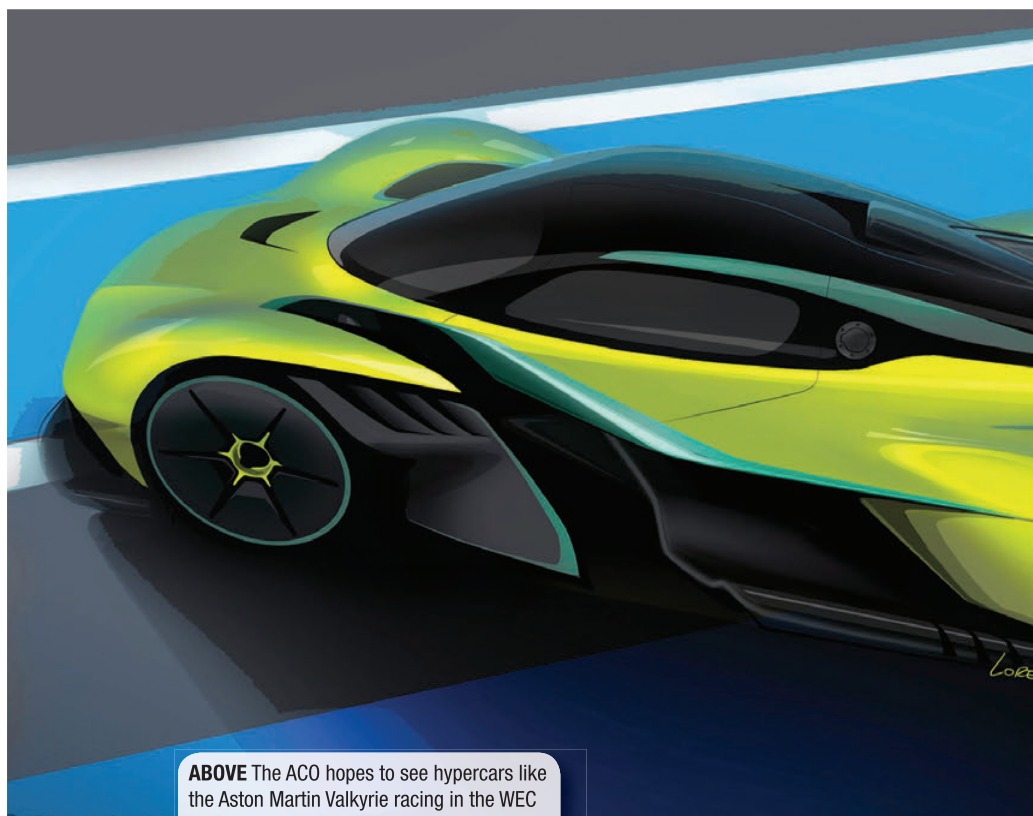
Alan Stoddart

PARIS, France: The FIA and the Automobile Club de l'Ouest, which runs the World Endurance Championship, have cut the proposed budget target for a two-car factory team running in the top class of the series from €25-30m down to €20m.

The new figure emerged from an outline presented to the FIA by the technical working groups. The full regulations of the new hypercar class, which was first revealed to industry insiders at the World Motorsport Symposium last November, will be delivered to the FIA's Endurance Commission, before being submitted for formal approval by the World Motorsport Council on 5 December.

The lower budget was revealed in a prospectus delivered to manufacturers in a bid to entice them to join the new hypercar class, which is set to replace LMP1 as the WEC's premier category in 2020 and calls for the next generation of racers to resemble the extreme roadcars and concept cars these manufacturers are making. It is also hoped that the €20m figure will encourage IMSA, North America's sanctioning body for sportscar racing, to adopt the regulations after it initially balked at the original €30m estimate.

These lower figures are expected to be achieved by reducing performance targets. Originally, when announced publicly at Le



ABOVE The ACO hopes to see hypercars like the Aston Martin Valkyrie racing in the WEC

Mans in June, the ACO suggested that the hypercar class cars would be able to lap the historic French circuit in around 3:20, more than five seconds slower than the 3:14.791 posted by Toyota driver Kamui Kobayashi in 2017. However, this target has now been revised down to around 3:24-25 a lap.

Budgets will also help to be contained by

limited opportunities for development once the cars are homologated, with updates only allowed for aesthetic reason or to recover performance if a car is not competitive with the field. Additionally, only 10 days of testing will be permitted throughout the season, none of which will be allowed during the non-European leg of the championship. **RT**

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ABOVE The Bloodhound SSC is built and has run but needs funding to go and set records

Bloodhound SSC programme enters administration

BRISTOL, UK: In just under a year since its successful public test at Newquay In Cornwall, there is now a question mark over the future of the Bloodhound SSC land speed record project.

Bloodhound Programme Ltd, the company behind Project Bloodhound, the initiative to break the land speed world record, has entered into administration with the appointment of Andrew Sheridan and Geoff Rowley, partners at specialist business advisory firm FRP Advisory LLP, as joint administrators on 15 October 2018.

Project Bloodhound was founded in 2007 and aims to hit speeds of 1000 mph at a specially built, 18 km long, 1500m wide race track at Hakskeen Pan in the deserts of the Northern Cape of South Africa.

In addition to seeking to break the land speed world record, the project is a major R&D catalyst and the focal point for a STEM education campaign which has reached over two million children since its launch, including

120,000 UK schoolchildren per year.

To date the project has operated on a partnership and sponsorship model, with support from a variety of partners including Rolls-Royce and Rolex as well as the Ministry of Defence which has lent prototype jet engines for the car, and the Northern Cape Provincial Government in South Africa, which has supported the creation of the track. Individual donations from members of the public have also supported the development of the car and the global education programme.

The project has already successfully built a viable racing car which has been tested to 200 mph, while developing or testing propulsion, aerodynamic and telecommunications technologies with the potential for far reaching applications outside of the project. The team is now seeking around £25m in investment to provide guaranteed funding and see the project to completion.

Andrew Sheridan, joint administrator, commented: "Bloodhound is a truly ground-breaking project which has already built a global audience and helped to inspire a new generation of STEM talent in the UK and across the world. Entering into administration provides some breathing space to identify an investor who will bring the guaranteed funding, impetus and expertise required to drive the project forward.

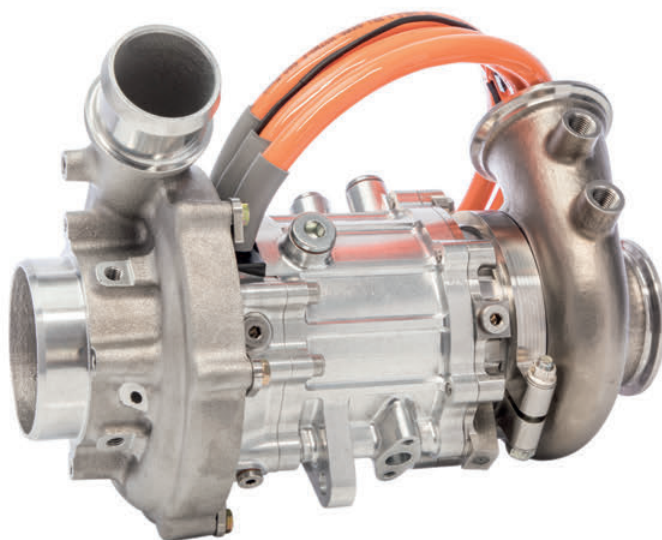
"Whilst not an insignificant amount, the £25m Bloodhound requires to break the land speed record is a fraction of the cost of, for example, finishing last in a F1 season or running an Americas Cup team. This is an opportunity for the right investor to leave a lasting legacy. We are already in discussion with a number of potential investors and would encourage any other interested party to contact us without delay."

"Bloodhound has had enormous success in creating the world's most advanced land vehicle," said Mark Chapman, Project Bloodhound's chief engineer. "As we now move out of the R&D phase and into the operational phase of the project, we recognise that we need a different approach to funding. This project is built around the most successful team in the history of Land Speed Racing, and with the right support we have no doubt that the project will achieve its aims and could be racing for the record in as little as 10 months." **RT**

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ABOVE Ligier has gone back to its roots with the new Ligier JS2 R which takes inspiration from the JS2 that finished second at Le Mans in 1975

Ligier goes back to its roots with new model

William Kimberley

LE MANS, France: The Ligier JS2 R, R as in Revival or R as in Racing according to Ligier, has been unveiled at the recent Paris Motor Show. While taking its inspiration from the Ligier JS2 that finished second in the 1975 Le Mans 24 Hours, the JS2 R is not a series production car adapted for driving on a track, but a real racing car as the company is at pains to point out. Easy-to-drive, fast and

reliable, its aim is to offer all enthusiasts a car to have some fun on a track.

Weighing 980 kg, it is powered by a Ford V6 3.7 litre engine producing 330 horsepower. Other items include a 100 litre fuel tank, Brembo brakes, centrifugal clutch, adjustable dampers, steering wheel paddle shift and a heated windscreen.

With low running costs, long gaps between revisions and easy mechanical maintenance, the Ligier JS2 R has been designed to provide

endless hours of pleasure behind the wheel. It can be homologated in the FIA Free Formula Sports Cars (Group E) category and is equipped with cutting-edge safety equipment. Ligier has also created the Ligier JS Cup for the JS2 R that gets under way in France in 2019.

"What better way to celebrate the 50th anniversary of the Ligier brand than a new sports car?" said Jacques Nicolet, CEO of Ligier-Onroak Automotive on presenting the car. "With its iconic livery, all is said. Ligier renews with the GT category. Remember, it was Guy Ligier's first love. In 1969, he had launched the Ligier JS1, the brand's first model, and in 1972, the Ligier JS2. We designed the Ligier JS2 R, a revival car, as a real racing car. A car to give maximum pleasure on the track, in races or on track days. Because this is what matters. I hope you will like it as much as we do."

It will be available for tests from November with various test days scheduled that month in Europe, including the Grand Prix track of the Nevers Magny-Cours circuit that has been reserved on 15 and 16 November. **RT**

WTCC champions partner with urban mobility company

William Kimberley

FUJI RACEWAY, Japan: Cyan Racing, the reigning FIA World Touring Car Champions for drivers and teams, has released details of a unique joint development programme with Lynk & Co, a new global urban mobility company. It will campaign the 03 TCR race car that has been developed by Geely Group Motorsport and which was shown publicly for the first time during an exclusive event at Fuji Raceway in Japan in October.

Better known as Polestar until Volvo Cars acquired the performance section and trademark in 2015, Cyan Racing has a long and successful history in Touring Car racing with multiple championships over the years. The partnership with Lynk & Co is new in that it will also be involved in the development of a 500 hp concept road car based on the TCR race car.

Named the Lynk & Co 03 Cyan, it will be built as Cyan Racing's interpretation of a TCR race car for the road. The concept car will be the first step towards an extended performance offer.

Lynk & Co's global mobility philosophy, which addresses the needs and preferences of the connected generation and challenging auto industry conventions, will be fused with Cyan Racing's two decades of experience from motorsport and previous automotive performance projects such as the iconic Volvo C30 Concept and Volvo S60 Concept.

"The fusion between Lynk & Co and Cyan Racing will form the spearhead of our automotive performance debut," said Victor

Yang, vice president of communications at Zhejiang Geely Holding Group. "The combination of Lynk & Co's challenge of auto industry conventions and Cyan Racing's vast motorsport and performance experience are two key elements in this unique cooperation."

"Our ambition as a race team is to reclaim our world title and explore new ways of automotive performance together with Lynk & Co," said Christian Dahl, CEO of Cyan Racing. "We will utilise our experience from past performance road car projects in combination with the vast data that we will gain from the racing programme through thousands and thousands of laps on racing circuits all over the world in extreme conditions." **RT**



ABOVE The 03 TCR race car that has been developed by Geely Group Motorsport and will be campaigned by Cyan Racing in TCR



VBOX VIDEO HD2 captures stunning video in full 1080p HD with real-time graphical overlay.

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HPD reveals new Civic Si for US saloon racing

Hal Ridge

SONOMA, CA: Following a Civic Si concept car being shown at the 2017 Performance Racing Industry show, Honda Performance Development has launched the HPD Civic Si race car. HPD plans to build, market and support a "turnkey, current-gen Honda Civic Si race car, and create additional

opportunities to use the highly capable, reliable, and affordable Civic in racing series such as the 2019 Pirelli World Challenge TCA, SCCA T3, and NASA H2 classes."

Tom O'Gorman drove a Civic Si to Pirelli World Challenge TCA glory last year, and parts developed in the programme will be utilised on HPD's new consumer car, priced at \$52,500.

"Since its launch, the current Civic Si has shown that it continues the legacy of racing success and performance for our customers," said John Whiteman, HPD commercial motorsports manager. "We're committed to providing the best Honda racing products to our Racing Line customers, and our in-house Honda Racing engineers ensure that they are developed, tested, and supported more extensively than any other available products. We're pleased to expand our Civic offerings to Racing Line members to include these new Civic Si race cars, and we can't wait to see them in competition." **RT**



ABOVE HPD has built a turnkey, current-gen Honda Civic Si race car for its Racing Line customers

Product Showcase Awards to be given at Autosport International

BIRMINGHAM, UK: Autosport International will play host to a Product Showcase Award, with a central focus on innovation, in the Engineering Hall at Birmingham's National Exhibition Centre (NEC) between 10-11 January 2019.

Categories for the awards include: innovation, lightweighting, energy efficiency, cross-industry application, vehicle performance tuning, manufacturing and fabrication, data and measurement, safety, electronics.

Each of these categories will have one winner and two highly-commended. All show exhibitors will be able to enter and judging of each category will be undertaken by an independent panel of experts from across the industry

once entries have closed on Friday 30 November. Winners will be selected based on a variety of factors that include level of innovation, technical achievement, quality, consumer appeal and marketability. The winners will be announced on the week commencing 17 December.

The winning products will be displayed on a dedicated feature in the Autosport Engineering Hall, a definitive international hub which attracts visitors from around the globe.

Autosport International events director, Kate Woodley, said: "The 2019 Product Showcase Awards will provide exhibitors with an exceptional opportunity to introduce their latest products to industry buyers, media and a truly global audience. We want

to recognise innovation and quality at what is a critical time for businesses across the globe and across all industries.

"Every year we are amazed by the quality of the innovations brought to the show, we thought it was time to formally recognise some of these amazing products. We encourage all exhibitors to get involved with this all-new feature for the 2019 show." **RT**

IN BRIEF

Formula E is considering introducing a full course yellow period following a 'pilot race' in Valencia during pre-season testing in late October according to eracing365.com. Race director Scott Elkins will be empowered to introduce them at his discretion during a race. It follows the practice in the US where such a system is used in NASCAR and IndyCar. **RT**

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RACE TECH WMS World Motorsport Symposium

You are invited to the **World Motorsport Symposium**
Tuesday 27th and Wednesday 28th November 2018

THIS year's World Motorsport Symposium reflects the growing technology trends and includes discussions on autonomous vehicles, the growing dependence on Artificial Intelligence but above all, environmental topics that have never before been addressed with such intensity at this event. It may therefore well be the most important WMS of the last 14 years if the conclusions reached will be implemented by the sport of tomorrow.

THE CHAIRMEN



 Audi Sport

ULRICH BARETZKY

Engine Development Director,
Audi Sport



 ILEY
DESIGN

JOHN ILEY

Founder, ILEY DESIGN
& F1 Aerodynamicist

“

The WMS presents a rare opportunity for like-minded engineers to discuss areas of the sport that they may not be so familiar with thereby expanding each other's knowledge for mutual benefit. It is also an excellent networking opportunity.”

Pat Symonds, Chief Technical Officer,
Motorsport Division | Formula 1



THE SPEAKERS



GILLES SIMON

Technical Director
FIA

*The evolution of
motorsport regulations*



ROBORACE

BRYN BALCOMBE

Chief Strategy Officer,
ROBORACE

*The challenge of Roborace
and what it means to the
motorsport industry*



JOHN GLENN

Retired EPA Official and Founder
of U.S. Governments Green
Racing Program

*How motorsport needs to
adapt to fit in a world concerned
with climate change*



WILLEM TOET

Motorsport, F1 and Aerodynamics
Expert, SAUBER F1

2020 Hyper Future for the WEC



ELIZABETH DONNELLY

Chief Executive Officer Women's
Engineering Society (WES)



ROB MILLAR

Head of Battery &
Electrical Systems,
Williams Advanced Engineering

*F1 - a counter-intuitive test bed
for the Autonomous Car?*



M.SC. LEA SCHWARZ

Doctoral candidate responsible
for sustainability in motorsports,
Audi Sport.

*The Sustainable Future
of Motorsport*



ARNAUD MARTIN

Chief Engineer - Motorsport,
Integral Powertrain

*The Future Direction of
Motorsport. A view from
an independent eDrive
manufacturer*



STEVE SAPSFORD

Market Sector Director- High
Performance Vehicles, RICARDO

*The case for low carbon
fuels - as part of a balanced
powertrain portfolio*



MARC HILBERT

Volkswagen Data: Lab, Team
Lead for AI in R&D incl. Racing
and Connected Car

*Artificial Intelligence and its
application in racing*



DOUGLAS CAMPLING

Chief Engineer - Motorsport,
Williams Advanced Engineering

*Electric Rally Cross - Designing
a Future Powertrain*



EWAN BALDRY

Technical Director, Ginetta Cars

*The Challenges of developing
and building an independent
LMP1 team from scratch*

THE CABINET MEMBERS



PAT SYMONDS

Chief Technical Officer Motorsport
Division,
FORMULA 1®



JASON SOMERVILLE

Head of Aerodynamics,
FORMULA 1®



ANDY COWELL

Managing Director, Mercedes
AMG High Performance
Powertrains Ltd



PASCAL VASELON

Technical Director,
Toyota Motorsport GmbH



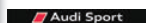
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Chief Engineer -
Engine Technical Leader,
Honda Performance Development



SERGIO RINLAND

Managing Director,
Astauto Ltd



THOMAS LAUDENBACH

Director Development HV
Storage Systems,
Audi AG, Audi Sport



LUCA MARMORINI

Former Technical Director Engine
and Electronics, Ferrari Racing
Dept & Engineering Consultants



THOMAS KRÄMER

Director Motorsport Quality
Management, Porsche Motorsport



MATTHIAS DANK

Global Business Segment
Manager Racing
AVL



RODI BASSO

Motorsport Director,
McLaren Applied Technologies



WERNER BRUCK

Managing Director
Pankl Turbosystems GmbH



DIALMA ZINELLI

Head of Aerodynamics
Dallara

RACE TECH WMS World Motorsport Symposium PROGRAMME

Tuesday 27th November 2018

09.30

WELCOME BY WILLIAM KIMBERLEY

Editor-in-chief, RACE TECH | Bernoulli

09.40

INTRODUCTION BY THE CHAIRMEN ULRICH BARETZKY & JOHN ILEY

10.00

KEY NOTE SPEECH BY ELIZABETH DONNELLY

Chief Executive Officer, Women's Engineering Society (WES)

10.30 - COFFEE BREAK, EXHIBITION AREA

11.00

PRESENTATION BY STEVE SAPSFORD

Market Sector Director, High Performance Vehicles, Ricardo

The case for low carbon fuels - as part of a balanced powertrain portfolio

11.30

DISCUSSION LED BY ULRICH BARETZKY

Director, Audi Sport Engine Development

The case for low carbon fuel

12.30 - LUNCH BREAK

13.30

PRESENTATION BY GILLES SIMON

Technical Director, FIA

The evolution of motorsport regulations

13.50

DISCUSSION LED BY ULRICH BARETZKY

Director, Audi Sport Engine Development

The evolution of Motorsport regulations

14.30 - COFFEE BREAK, EXHIBITION AREA

15.00

PRESENTATION BY WILLEM TOET

Motorsport, F1 and Aerodynamics Expert, Sauber F1

2020 Hyper Future for the WEC

15.20

DISCUSSION LED BY JOHN ILEY

Founder & Director, Iley Design

2020 Hyper Future for the WEC

16.00

PRESENTATION BY M.Sc. LEA SCHWARZ

Doctoral candidate responsible for sustainability in motorsports at Audi Sport.

Institute of Internal Combustion Engines and Automotive Engineering (IVK), University of Stuttgart

The Sustainable Future of Motorsport

16.40

DISCUSSION LED BY ULRICH BARETZKY

Director, Audi Sport Engine Development

The Sustainable Future of Motorsport

17.30

REVIEW AND CLOSING REMARKS BY THE CHAIRMEN ULRICH BARETZKY & JOHN ILEY

Wednesday 28th November 2018

09.00

SUM UP DAY ONE AND OUTLINE DAY TWO BY THE CHAIRMEN ULRICH BARETZKY & JOHN ILEY

09.30

KEYNOTE SPEECH BY JOHN GLENN

Retired EPA Official and Founder of U.S. Governments Green Racing Program

How motorsport needs to adapt to fit in a world concerned with climate change

10.00

PRESENTATION BY ROB MILLAR

Head of Electrical, Williams Advanced Engineering

F1 - a counter-intuitive test bed for the Autonomous Car?

10.20

DISCUSSION LED BY ULRICH BARETZKY

F1 - a counter-intuitive test bed for the Autonomous Car?

11.00 COFFEE BREAK, EXHIBITION AREA

11.30

PRESENTATION BY BRYN BALCOMBE

Chief Strategy Officer, Roborace

The challenge of Roborace and what it means to the motorsport industry

11.50

DISCUSSION LED BY JOHN ILEY

Founder & Director, Iley Design

The challenge of Roborace and what it means to the motorsport industry

12.30

PRESENTATION BY MARC HILBERT

Volkswagen Data: Lab, Team Lead for AI in R&D incl. Racing and Connected Car

Artificial Intelligence and its application into racing

12.50

DISCUSSION LED BY JOHN ILEY

Founder & Director, Iley Design

Artificial Intelligence and its application into racing its application into racing

13.30 - LUNCH BREAK, EXHIBITION AREA

14.30

PRESENTATION BY ARNAUD MARTIN

Chief Engineer - Motorsport, Integral Powertrain

The Future Direction of Motorsport. A view from an independent eDrive manufacturer

14.50

DISCUSSION LED BY ULRICH BARETZKY

Director, Audi Sport Engine Development

The Future Direction of Motorsport. A view from an independent eDrive manufacturer

15.30 - COFFEE BREAK, EXHIBITION AREA

16.00

PRESENTATION BY DOUG CAMPLING

Chief Engineer - Motorsport, Williams Advanced Engineering

Electric Rally Cross – Designing a Future Powertrain

16.20

DISCUSSION LED BY ULRICH BARETZKY

Director, Audi Sport Engine Development

Electric Rally Cross – Designing a Future Powertrain

17.00

PRESENTATION BY EWAN BALDRY

Technical Director, Ginetta Cars

The Challenges of Developing and Building an Independent LMP1 Team from Scratch

17.20

DISCUSSION LED BY JOHN ILEY

Founder & Director, Iley Design

The Challenges of Developing and Building an Independent LMP1 Team from Scratch

18.00

REVIEW AND CLOSING REMARKS BY THE CHAIRMEN ULRICH BARETZKY & JOHN ILEY

NB. The programme is subject to change

RACE TECH WMS World Motorsport Symposium

What do I get out of it?

The World Motorsport Symposium is the only event of its kind where the most senior international motorsport and automotive engineering decision makers get together for two days to discuss how technology will shape the future of their sport and in turn influence and affect engineering sectors across the globe. By listening to the presentations by leading industry experts and also joining the debates where everyone has a voice, attendees will be given a head start in the emerging markets in this fast paced field. Also be the first to hear about new ideas and decisions before they are formally announced and be privy to highly confidential industry information only available due to Chatham House rules. A networking opportunity like no other has also meant that this Symposium has gained a reputation as the 'Davos of Motorsport Engineering'.

Your ticket also includes:

Lunch at the Institution of Mechanical Engineers (IMechE) as well as a Champagne drinks reception followed by a three course meal and wine at the Millennium Gloucester Hotel London Kensington on the evening of Tuesday 27th November if you book the full package.

WHERE

The two day Symposium will take place at:

Institution of Mechanical Engineers (IMechE)
1 Birdcage Walk, Westminster, London, SW1H 9JJ



The Networking Awards champagne drinks reception and dinner will take place at:

Millennium Gloucester Hotel, London Kensington
4-18 Harrington Gardens, London SW7 4LH



TO BOOK TICKETS

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"I was very impressed with the format – it's rare to have an opportunity to openly discuss important matters affecting the future of our sport, from club racing to F1. The mix of industry experts and the next generation of engineers and designers brought a healthy balance to the debates. A very informative and thought-provoking event – keep it up!"

JASON SOMERVILLE, Head of Aerodynamics,
Formula One Management

"To shape the future of motorsport – the World Motorsport Symposium is a must for all key people in that business."

THOMAS KRAEMER, Manager Engine Design
LMP1, Porsche Motorsport LMP Team

"The WMS offers a fantastic forum to gain opinions from some of the most influential people in the world of motorsport."

JOHN MANCHESTER, Operations Director, Gibson Technology Ltd



THE RACECAR OF THE FUTURE?

Futuristic bodywork, a 'Mario Kart'-style power boost and no more embarrassing mid-race car swaps: Formula E's Gen2 car marks the start of a new era of electric racing, says **Craig Scarborough**

LOVE it or loathe it, Formula E continues to be arguably the biggest story in motorsport. The press attention is understandable, for the category's fifth season brings the exciting new Gen2 car and major changes to the format.

The FIA's official electric single-seater championship boasts the arrival of BMW this season and, ahead of their entry next year, the presence of Mercedes and Porsche-backed drivers, engineers and management,

both within the existing teams and the new outfit, HWA. This maturing of the category is marked by a change in chassis, battery and powertrains. Finally, the series will run full races without car swaps. In the process, the motor performance jumps to 335 hp.

Since its formal unveiling at the Geneva Motor Show, the Gen2 car has drawn comments for its adventurous looks. The reception has been largely positive, although some purists are still irked by the semi-

covered front wheels and opinion is still split over the Halo. But as a single chassis series, the looks can be played with as long as the performance of the chassis is up to the job.

As yet unraced, the Gen2 car aims to gain in performance, especially for a car following in another's wake, with the front bodywork tidying up the turbulence of the front wheels. Another aspect of the design is the size of the diffuser, which is exceptionally large, perhaps too large to be fully effective,



ABOVE The Gen2 car features futuristic bodywork, more power and an 'attack mode' to create an element of strategy now cars will no longer be swapped halfway through the race

BELOW Beneath the skin of Audi's e-tron FE05

Chassis

Spec carbon fiber chassis with spec carbon bodywork, FIA crash and safety standards

Steering wheel

Removable steering wheel, display, regen paddle and FIA marshalling indicators

Powertrain

Rear-wheel drive, Audi Schaeffler MGU03 Motor Generator Unit, 1-speed-transmission

Battery

Lithium-ion battery from McLaren Applied Technologies, available capacity 52 kWh, charging time approx. 45 minutes, weight approx. 374 kg

Brakes

Hydraulic dual-circuit brake system, electronic-control brake force distribution, carbon fiber brake discs, "Brake-by-Wire" on rear axle

Rims & Tires

Aluminum rims, front 9 x 18 inch, rear 11 x 18 inch, profiled road-like tires from Michelin

Dimensions/Weight

Length	5,200 mm
Width	1,800 mm
Height	1,250 mm
Wheelbase	3,100 mm
Minimum weight	900 kg (incl. driver)

Performance

0-100 km/h	approx. 3.1 seconds
Top speed	240 km/h

but nonetheless creates downforce from the underbody, leaving the rear wing to be just a small, stylised X-wing set up. The car's bodywork is all detachable from the inner monocoque, which retains a similar conventional shape to the Gen1 car. This leaves the formula free to redevelop the bodywork for future seasons.

With the Gen1 car developed in a very short space of time, there was never the time to match the battery and powertrain to their full potential. The Gen2 programme has allowed a better balance between battery and the permitted power/energy/regen allowances. Thus, the peak output is now up 50 kW to 250 kW for qualifying, with the race power being increased to 200 kW from 190 kW. The regenerative energy allowance is increased to 250 kW, this previously being capped to manage the battery temperatures. The Fanboost system remains, with three drivers getting a boost in the race, as a result of a social media vote. Now Fanboost allows the driver an extra 100 kJ of energy at an output of between 240 and 250 kW. So, the driver can have a shorter, more powerful boost or a slightly longer duration boost at the lower power level.

This high-power boost mode will also be available to every driver twice in the race, with the new trick called Hyperboost. In the absence of mid-race pitstops or car swaps, this offers the driver something to use tactically in the race to attack or defend position. Already dubbed the 'Mario Kart' boost, or 'attack' mode, the driver will have to drive offline over a specific area of track to initiate Hyperboost. They will then get the boost for four minutes.

These new power settings are only possible with the new McLaren Applied Technologies-produced battery, itself a step up in capacity, with the outgoing 28 kWh battery replaced by a 56 kWh unit. This allows the cars to race for the full 45-minute (plus one lap) distance, without resorting to car swaps or in-pit recharging. This has been allowed partly

“Hyperboost, already dubbed the ‘Mario Kart’ boost, or ‘attack’ mode, offers the driver something to use tactically in the absence of mid-race car swaps”

Photos: Audi AG



ABOVE The huge diffuser creates underbody downforce, leaving just a small, stylised X-wing

by a realistic development period, unavailable for the original Formula E battery.

Real details of the battery are vague, but there is a known change in cell format, from pouch to cylindrical cells, while the exact chemistry is still undisclosed. To achieve the energy capacity with this change there is a significant revision to the number of cells from the 150 or so larger XALT-made pouch cells in the Gen1 battery. Another change is in the battery's operating voltage, doubling from 400V to 800V, in line with common road car EV standards, allowing for faster charging/discharging.

BATTERY BREAKTHROUGH

Physically the battery is different to the Gen1 car. It is now encased within the monocoque, rather than being a structural bolt-on unit to a truncated tub. Thus, the battery fits up underneath the chassis with a bolt-on base plate, the car needing to be lifted up on jacks to leave the weighty battery on its trolley below. While the battery isn't structural any more, the internals are protected and hidden away from prying eyes within a lightweight carbon fibre casing.

Powertrain design has been free within Formula E since Season2. Over this time many layouts have been tried, from different motor formats of radial flux and axial flux, to multi-gear or single-speed transmissions. With the substantial changes to the rules affecting



ABOVE & RIGHT Brembo has developed the Season5 brake package, including brake-by-wire, while Michelin returns with an all-new tyre to last the full race distance

power, energy and battery format, each of the manufacturers has gone for a major redesign of their powertrains for Season5.

Unsurprisingly protective of their IP, little information is available on the specifics of each manufacturer's set up. It appears that most, if not all, cars will have a near-identical layout of a single high-speed axial flux motor, transversely mounted with fixed speed reduction gearing to the differential. This is the successful layout pioneered by Renault in Season3. Teams such as Nio NextEV and DS Virgin continued with slightly different layouts up to Season4, but each now appears to have followed the trend and gone for the Renault layout.

Beyond layout, the trend towards Silicon Carbide (SiC) MOSFET over Silicon (Si) IGBTs in the inverter is likely to be adopted by all, the ever-greater motor speed and increased



voltage being the key driver. The reduced cooling demand for SiC inverters means small radiators in the left-hand sidepod, which is better for weight and drag.

All of these components are routinely mounted inside a structural carbon rear case. This places the weight low down and the close proximity of the motor and inverter means shorter and therefore lighter high voltage cable and cooling pipe runs. The overall car ►

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weight is now increased to 900 kg from 880 kg, so any weight reduction for the teams within their powertrain means ballast can be used to lower the CofG, although the front to rear weight distribution is fixed by the rules.

HALO PROTECTION

Since the very first Formula E race in Beijing, back in 2014, ended with Nick Heidfeld's car landing inverted against the barriers, Formula E has been hot on safety – all the more so because of its close contact street fighting race format. Being an FIA single-seater category, the car must meet its global safety standards, hence it now wears the Halo frontal cockpit protection. This is the same V3 Halo as used in F1 and F2. The 4 mm thick wall titanium hoop protects the driver's head from impact with other cars, flying objects and trackside obstacles. Without a screen, the Halo is not a comprehensive solution, but the first season's experience of it at Grand Prix level demonstrated its obvious safety benefits in a variety of incidents.

Unlike F1, the Formula E Halo is raced bare, with no aerodynamic bodywork fitted to it, making it appear slimmer than the same F1

structure. Practical use of the Halo is made with a series of LEDs being fitted into the front perimeter, that will flash when Fanboost or Hyperboost modes are engaged.

Zylon anti-intrusion panels along the flanks of the footwell area of the tub are less visible, but safety additions nonetheless. Hiding in plain sight, a lower nose tip follows F1's lead to prevent nose-to-tyre flip-over incidents.

BRAKES PUSHED TO THE LIMIT

A key change in the new car's specification is the brakes. The greater speed and weight of the Gen2 car demands more deceleration and Brembo has been picked as the new braking partner until 2021. The car now sports Brembo's callipers and master cylinder, as well as the Italian company's carbon pads, discs and mounting bell. Front and rear callipers are of a four-piston design, made in aluminium.

According to Brembo, the design of the bespoke Formula E calliper "has been pushed to the limits. The calliper has been considerably lightened in the less stressed areas in order to maximize weight reduction without compromising its stiffness." To this end the front and rear callipers weigh 1.2

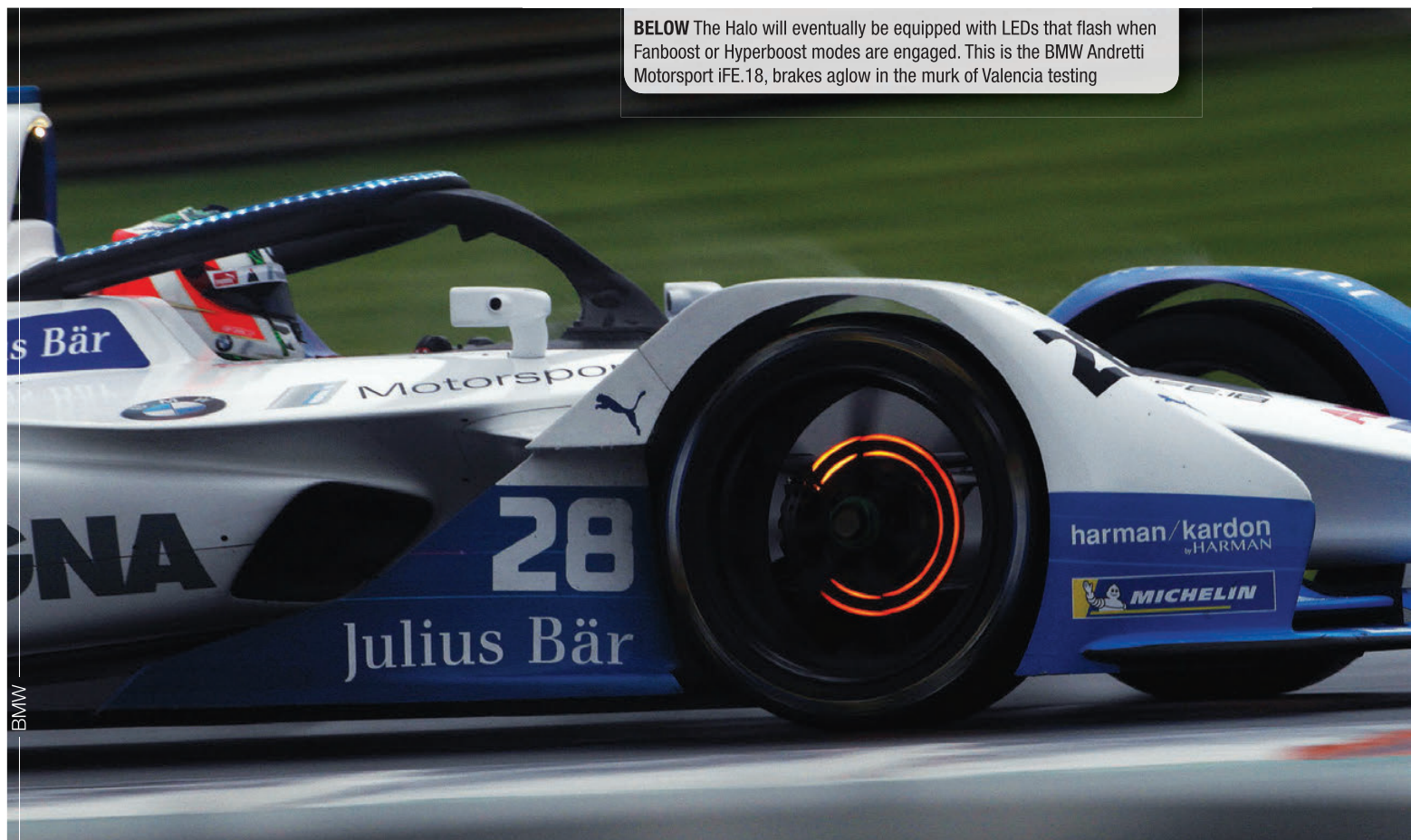
and 1 kg respectively, some 25 and 50% lighter than Brembo's own F1 callipers.

The rear brakes are both lighter and smaller than the fronts, with thinner, smaller diameter discs, thinner pads and smaller calliper pistons. While this is not unusual in racecar design, for the Formula E car the rear braking is also achieved harnessing the electric powertrain's regenerating energy under deceleration on corner entry.

In the first four seasons the rear braking effort was achieved with a passive balance of rear calliper force and regenerative braking effect. While both were driver-adjustable, there was no active method to alter brake bias with the change in the battery's state of charge (SOC). Thus, if the battery was full or too hot, the regen effect would be reduced and rear braking effort equally reduced, unbalancing the car and most likely forcing a lock-up or spin.

Now an active Brake-By-Wire (BBW) system is permitted, the driver demands the total braking effort from the pedal as usual, but the master cylinder only directly operates the front callipers. The rear callipers are under the control of the BBW system. The ECU balances the driver's total braking demand with the regen effort available and then operates the rear callipers to meet the ▶

BELOW The Halo will eventually be equipped with LEDs that flash when Fanboost or Hyperboost modes are engaged. This is the BMW Andretti Motorsport iFE.18, brakes aglow in the murk of Valencia testing





Gain a competitive advantage whilst improving safety

Using their clean break technology, Stäubli have developed a tyre valve connector which ensures no pressure loss on disconnection, providing both certainty and security. Combined with two stage valving, the TDV 03 maintains the correct tyre pressure even if the connector is damaged. This technology also removes the need for a dust cap.

Developed to withstand the g-force loads generated by rapid acceleration and deceleration as well as the high centrifugal loads experienced during racing, the TDV 03 quick coupling is further available in variants which fulfil the demands of individual race teams and series.



remaining braking requirement.

With this set up the master cylinder has been simplified from the classic racecar twin master cylinders on an adjustable bias bar. Instead it is formed of a bespoke Brembo tandem master cylinder, so both front and rear braking circuits are supplied from a single unit. The rear brake circuit goes into a team-developed Brake-By-Wire module, which has its own proportional electro/mechanical pump to operate the rear brakes. In the event of a BBW system failure, the rear callipers will revert to being operated by the pedal master cylinder. The BBW system will not be allowed

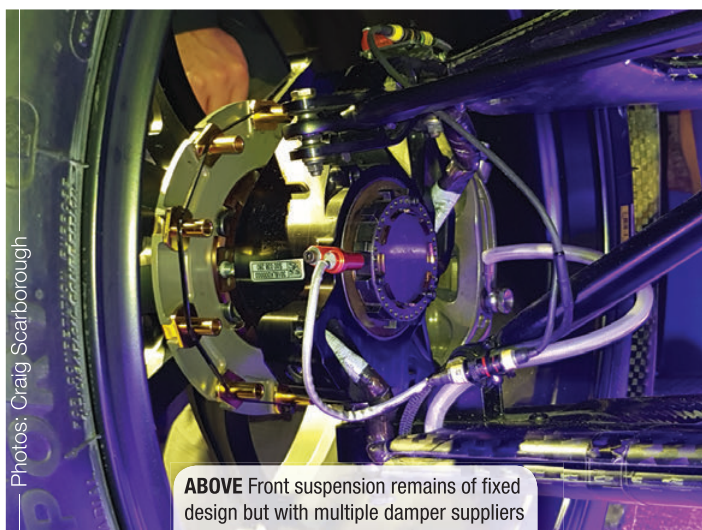
to provide an Anti-Lock Braking effect.

One smaller new feature for Formula E is the freedom to fit a brake cooling duct to the front brakes. The simple carbon snorkel seen in testing is the first time any form of brake cooling/blanking has been permitted.

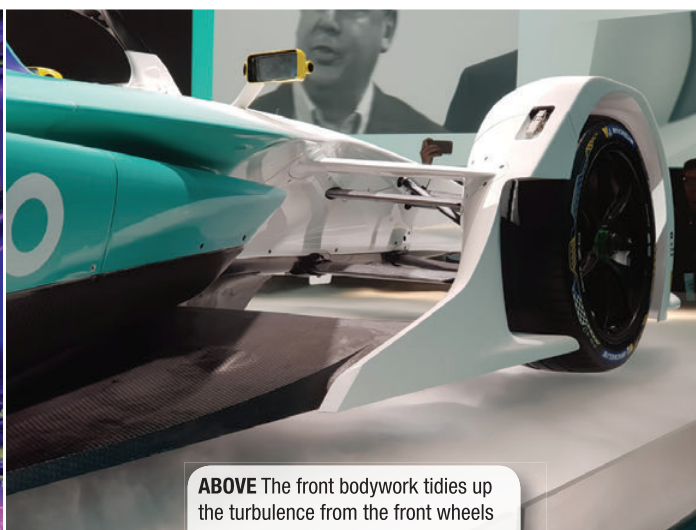
Suspension freedom remains unchanged with the front suspension being of fixed design, aside from the damper specification, with Multimatic, ZF Sachs and Öhlins all producing specific designs for the category. The rear suspension is essentially free, with the only basic demands for a double wishbone/track rod set up with a pushrod

operating spring/dampers and anti-roll bar. The rear uprights are of a fixed design, somewhat restricting geometry choice, while no heave elements or interconnecting/active hardware are allowed. Manufacturers play with the geometry to gain roll steer to help the rear-heavy cars get through tight corners and put the tractive torque of the electric motor down to the ground. This is an area of freedom, but not a primary performance factor according to Dieter Gass of Audi Sport.

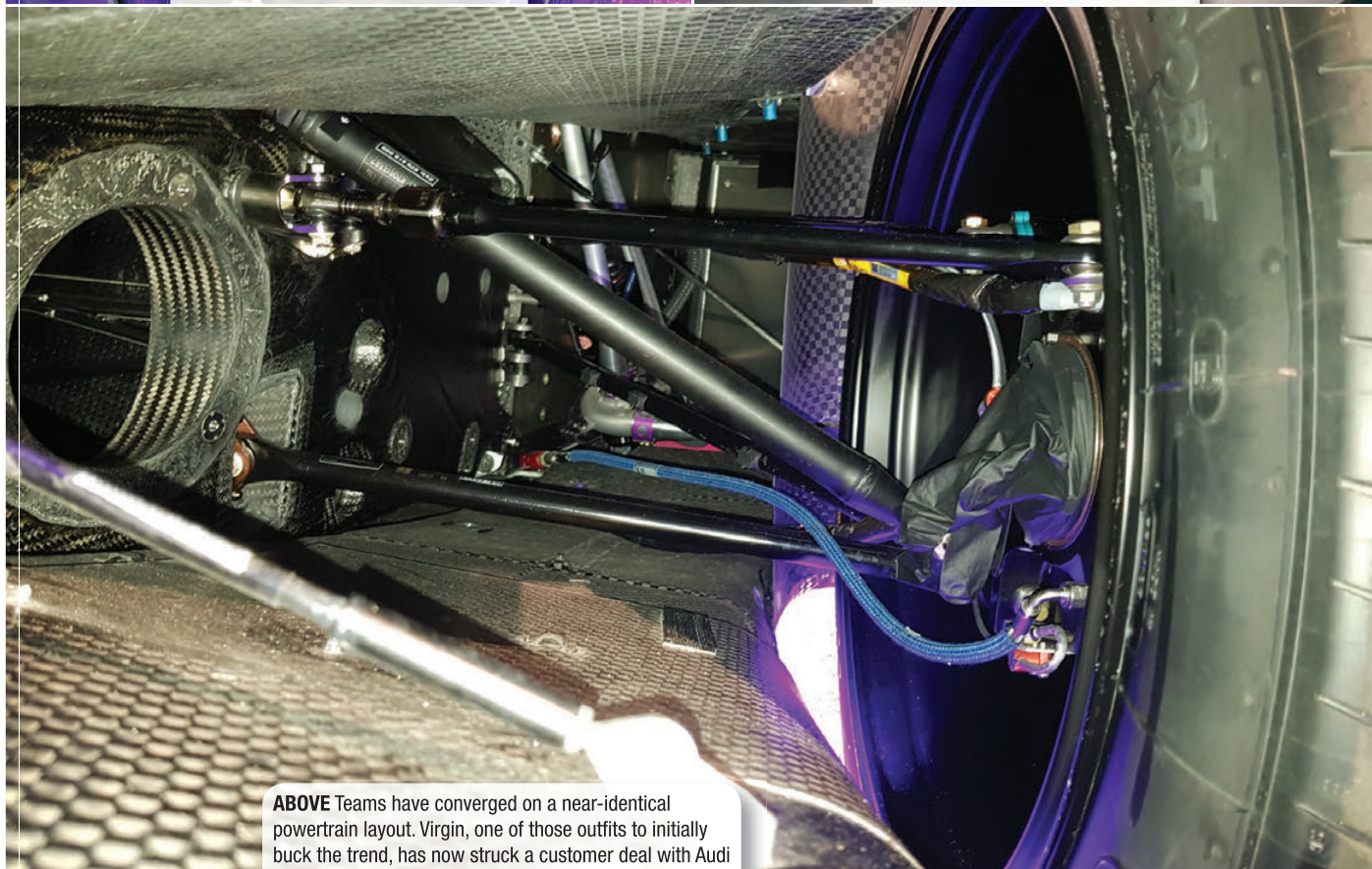
Michelin has brought an all-new tyre to the category this season, not least because the race is now completed on a single set of ►



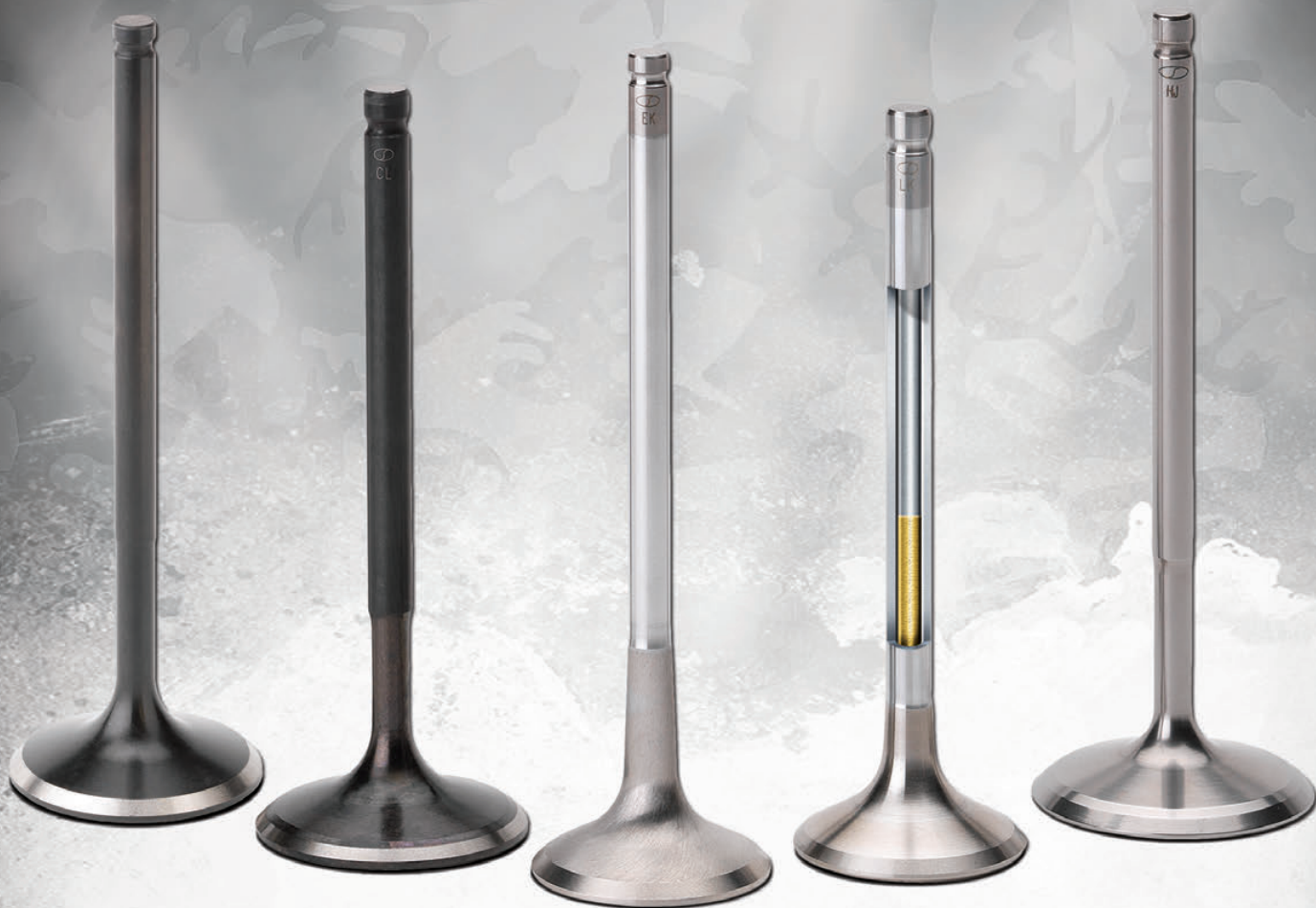
ABOVE Front suspension remains of fixed design but with multiple damper suppliers



ABOVE The front bodywork tidies up the turbulence from the front wheels



ABOVE Teams have converged on a near-identical powertrain layout. Virgin, one of those outfits to initially buck the trend, has now struck a customer deal with Audi



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tyres, rather than split into two sets with the car swaps of Seasons 1-4. Again, a treaded all-weather format tyre is used, to save shipping large numbers of wet tyres to races that will remain unused in dry conditions. The tyre is both lighter and has even less rolling resistance to maximise energy efficiency.

Electronics are a key part of the sport, with the McLaren Applied Technologies TAG-400i the favoured ECU, although both Magneti Marelli and Bosch ECUs have been used too. Low voltage 12V power is supplied to the loom via a DC-DC converter, which can either be integrated into the inverter or a separate item. Other key items are the cooling pumps, with the battery's dielectric fluid now cooled by a Bosch pump and controller, while manufacturers can specify their own pump supplier for the inverter/motor cooling.

REVISED STEERING WHEEL

XAP has revised the fully configurable steering wheel, with its colour display screen complete with 10 buttons, five rotaries and six paddles. As the cars have never required a clutch and no longer need gearshifts, the paddle functions are dedicated to regenerative brake, Lift and Coast and power modes.

Manufacturers have had the detail design of the Gen2 chassis fixed for some time, allowing them to design the powertrain, rear carbon case and suspension. Chassis were supplied earlier this year and through the summer 15 days of testing have been allowed for the manufacturer teams. Technically-speaking, teams taking a customer supply of a manufacturer's powertrain are unable to test alone, but can be involved with the supplying manufacturer's tests. Lastly, there was but a three-day public test for all teams to run



ABOVE The intent is to create plenty of action in a street racing environment

collectively at the Valencia track before the first ePrix in Saudi Arabia in December.

With testing limited and a tranche of new teams and drivers, simulator testing has been critical and a proven way to prepare for the upcoming races. The technical issue of engineering the Gen2 car at the track is complicated by its aero set up. The small rear wing flaps are fixed in angle of attack, thus the car's total drag is almost defined by its base set up. Along with the fixed power output of the electric drivetrain, only the final drive ratio, rake and electrical efficiency will be the variable in the cars' top speed. I can think of no other series that fixes rear wing

setting in this way. The front flap is both available in two specifications and adjustable, but this is the only aero set up option available to balance the car front to rear.

Allied to this, there is the ability to qualify with 20% more power than they will race with. It means those laps deciding the grid will be quite exciting. Despite there being no parc ferme, there is little on the aero side to adjust between qualifying and the race.

Come the race itself, two other managing techniques will be battery and tyres. Being an EV category, the battery management will always be vital, but the new battery should be easier to manage from a thermal perspective. The new higher voltage should help too: it was found with the old 400V battery that as the SOC declined there needed to be more current drawn to provide the power. This heats up the battery and further adds to the thermal management headache. With the higher voltage of the new battery, the current draw at low SOC is less of an issue, allowing for harder racing through the entire race distance.

Given its ever-growing media presence and manufacturer involvement, Formula E is now equipped with a car to match the attention. Already the design of the Gen3 car is under discussion to further evolve the EV series into the future. **RT**



ABOVE Paddle functions on the XAP wheel are dedicated to regenerative brake, Lift and Coast and power modes

Craig Scarborough

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FROM ZERO TO HERO

Chris Pickering quizzes the creator of the zero-emissions prototype acting as a laboratory for the ACO's mission to introduce hydrogen-fuelled racecars to the Le Mans 24 Hours

SEEMINGLY, not a day goes by without another car manufacturer throwing its hat into the electric vehicle ring. It's a phenomenon that's rapidly gaining traction in motorsport, with genuine OEM involvement in Formula E soon set to outweigh that in the badge-engineered world of Formula 1.

But there are some applications that battery electric vehicles will struggle to conquer. The principle problem remains energy density. That's not insurmountable if you're looking to send a passenger car 500 km between charging points, but it remains a real issue if you want to fly an airliner from London to Sydney. Even if you

could achieve the required storage capacity, there's the question of how quickly it would be possible to recharge, plus all the associated complexities, such as battery management and cell ageing.

Motorsport poses a similar problem in the form of endurance racing. While a Formula E event typically covers around 90 km, the current distance record at Le Mans is a little over 60 times that figure at 5,410 km. The only practical solution is to refill your energy storage system at regular intervals and to do so very quickly. That brings us to hydrogen, which can be burnt in a combustion engine or oxidised in a fuel

“Hydrogen racing cars are already a reality”

cell. In either case, the final products are the same: water and oxygen.

This approach is certainly not without its challenges and for many applications it's likely that battery storage will be a more practical solution. However, that still leaves some significant cases where hydrogen may well be the only zero-emissions option. And if you're forced to invest in a widespread hydrogen infrastructure for those instances it strengthens the case for using it elsewhere as well.

It was arguments like these that prompted the ACO to announce its Mission H24 initiative back in September. The aim of the programme is to establish a technical framework that would allow a class of hydrogen vehicles to race alongside more conventional machinery at the 24 Hours of Le Mans from 2024.

Earlier this year, BMW Motorsport boss Jens Marquardt fuelled long-running rumours that the brand was considering a hydrogen entry when he admitted that discussions about fuel cell technology had taken place with both the FIA and the ACO. More recently, French newspaper *La Mairie Libre* claimed to have information from “good sources” that Audi was working on a fuel cell prototype.

Look elsewhere, however, and hydrogen

racing cars are already becoming a reality. Back in the spring, Dutch university team Forze Delft made history when it completed a round of the Supercar Challenge series in a fuel cell-powered prototype. Meanwhile, GreenGT, which came close to fielding a Box 56 entry at Le Mans in 2013, has been steadily refining its own fuel cell technology. The Swiss company demonstrated its latest prototype, the LMPH2G, at the European Le Mans Series round at Spa in September.

MAJOR STEP FORWARD

GreenGT has been associated with the fledgling world of fuel cell racing for more than half a decade now, but the new car is its

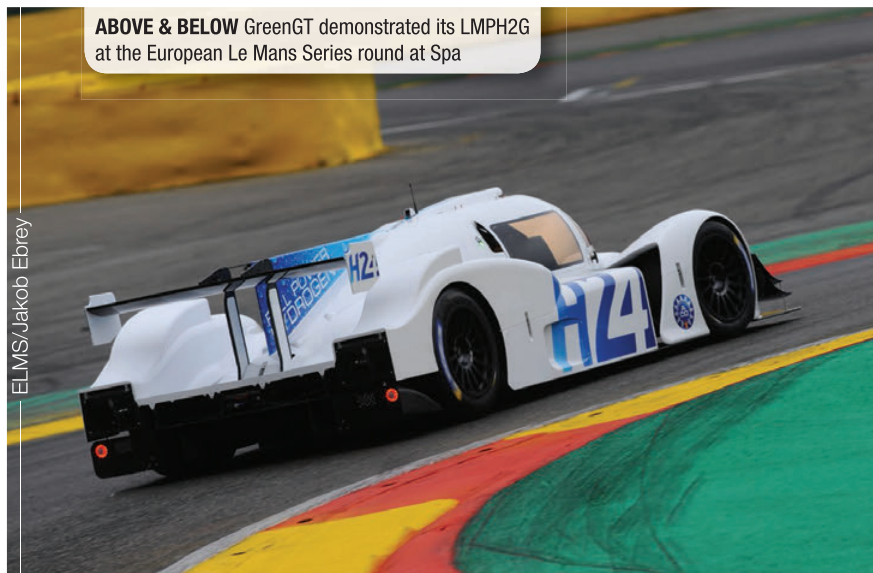
most significant effort to date. Fast, compact and reportedly close to matching the fuel range of a conventional design, the LMPH2G appears to be a major step forward.

It's being used as a laboratory, both for the company to develop its own technology and to supply data to the ACO, which will help to shape the upcoming rules, explains Jean-François Weber, GreenGT's founder and head of R&D.

“The car that we've built is being used to prepare the rules,” he says. “It's also useful to show the world that this technology exists already. We hope that will inspire the car manufacturers to start their own projects in time for 2024. There is time to prepare the cars for that date.”

GreenGT's previous car, the H2, was a landmark achievement, setting the first ever fuel cell-powered lap of Le Mans in 2016. But it was also comparatively ponderous, ▶

ABOVE & BELOW GreenGT demonstrated its LMPH2G at the European Le Mans Series round at Spa



ELMS/Jakob Ebrey

with a bespoke chassis from Welter Racing to accommodate the plus-sized fuel cell and a total length of well over five metres. The new machine, however, is based on a lightly-modified Adess LMP3 chassis and looks much like a conventional sports-prototype.

Weber is the first to admit that GreenGT's area of expertise is the fuel cell and the remainder of the package has been chosen principally for convenience. The suspension, for instance, uses off-the-shelf dampers from PKM while the brake package is straight from the Brembo catalogue.

The real magic lies with the powertrain, he points out: "Most of the work has focused on making the fuel cell lighter and more efficient. The very first race fuel cell we built was 400 kg; now it's down to 133 kg. Originally, we used a standard membrane and bipolar plates that came from the mainstream automotive market, but now everything [in the fuel cell] is built in-house with our own components."

The original design consisted of 18 fuel cell stacks of 20 kW each, but the latest version

uses just four stacks, developing 80 kW apiece. This has been achieved by doubling the size of the active area (the area of the membrane able to process hydrogen). Other refinements to the membrane and the bipolar have helped, as well as the switch to a lightweight titanium endplate design.

"We have been collaborating with our industrial partners, the Michelin Symbio partnership, who are looking into fuel cells for trucks, because their power requirements are actually very similar to the racecar," comments Weber.

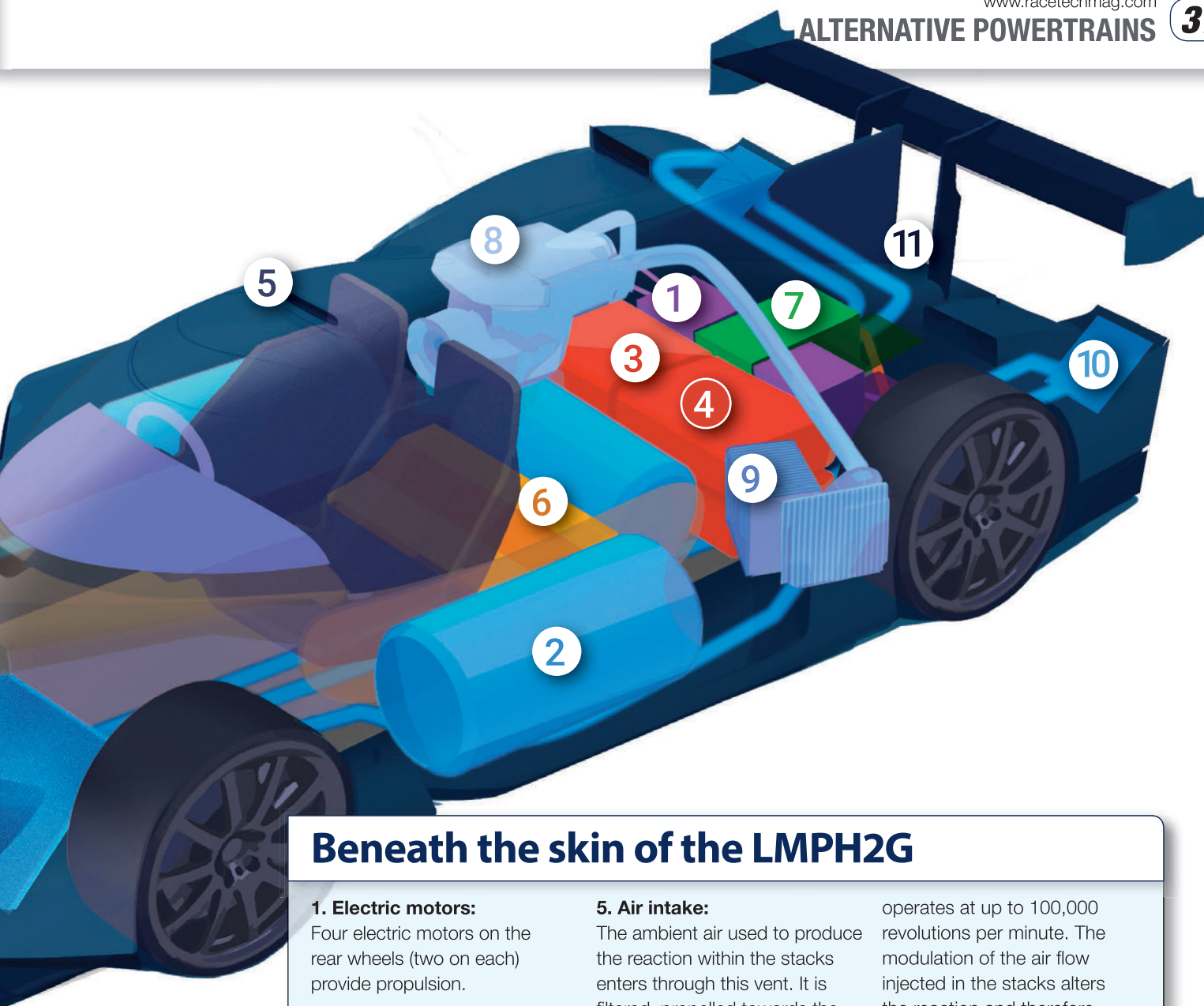
The drive comes from four electric motors produced by YASA in Oxford – two on each rear wheel with a fixed-speed transmission, the shafts for which are produced by Sadev. The hydrogen is stored in three tanks: two in the sidepods and one behind the driver. At the beginning of the H2 project the team were using road car-derived tanks with a maximum press of 350 bar, but these have since been upgraded to a bespoke design capable of operating at twice the pressure.

BESPOKE DESIGN

The LMPH2G is a significant departure from its predecessor, the H2. Only one part is actually shared between the two cars (an inverter used in the power electronics for the fuel cell's air compressor). What's more, there are some fundamental differences in the design philosophy. Notably, there's now a battery to act as an energy buffer. Most road-going fuel cell vehicles ▶



ABOVE The by-products of hydrogen are water and oxygen, a fact celebrated here by (left to right) Pierre Fillon (ACO President), Henrik Hololei (European Commission, Director-General for Mobility and Transport) and Christophe Ricard (GreenGT President)



Beneath the skin of the LMPH2G

1. Electric motors:

Four electric motors on the rear wheels (two on each) provide propulsion.

2. Three hydrogen reservoirs:

The dihydrogen (H₂) is stored in three pressurized (700 bars) carbon filament tanks used to fuel the cell. The first two are placed either side of the cockpit and the third just behind the driver.

3. Hydrogen fuel-cell:

Comprises four stacks, at the core of which molecules of dihydrogen (H₂, stored in the tanks) and oxygen atoms combine to form water molecules (H₂O). This reaction produces heat, and electricity, which powers the car's electric motor.

4. The stack

A layered pile of 230 cells, bipolar plates and hydrogen porous membranes.

5. Air intake:

The ambient air used to produce the reaction within the stacks enters through this vent. It is filtered, propelled towards the compressor, then the humidifier, before entering the stacks.

6. Buffer batteries:

Excess electricity produced by the hydrogen fuel-cell and by the KERS system (when braking) feeds into high-performance cells. The driver can therefore double the car's acceleration potential (250–480 kW, the equivalent of 653 hp).

7. Transmission:

A special, clutchless one-gear gear box manages rear wheels independently and is designed to reduce grinding.

8. Compressor:

Compresses and accelerates the air that enters via the vent (up to 300g per second). It

operates at up to 100,000 revolutions per minute. The modulation of the air flow injected in the stacks alters the reaction and therefore determines the amount of electric power produced.

9. Humidifier:

Humidified air improves the interaction between oxygen atoms and dihydrogen molecules. The humidifier ensures the level of humidity of the air injected in the stacks remains constant.

10. Radiators and cooling system

11. Exhaust:

The only emission produced by the GreenGT LMPH2G is water (H₂O). Steam escapes through four vents (one per stack) to the rear of the car, in the middle of the aerodynamic diffuser. 



ABOVE & BELOW Fresh challenges in the cockpit and new messages on the dash readout

follow a similar philosophy: the fuel cell is used to charge an onboard battery and the system relies heavily on this storage system to respond to transient demands. GreenGT initially followed a slightly different approach, developing a 'throttled' fuel cell capable of reacting to these changing pedal demands on its own. Indeed, when the H2 completed its demonstration lap of Le Mans it did so without any additional energy storage.

The main issue with this approach is that it prevents the car from recovering energy during braking. For that reason, a 2.4 kWh (8.64 MJ) lithium ion battery pack has been added to the LMPH2G. The output of the fuel cell still varies considerably depending on the pedal input, but while it produces an average of 250 kW, the hybrid system now allows up to 480 kW to be supplied for a 20-second burst. The battery pack is an off-the-shelf item, chosen for its high power capability, with discharge rates of up to 150C.

"When you're going down the straight it's full power on the fuel cell, plus whatever is available in the battery. Under braking, we try to harvest as much energy as possible," comments Weber. "We have



quite a complex strategy that's designed to top up the battery during the corner so it reaches 80 per cent capacity before the driver starts to accelerate. Over the course of the lap the fuel cell output can vary from 30 kW to 250 kW."

The principal downside to adding a battery is, of course, weight. In comparison to an electric car, however, the penalty is fairly mild, with the complete battery pack, including its cooling system, weighing in at just 70 kg.

Effectively, the car is a hybrid, with battery and the fuel cell capable of working independently. In fact, one of the biggest

challenges in the project so far has been getting the two power sources to work together, Weber explains: "We have quite a sophisticated control system. The high charge and discharge rates involved make the battery management rather more complex than usual. Plus, we have to manage the voltages in different parts of the system. The battery and the fuel cell both operate at a nominal 750 volts, but their power curves look very different."

In contrast, the power electronics hardware is said to be relatively conventional, with GreenGT sticking with the tried and tested technology used in previous projects. ►



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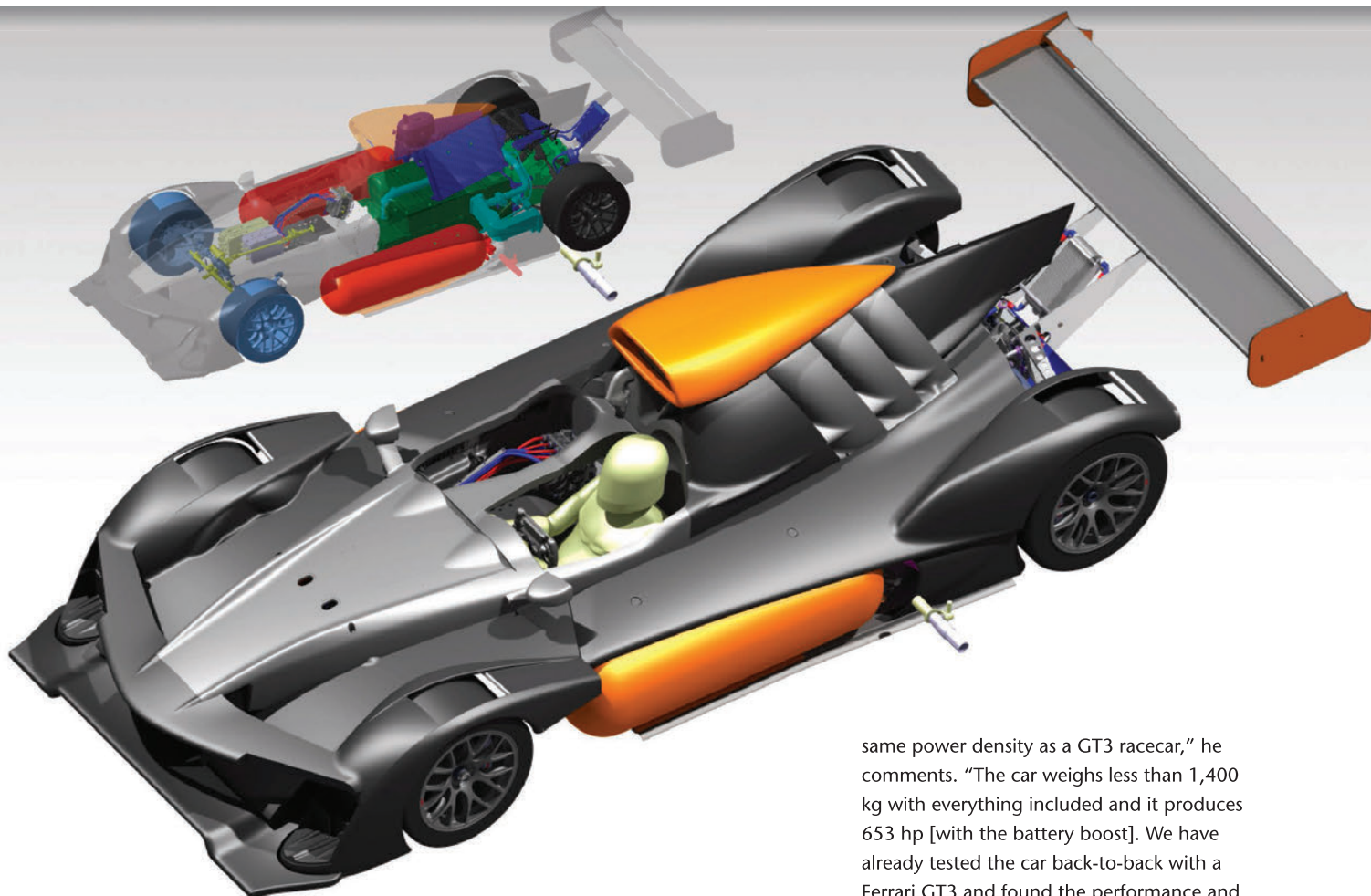
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"We know this is an area we could improve upon," he acknowledges, "but at the moment we need something that's convenient for the development work. For instance, we have five separate inverters, currently, because we can get to each of them individually if we need to change them. If we combined those into one unit we could condense the cooling system and the wiring into one as well."

Knowledge gained from the first two cars has also allowed the team to refine the fuel cell's ancillary systems. The cooling requirements, for example, were quite hard to predict for the earlier iterations, so the engineers deliberately erred on the side of caution. Since then, data from the test sessions, combined with lower heat rejection from the increasingly efficient fuel cell designs, has allowed them to significantly reduce the size of the cooling system.

"The total cooling requirement is around the same as a combustion engine car," Weber explains. "The efficiency of the fuel cell is approximately 50 per cent, so it's better than a conventional powertrain. But with a combustion engine a lot of the waste energy goes out through the exhaust, whereas here we have to dissipate it with the cooling system."

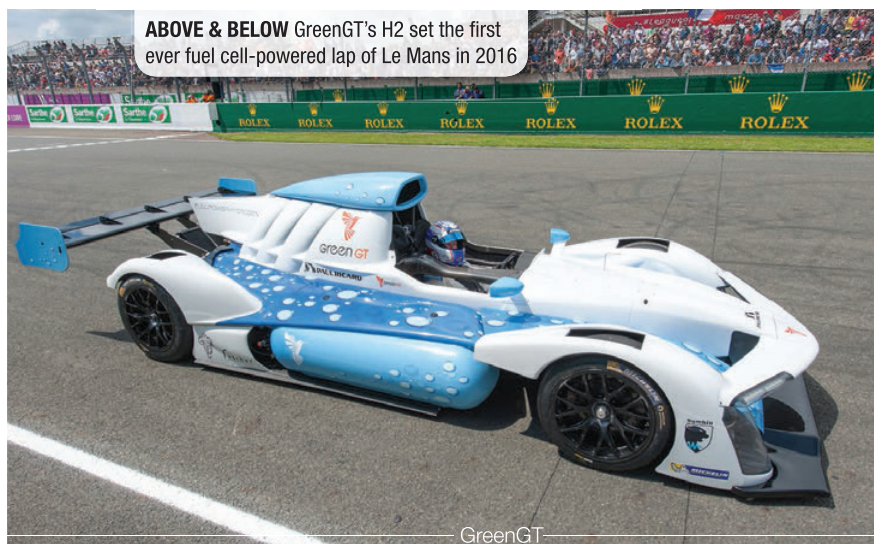
DEMO RUNS

Although the recent demonstration run at Spa was the LMPH2G's first public outing, the team has also been carrying out private testing at, amongst others, the Lurcy-Lévis circuit, not far from Magny-Cours. This 4.2 km track includes a 1.7 km straight, which means a substantial proportion of the lap is spent flat out, yet Weber says the car is capable of running for upwards of 45 minutes between refuelling stops.

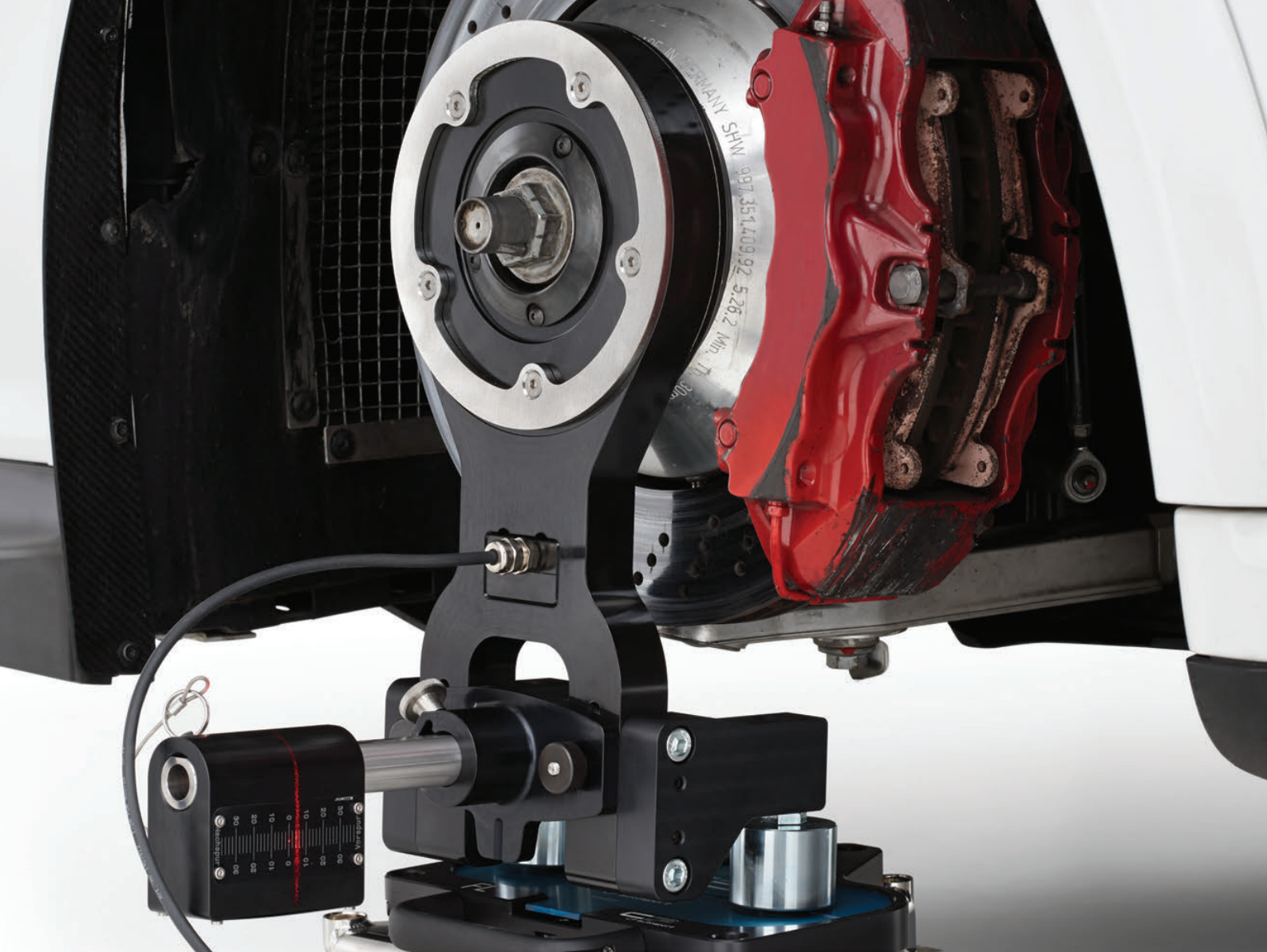
"For the moment we have roughly the

same power density as a GT3 racecar," he comments. "The car weighs less than 1,400 kg with everything included and it produces 653 hp [with the battery boost]. We have already tested the car back-to-back with a Ferrari GT3 and found the performance and the range to be very similar. The LMPH2G was just over a second away from the Ferrari on lap time, but so far we have concentrated our effort on the powertrain; we haven't looked a great deal at the aerodynamics or the chassis itself. We're also using standard GT tyres at the moment."

When the fuel does run out, of course, you simply return to the pits and get some more. The company uses the same refuelling equipment as a standard road-going fuel cell vehicle. With this technology, Weber explains, it takes 2 minutes 40 seconds to fill the tank, but with a refrigeration system ►



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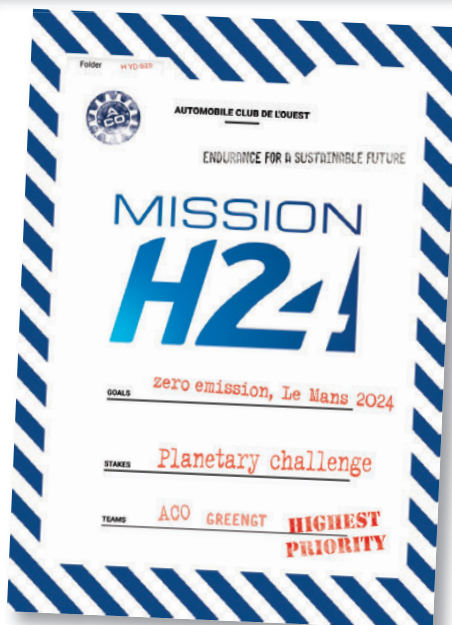


for the hydrogen tanks he believes under a minute would be plausible. That would put it close to the time taken for a refuelling stop with tyres and a driver change in a current LMP car, and certainly well ahead of anything that involves charging a battery.

Inevitably, safety is one of the main questions when it comes to hydrogen, but Weber and his colleagues are very keen to dispel any myths about the process. The recent run at Spa included a demonstration pit stop, carried out by an operator in normal clothes rather than the usual fireproof overalls. As with a road car system, this included an automatic pressure check carried out by the refuelling rig to ensure that everything was safely sealed before it began filling the tank.

"We've actually taken our cars on a truck and refuelled at a normal public filling station before," comments Weber. "At the circuit you don't need a lot of storage. If you're running a small number of cars, it's practical to do it with bottled storage on trucks. We have a mobile container with a compressor and buffer storage for the pressurised hydrogen."

Alongside component testing and data collection, the other purpose of the car is to give people a first-hand demonstration of the fuel cell's capabilities. One of the main reasons for picking an LMP3 chassis is that



ABOVE Mission H24 aims to introduce hydrogen-powered racing cars to the 24 Hours of Le Mans in 2024

the safety cell is designed as a true two-seater, able to accommodate passengers up to 1.9 metres (6ft3) tall for demonstration laps.

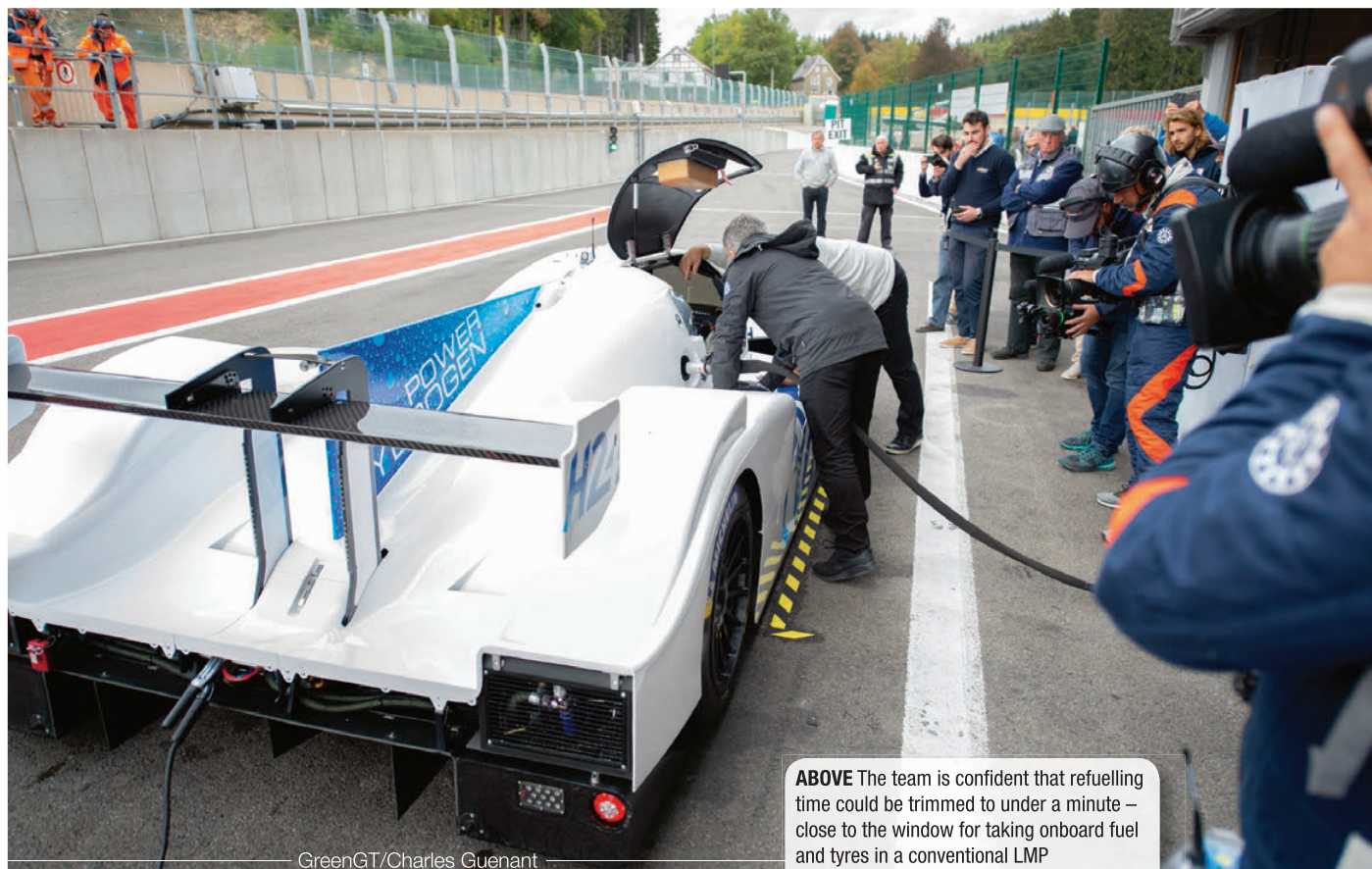
Weber was one of the first to take to the seat. "It's a real racecar with plenty of noises and emotion," he says. "At low speeds you can hear a lot of noise from the compressor and after that you really notice the wind noise. It is quieter overall than a combustion-engined racecar, so you start

to notice other noises that you wouldn't normally hear like the tyres."

Of course, the challenge now is to convince everyone else – including perhaps those car manufacturers that have been sat on the fence.

Weber says he isn't ruling out future partnerships, but as it stands, GreenGT is pitching itself as a powertrain supplier: "It's possible that we could partner with someone to develop a complete car, but right now our main focus is on the fuel cell. We certainly don't want to be alone. I think we've proved that the technology is viable and now we need others to come forward and make it a competition. We're right at the start of fuel cell technology – certainly for motorsport – so there is a lot of development potential remaining. That gives you a lot of motivation as an engineer."

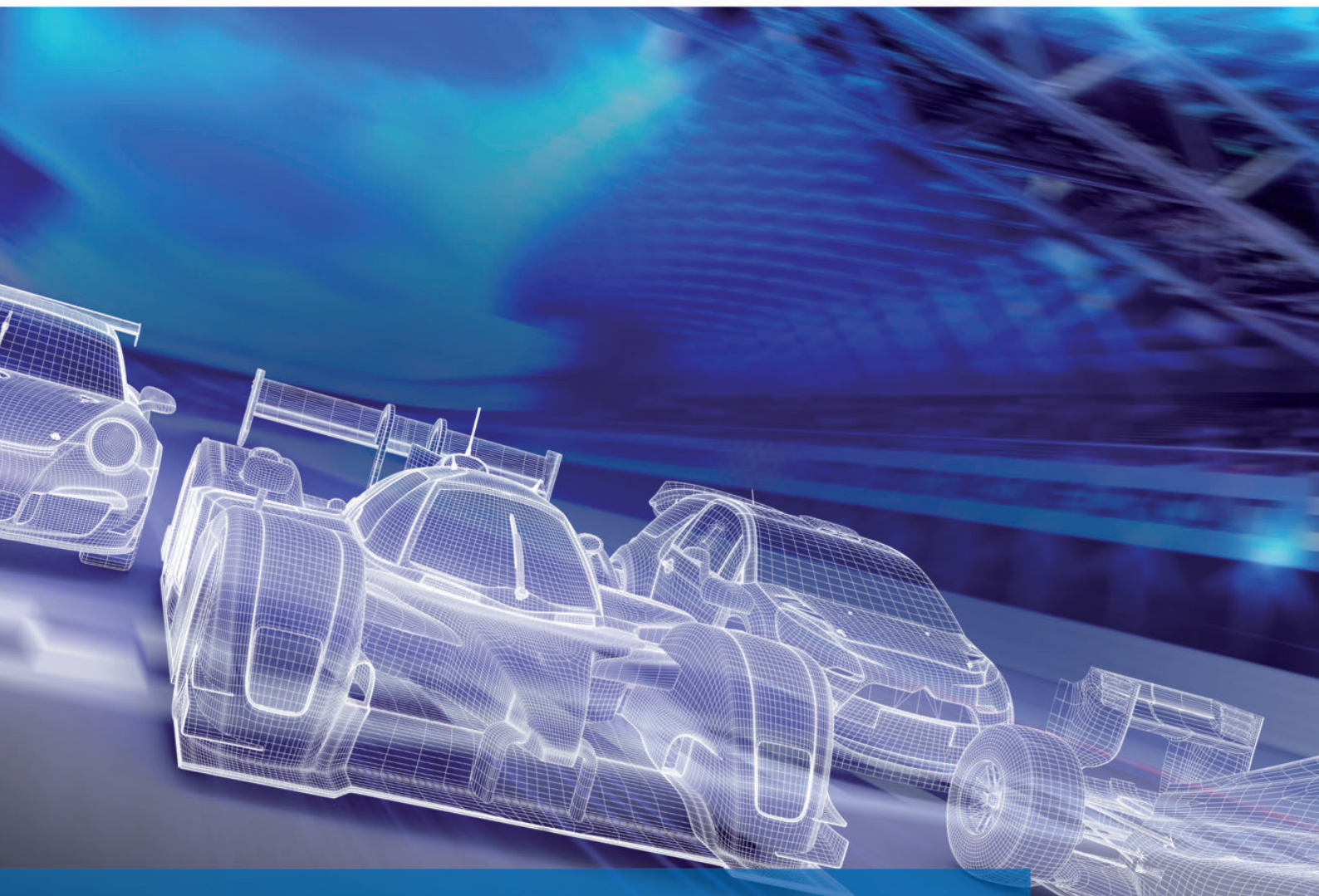
With the ACO throwing its weight behind hydrogen motorsport and the pressure on car manufacturers to reduce their carbon footprint growing every year, the incentives are certainly there. If a fuel cell car could indeed be made to complete the 24 Hours of Le Mans in 2024 it would not only be a landmark moment for hydrogen; it would be an achievement that no battery electric vehicle is ever likely to emulate. **RT**



ABOVE The team is confident that refuelling time could be trimmed to under a minute – close to the window for taking onboard fuel and tyres in a conventional LMP

GreenGT/Charles Guenart

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PINK PANTHERS ARE SET FREE

After a tempestuous first half of 2018, Force India came back from the dead. Sahara Force India is gone; Racing Point Force India has arrived. Will a brush with disaster be a spur to greater things? **Matt Youson** investigates



ABOVE The team's first major upgrade of the car didn't arrive until Singapore. Tellingly, it immediately qualified best-of-the-rest

FOR every Formula 1 team on the grid, today there are 15 who aren't. The sport shortly to celebrate its 70th birthday has a famously high rate of attrition.

Averaged-out, it loses two teams every year. Granted, half of the 159 names on the list didn't last anything like as long as a full season – but the principle remains sound: F1 is a sport where survival of the fittest is a phrase with genuine resonance.

Or... perhaps not. If the travails of the Force India team in 2018 prove anything, it's that fitness for purpose is not necessarily the arbiter of who survives.

In an increasingly bi-divisional championship, Force India were the B-team champions in both 2016 and 2017, finishing fourth in the Constructors' Championship and earning the patronising accolade 'best of the rest'. Famously parsimonious, it out-competed, rather than out-spent its midfield rivals and, bang-for-buck, was probably the best team in F1 – but there was always a suggestion of all not being well behind the scenes.

That bit hard at the start of 2018. The team could barely afford to remain operational, and only a buy-out during the summer saved it from becoming another statistic. The labyrinthine commercial and sporting rights of F1 ensured

“Bang-for-buck, probably the best team in F1”

the process was far from straightforward, resulting in a situation where Sahara Force India ceased to be and Racing Point Force India arose, phoenix-like, from their ashes. The new team forfeited the 49 points its predecessor had scored in the first half of the season – but the Pink Panthers lived to fight another day.

Otmar Szafnauer, formerly the team's chief operating officer, became CEO and team principal during the regime change. It was he who spoke before a curious paddock at Spa-Francorchamps at the Belgian Grand Prix in late August to explain the situation, shortly after the new(ish) team had been granted its eleventh-hour entry.

PHOENIX FROM THE ASHES

“We are a new entrant and we start from zero,” he said. “We’ll do the best we can to score as many points as we can in the remaining races and we’ll see where we end up at the end of the season, and that will determine some of the prize fund for the following year. As far as engine allocation goes, we had confirmation today that we will continue with the engine allocation and ▶





Photos: Racing Point Force India

gearbox allocation as if we never ceased racing. [Race director Charlie Whiting] thought that was the fairest thing to do vis-à-vis the other teams, so that's how we're going to go forward."

Alongside the discussion of the team's restoration, there came a gradual enlightenment on the constraints under which the squad had been operating in the first half of the season. It wasn't particularly revelatory to hear that Force India's less-than-usually competitive start to the year was a consequence of a crippling lack of funds – though it was new to hear it directly from the team itself. "This year, our first race car, that we should have had in Australia, came in Barcelona," said Szafnauer.

Technical director Andrew Green fleshes out the story. "We were a little bit on the back foot after winter testing," he concedes. "I think by the time we got to Barcelona we had the car we thought we were going to have at the beginning of the season. I think that's how far behind we were."

FIGHT TO STAY ALIVE

"From there until the break, we really were just trying to go racing. It was very much hand-to-mouth: what we could do, what we couldn't do. Updates were stacking up. We had a new front wing we wanted to run but for various reasons we could only manufacture one of them – which isn't

enough to go racing with. Eventually we got two, I think in Monaco, so we could run it – but we still didn't have any spares. It was quite risky. If we'd damaged the front wing in qualifying, we'd have been at the back of the grid. So, it was a big risk – but I think it paid off. Eventually we did get a couple of spare front wings, so we were a bit more comfortable but still, there were no upgrades coming through to the car. We really were fighting to stay alive. It was really tough. As tough as I've ever known."

The team that became Force India started life as Jordan Grand Prix, making its F1 debut in 1991. As one of the more venerable outfits on the grid, its short-term problems in a financial crisis centred on variable, rather



ABOVE & RIGHT The financially beleaguered team had the infrastructure and the staff but simply couldn't afford to manufacture the parts

A peculiar no-man's land: development at the factory continued at breakneck pace, but nothing was making it to the car

administration and there was a big injection of cash which basically freed up the design."

Having pushed the button, Force India was able to have its first major upgrade of the season available for mid-September and the Singapore Grand Prix. How much ground the team had lost in the interim is difficult to estimate. The design of the VJM11 had been steadily going through the usual iterative process – it just hadn't had the empirical validation that usually goes alongside the modelling work.

"The merry-go-round was spinning around for quite a while, developing parts, and the base performance of the model was getting better and better – though the full-

size car was stagnant," says Green. "When we did press the button and release the parts, it was quite a significant change. It's what we would have liked to have done incrementally, but couldn't."

Force India's target for the second half of the year is to claw its way back up to sixth position in the Constructors' Championship – a goal Szafnauer describes as: "attainable but not easy to do" – but the conclusion of the 2018 season feels more like a coda to the previous era for Force India, rather than the beginning of something new. It has its sights set firmly on a fresh start, concentrating its resources on 2019. The team is understandably coy about exactly ►



than fixed, costs: it had the infrastructure and the staff – it simply couldn't afford to manufacture the parts. As such, Force India was in a peculiar no-man's land: development at the factory continued at the usual breakneck F1 pace, but nothing was making it to the car.

"Manufacturing was always the issue," confirms Green. "Our core objective, even when we were in financial strife, was to continue developing within the factory, so we didn't stop learning. People were being paid; CFD and the wind tunnel were running, so the development progressed but for quite a few months nothing got to the car. It kicked off around the Hungarian Grand Prix [at the end of July]. We went into

how much of a budget it has to go racing with next year, but the understanding is that it's more than it's been accustomed to in the past. Famed for its parsimony, it is interesting to contemplate what Force India will do with more.

"Had we had the money this year, for example, our performance would have been much better, much earlier – and that we will not suffer from next year," says Szafnauer. "Over the winter, we will be able to realise all our developments; we'll be able to put them on the car because of the improved financial stability and that will for sure help performance.

"We are going through the budgeting process now, as we do every year, and we will increase that budget, especially in capital expenditure – [because] the team has lacked capital expenditure for quite some time – and then, other areas of operating expenditure that will bring performance: we'll have the ability to increase that too."

Force India takes a power unit, gearbox and hydraulics package from Mercedes HPPT, and thus Mercedes was one of its more significant creditors in the court-ordered winding up procedure over the ►



Etherington/LAT

ABOVE & BELOW The power unit, gearbox and hydraulics package are all sourced from Mercedes HPPT. That tie up could be set to get closer still



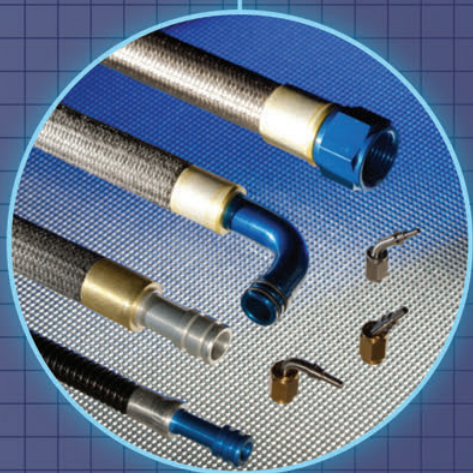
Craig Scarborough



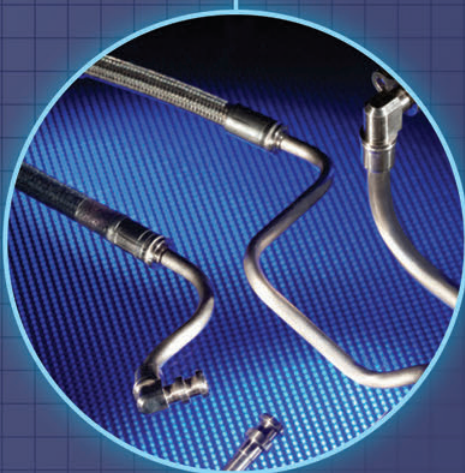
BELOW The technical development of the VJM11 was crippled by the team's descent into Administration

Craig Scarborough

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“The base performance of the model was getting better and better – though the full-size car was stagnant”

summer. Behind the scenes, it was an active participant in getting the team re-floated, and the rumour mill was working overtime to suggest the reigning World Champions had their eye on a strengthened relationship with the team based only eight miles from its own factory.

The issue of satellite teams is a delicate one

at the moment, with some disquiet over the notion of surrogates being used strategically as a tool for the big teams to circumvent the resource restriction agreements. Ferrari and Red Bull have their acolytes; Mercedes does not. Green doesn't discount the potential of closer collaboration in the future, but emphatically rules out any possibility of

Force India becoming a Haas-style catspaw.

“Mercedes were very good with us when we were going through the financial difficulties; we were leaning on them heavily to allow us to race really,” he says. “Regarding the future, nothing has been discussed yet. As far as we know, we're carrying on as we were. Our new shareholders are nothing to do with Mercedes but let's see whether they've got plans in the future to get a closer working relationship. I think a lot of that will depend on how the FIA move.

“That said, there's no way we're ever going

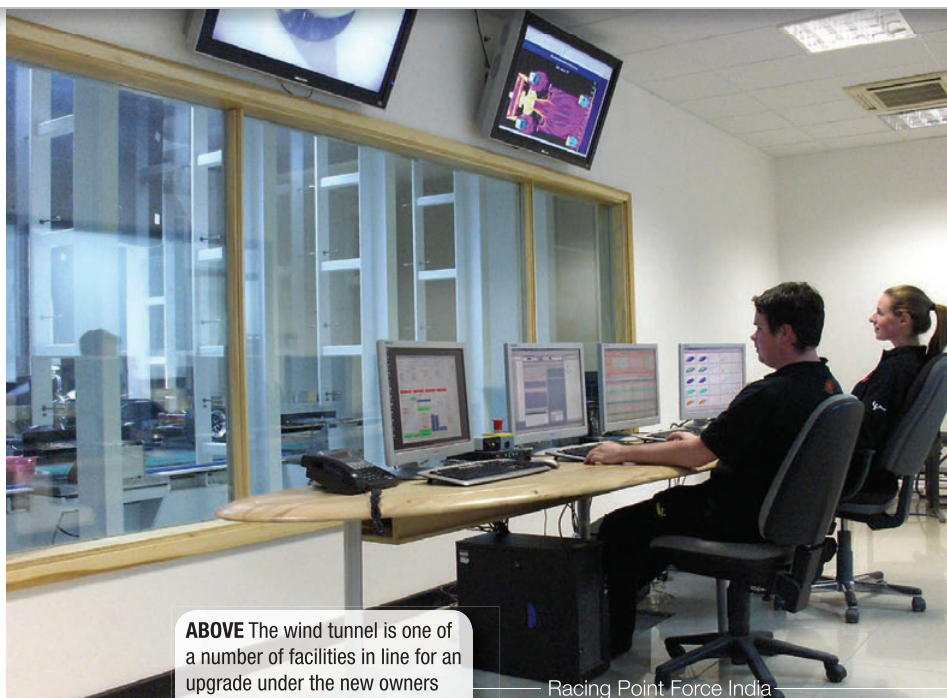


Racing Point Force India

ABOVE The final months of the campaign have been rendered a frantic chase for points to retrieve as much lost ground as possible in the Constructors' series

to become a Haas. The shareholders wanted to keep the team intact, keep the people we have here and carry on doing what we're doing. There was never a desire from them – ever – to become a customer team. There's a part of the Haas model that we're not comfortable with. We're all for teams saving money by purchasing non-listed parts from other teams. We do it. My issue is how the aerodynamic development is achieved across the two teams, and how that is... amalgamated. That's something that needs to be looked at."

The largesse of the team's consortium of new owners, and its potential to transform



ABOVE The wind tunnel is one of a number of facilities in line for an upgrade under the new owners

Racing Point Force India



ABOVE Team principal and CEO Otmar Szafnauer and tech director Andrew Green face the media after the team's escape from financial disaster

Racing Point Force India

to pole as the datum for where they are and where they need to be. "It was 1.9 seconds to Lewis Hamilton in Singapore – but there's not another Lewis so maybe we need to find between 1.0s and 1.5s. There's a big push and huge desire to close that gap. We've got the financial backing to do it; we've got shareholders that want us to do it and they're giving us everything that they can in their power to do that job. We are actively changing the structure of the team to achieve that. Hopefully we'll be able to close up a bit next season but we're looking, within the next two years, to have closed that gap right down. That's our target.

PIE IN THE SKY

"We're on a big recruitment drive, facilities at the factory are all getting upgraded: CFD; windtunnel... all the things that we've always wanted to do but have never had a chance of doing because it was pie in the sky, way too expensive. That's now becoming the new reality. It's not a money-no-object thing: it's a keep-doing-what-you're-doing thing, but do what you've always wanted to do. In the past we've been working with both hands tied behind our backs. Now those shackles have been released and we're going to see what we really can do. I think we've got every opportunity to close that gap down. It's not an overnight change – these things never are – but I'm very excited about what we're going to achieve in the next 12-24 months."

Survival of the fittest has its place but, going forwards, Force India wants to do a bit more than simply survive. **RT**

Force India, does not come without a hint of mild jeopardy. At the core of Force India is an operating principle on making a little go a long way. It's been effective as a lean, hungry underdog working on a shoestring budget, and doesn't want to relinquish that attitude in the absence of the shoestring. "We have to be careful that the ethos of the team doesn't degrade," agrees Szafnauer. "We still have to spend our money wisely, but for sure financial stability helps in this sport."

With the head of the midfield becoming ever-more competitive, Force India will struggle to claw its way back to P4 next year, though its ambitions are rather greater than that. The goal is to close the gap to the top three, before the regulation change in 2021.

In Singapore, with the upgraded car, Force India qualified best-of-the-rest with seventh and ninth on the grid. Green uses their gap



ABOVE Race to the Clouds: VW's I.D. R is nominated for its record-breaking feats with an all-electric powertrain

THE MORE THINGS CHANGE...

The nominations for Race Tech's technical awards, to be presented at this month's World Motorsport Symposium, reflect the changing nature of the industry

PLUS ça change, plus c'est la même chose" – the more things change, the more they stay the same. If ever there was a motorsport season that lived up to the old adage, coined by the editor of French newspaper *Le Figaro*, then 2018 was it.

The headlines were dominated by two awesome machines that exemplified the remarkable pace of change within the automotive industry – one a hybrid, the other all-electric. Yet both were tailored

to achieve an ambition that has preoccupied designers since the very birth of our sport: smashing records.

Porsche's 919 Hybrid Evo and Volkswagen's I.D. R both achieved their objective, pulverising the existing record times at the Nordschleife and Pikes Peak Hill Climb respectively. The technology they harnessed to do so merits their inclusion in our list of nominations – which also features contenders from disciplines as diverse as IndyCar and the World Rally Championship – for the Race Tech Dino Toso Racecar Aerodynamicist of the year and Race Powertrain of the year awards. Both prizes will be presented at next month's World Motorsport Symposium, to be held at the prestigious Institution of Mechanical Engineers in the heart of London.

RACE POWERTRAIN OF THE YEAR

Integral Powertrain, nominated for its I.D. R Pikes Peak all-electric powertrain

THE 12.42 winding miles that make up the journey to the finish line of the Pikes Peak International Hill Climb, which is perched some 4,720 ft higher up than the start line at a dizzying 14,110 ft, inherently favours an electric powertrain. For one, air at the finish line is some 40 per cent less dense than air at sea level, causing combustion-engined cars to struggle. On top of that there is also the ►

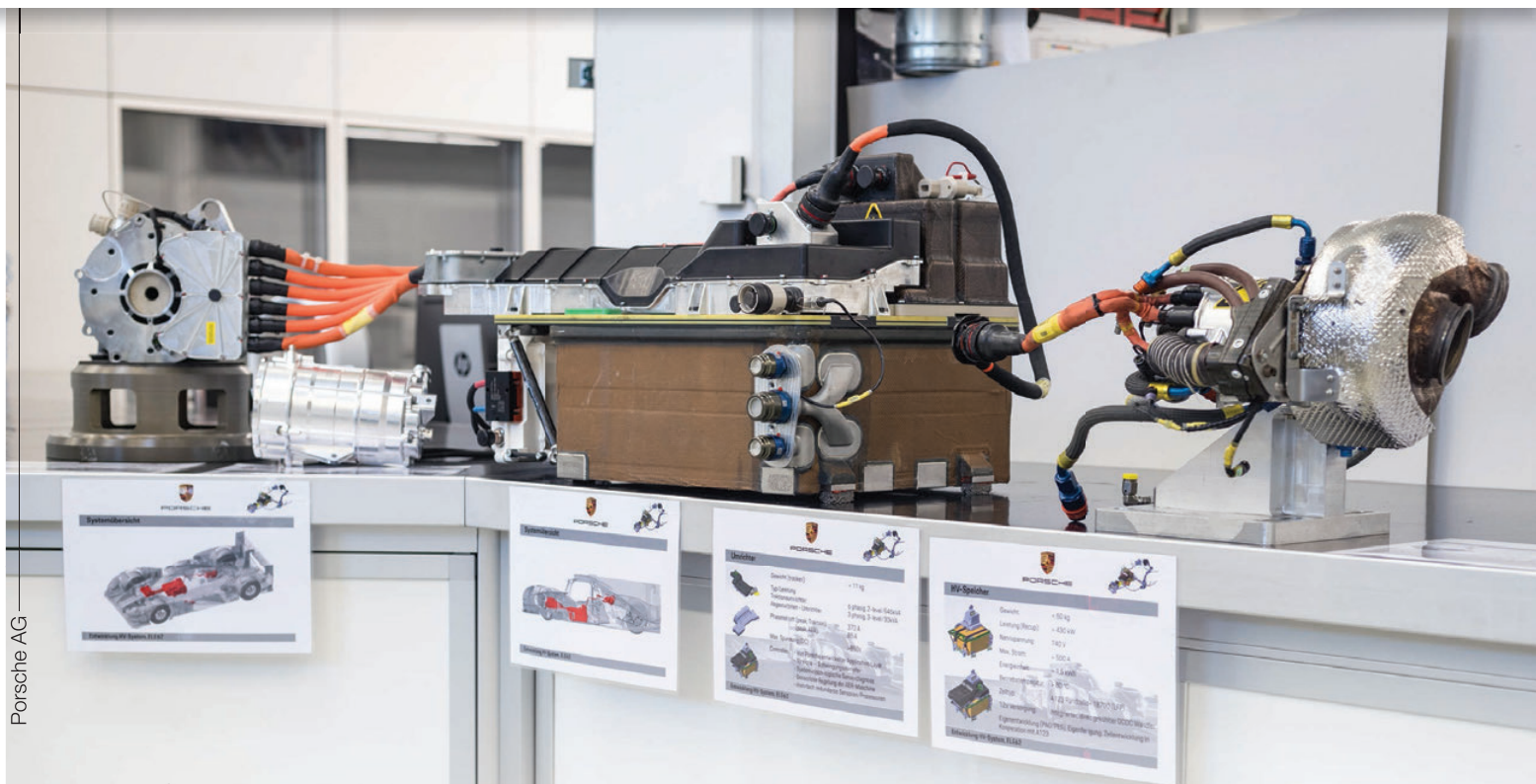


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ABOVE From its earliest iteration, Porsche's 919 hybrid system pushed engineers to find new solutions – and drove the company forward

ability to deliver maximum torque as soon as the pedal is pressed – an advantage on a hill climb when gravity is a constant enemy.

For these inherent advantages to be exploited however, engineers must first build a suitable motor, and so it was to this end that Volkswagen Motorsport turned to Integral Powertrain for its record-breaking I.D. R Pikes Peak.

To meet Volkswagen's needs, Integral provided a pair of surface permanent magnet motors, which, alongside the inverters, offered a very low weight package, but one which could still offer a high power output for the duration of the I.D. R's Race to the Clouds. The short timescales involved prevented Integral from starting a design from scratch, so the company instead set about scaling an existing motor while ensuring that VW's power and efficiency requirements would be met.

The end result was a motor/inverter package that weighed 25 kg at the front and 30 kg at the rear, but offered 280 Nm and 460 Nm of torque and peak power outputs of 270 kW and 280 kW respectively. Adding to their suitability was the motors' 'Constant Power Speed Region', which meant that they were able to run at peak power for more than two-thirds of the rev range without sacrificing torque density. The ingenuity of these motors

was key in the I.D. R, helping the 500 kW electric racer succeed where others, even those like the 1,100 kW Tajima Rimac E-runner, failed, and take the crown at Pikes Peak.

Porsche, nominated for its 919 Hybrid Evo

PORSCHE'S 2-litre V4 powerplant became the benchmark for rivals to aim at during the formative years of the World Endurance Championship's hybrid era. But yet more accolades have come its way in the Porsche 919 Hybrid's 'Evo' guise on the car's farewell Tribute Tour.

The Evo's powertrain is mechanically identical to the original racecar, which won six world championships and triumphed in the Le Mans 24 Hours three times. It runs a single motor generator unit (MGU) on the front end, combined with an exhaust energy recovery system (ERS) on the engine. But calibration changes, unshackled from the LMP1 regulations, have seen power rise to 720 bhp from the combustion engine and some 440 bhp from the front axle's motor generator unit, giving an eye-watering total of 1,160 bhp.

Freed from the WEC's fuel and energy restrictions, the powertrain has been allied to a heavily revised aerodynamics package and a set of specially-developed Michelin tyres.

The end result is rather impressive. "Like riding a bullet," was the verdict of Neel Jani, who beat the previous year's F1 qualifying pole position time at Spa Francorchamps.

More impressive still, the 919 Hybrid Evo went on to demolish the Nürburgring-Nordschleife lap record. Timo Bernhard's 5m 19.55s lap beat Stefan Bellof's mark, which had stood for 35 years, by a remarkable 51.58 seconds.

The Tribute Tour marked the end of a long journey for the 919 project, which, Porsche recently revealed, had encountered significant problems in its infancy. In May 2013, when the engine was first run in the car, the moment the clutch was released, the shaft going into the gearbox sheared off due to a torsional vibration issue. A temporary fix was found in the form of a raised idle speed, but more problems were to come. Vibration was interfering with the resonant frequency of the car's suspension, causing the drivers breathing difficulties and dizziness.

It is a mark of the engineers' success in overcoming such obstacles that the 919 Hybrid went on to mark a turning point for the whole company, signalling the start of Porsche's electric era. Its forthcoming Formula E car will benefit extensively from experience gained with the design of the 919's motor and power electronics. Likewise, expertise from these projects is filtering down ►



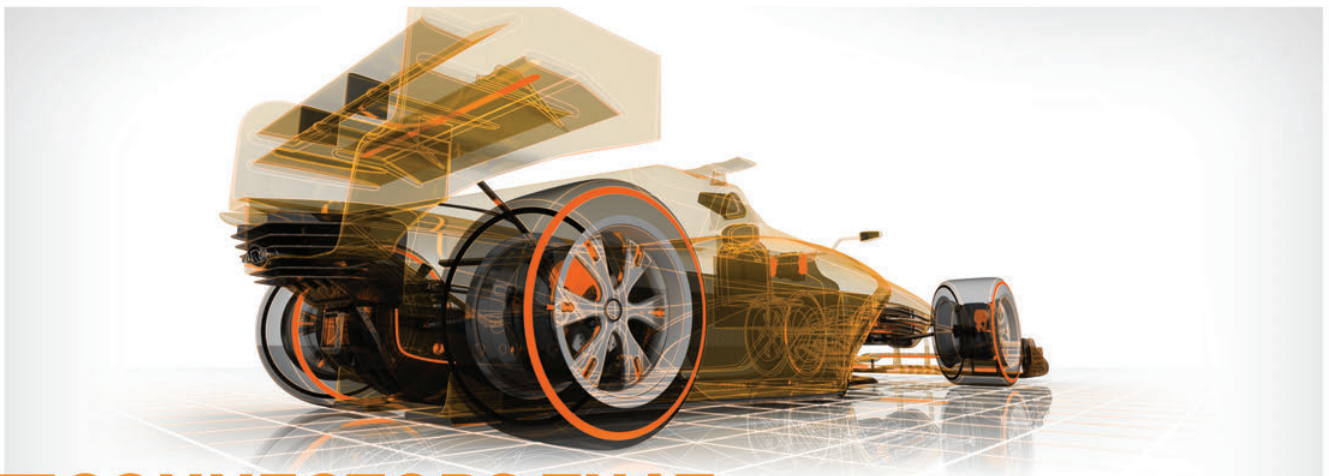
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ABOVE The Toyota Yaris WRC has emerged as arguably top dog in the WRC's latest arms race

into the company's road cars, including the all-electric Taycan, which shares the innovative 800 V technology at the heart of the 919 racecar. It is now predicted that over 50 percent of Porsche models delivered from 2025 will be electrified.

Toyota Gazoo Racing WRT, nominated for its Yaris WRC engine

WHEN Toyota's Yaris WRC contender was first being developed, it became the butt of service park jokes. Nobody's laughing now.

Instead, the performance of the turbocharged 1.6-litre, inline 4-cylinder, direct injection engine has become acknowledged as the strongest in the fierce contest for World Rally Championship bragging rights. In the process, the TMG-developed engine has eclipsed heavyweight opposition from Citroën, Ford and Hyundai.

It has been a staggering transformation.

Norio Aoki, project manager of the Yaris WRC engine, worked originally on Toyota's F1 project, so was no stranger to the demands of motorsport. Nevertheless, his first meeting with the rally squad's team principal, Tommi Mäkinen, still made an impression.

"Tommi-san told me in the first meeting, in October '15, 'Norio-san, this engine's too big'," he recounts. "And as usual, like many engineers, we put 200 reasons why it should be like this. But he said, 'It's too big. To make a better car, you have to make a smaller one.' So until we saw the car really racing with others in a competitive level in 2017, in Monte Carlo, I was not quite sure. But on Sunday night, in his team dinner, Tommi said, 'TMG, I'm sorry how I pushed you, but you guys made it.' That was a big relief for us."

But not such good news for rivals, for the package won on only its second outing, in Sweden. Since then, in two seasons of

competition, the unit has gone through multiple iterations, some of them quite significant. The one constant, though, has been bullet-proof reliability.

In its first campaign, 2017, there were problems getting sufficient cooling to the engine, so some overheating was encountered. Nevertheless, not one engine failure has blighted its record in two seasons. More impressive still, its outright performance has startled the opposition.

Already impressed by its speed from 75 km/h to 150 km/h, which one rival claimed earlier this year was "embarrassing", they were further dismayed by the use of a mid-season homologation joker to improve torque, without sacrificing top speed. The result was a string of victories that propelled Ott Tänak to within touching distance of the drivers' title, and gave Toyota a clear lead in the chase for the manufacturers' crown. ►

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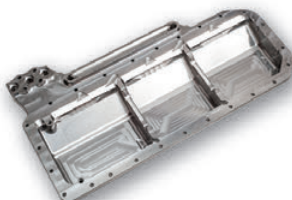
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DINO TOSO RACECAR AERODYNAMICIST OF THE YEAR

IndyCar, nominated for the Universal Aero Kit

OVERTAKING, or rather the lack of it, has long been an issue in Formula 1 with the current Drag Reduction System (DRS) providing some sort of solution, although it's not a particularly popular one as it's a bit clumsy and not very neat. However, it has opened up overtaking opportunities and is being further refined for the 2019/2020 season but could well be replaced in 2021.

Faced with the same problems, IndyCar has gone a different route in its quest to deliver the best show possible, to make this era of IndyCar racing the best it's ever been.

First shown at the Detroit Auto Show in January, the IndyCar Universal Aero Kit was developed by Tino Belli, IndyCar's director of aero development, the aero experts from Dallara and Chris Beatty of Beatty Design to improve close racing and to enhance safety in the cars, making them look leaner and more reminiscent of Indy cars of the past. The generally disliked shroud, that once enclosed the rear wheels – originally developed to prevent airborne "ramping"

accidents of the kind that killed driver Dan Wheldon in 2011 – also disappeared.

The primary sources of aero grip moved from outboard features at the front and rear, with smaller front and rear wings, toward a wider, more suction-generating central floor. Most of the downforce is generated underneath the car, which doesn't allow a wake of turbulent air behind it, enabling trailing cars to close more easily and attempt to pass. A reduction in add-on pieces also means less debris after a crash, and larger sidepods, which accommodate the new intakes, improve side protection.

Although not an aerodynamicist but rather a product designer, Beatty was brought into the project to give an independent objective view. As reported in Race Tech 213, he said: "It was really a case of taking a fairly standard-looking concept racing car and making it look quick. There was no real aggression in there and it just didn't hang together properly. At this stage, the engine cover and the rear pods had already been removed and lowered. My first input was getting the roll hoop leaning forwards and wings swept back. The sidepods were halfway there, but the front was just a straight cut-off. I also wanted to bring the leading edge as far forward as we could to increase driver protection. This in turn led IndyCar and Dallara to develop the new crash structures."

The aerodynamicists and engineers behind

the IndyCar Universal Aero Kit were duly acknowledged in winning the prestigious Louis Schwitzer award just prior to this year's Indy 500, while the kit has generally found favour with the drivers and spectators alike.

VW, nominated for its I.D. R Pikes Peak challenger

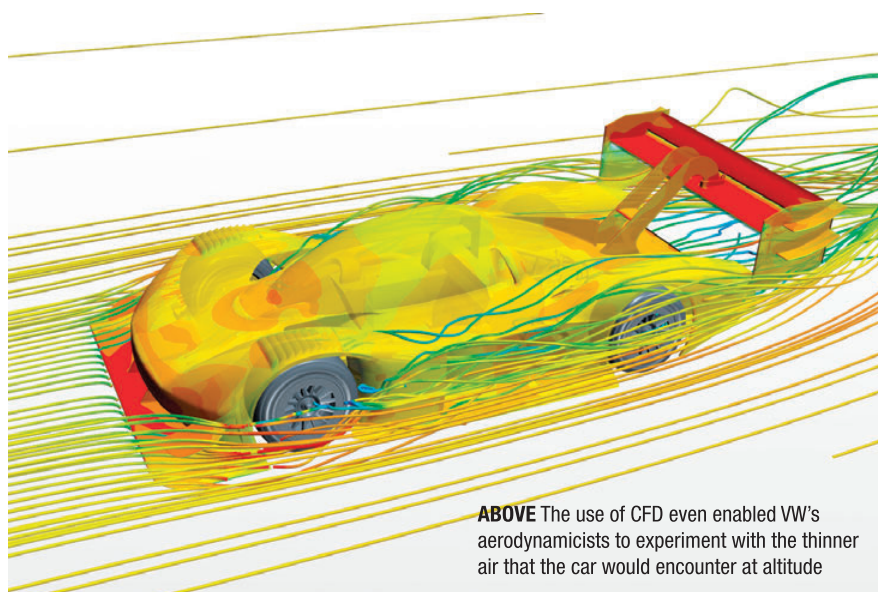
WITHOUT the burden of having to perform at many different rounds of a series, VW was able to myopically focus on a single goal: conquering Pikes Peak. The high altitude and the resultantly thinner air might not have affected the car's electric powertrain, but it meant that the aerodynamics became even more crucial, with the I.D. R's body effectively having to do more with less.

Fortunately though, the regulations for the Race to the Clouds are very open which gave Volkswagen the chance to get creative, although the eight-month window for design and manufacture meant the team had to do so efficiently. To this end, VW used 3D printing. Not only did it dramatically shorten the time between design and testing, it also afforded the designers more freedom with aerodynamic parts, given the speed at which they could try alternatives if the desired effect wasn't achieved. For some parts with very specific aerodynamic functions however, such as the diveplanes at the front, this meant that Volkswagen was able to progressively refine as many as six ►



ABOVE The success of IndyCar's Universal Aero Kit on road circuits has even prompted dialogue with F1, which is confronted by the same destructive wake problems

IndyCar



ABOVE The use of CFD even enabled VW's aerodynamicists to experiment with the thinner air that the car would encounter at altitude

iterations of a part, before committing it to the car heading up the hill.

Before any of those many iterations were tested on a 1:2 scale model in the windtunnel however, hundreds of different aerodynamic configurations were tested using computational fluid dynamics to assess how even small modifications to the body or wings affected drag, cooling, and downforce. Not only did this help Volkswagen's engineers to efficiently decide on a design direction, it also handily allowed them to simulate the thinner air on the hill climb, something that could not be done in the windtunnel.

As is now history, this perfected aero package helped the 670 bhp I.D. R to smash the overall Pikes Peak record, set by Sébastien Loeb in the Peugeot 208 T16 Pikes Peak, despite weighing 200 kg more and serving up some 200 hp less.

Porsche, nominated for its 919 Hybrid Evo

ANOTHER car free from the restrictions of a series, the 919 Hybrid Evo was born out of Porsche's desire to show what its Le Mans champion could really do when unshackled from the strict regulations of the World Endurance Championship. To really hammer this point home, the LMP1 team achieved two dramatic milestones. It beat the then-F1 pole lap time around Spa-Francorchamps, and it obliterated the lap record for the Nordschleife.

The hybrid powertrain the car used was unchanged, albeit freed from the fuel-flow and energy usage restrictions imposed on it in the WEC. Aerodynamic improvements were therefore necessary to make up the 11-second

difference between the 1:53.756 lap achieved by the Porsche 919 Hybrid during qualifying at Spa in 2017 and the 1:42.553 lap achieved by Lewis Hamilton in his Mercedes F1 car that they were gunning for.

The big visual changes were the huge new rear wing and the new front diffuser, both of which are equipped with active drag reduction systems to ensure the car

has maximum downforce when necessary without compromising the Evo's top speed. Underneath the car this aero refinement continues with turning vanes optimised to be used with fixed height side skirts to further improve the racer's downforce, but to do so as efficiently as possible. In total, when compared to 2017 Spa qualifying, these aero modifications resulted in an increase in downforce of 53 per cent, while efficiency was improved by an enormous 66 per cent.

What's more, these gains were thoughtfully made. It would have been all too easy to ruin the drivability of the 919 Hybrid by simply increasing downforce, but cleverly these changes were made as part of a holistic package. Stronger wishbones and an altered power steering setup were used to ensure the suspension could cope with the higher loads, while Michelin was brought in to develop a new compound that could live with the improved aero package.

The changes Porsche made in creating the Evo have helped to ensure that the 919 Hybrid will not only be remembered as an icon of the current rules era, but as a testament to what engineers can achieve when they are unshackled from restriction. **RT**



ABOVE Porsche's aero work was instrumental in its 919 Hybrid Evo obliterating a Nordschleife lap record many thought would never be equalled

HOLINGER ENGINEERING

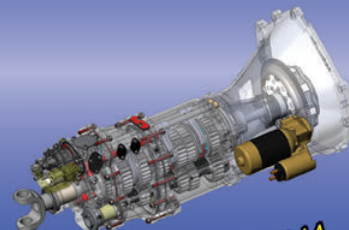
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CHANGING THE GAME

William Kimberley examines some of the nominations for the Don Burgoon award for the Most Innovative New Motorsport Product of the Year

MOTORSPORT suppliers never stop innovating, driven by their own and their customers' desire to do better, whether in terms of performance, weight or efficiency, usually all three. This year has been a bumper one for new products coming onto the market, with the few here that have caught our eye.

Shiftec

Nominated for its electro-hydraulic system

Shiftec has an innovative new electro-hydraulic system which combines the benefits of the energy storage and small actuator size of a hydraulic system with an independent electric powerpack. Eliminating some of the typical challenges with hydraulics, the system has been made robust enough to allow for automated bleed/fill on the pit lane. Using high-precision proportional valves from MOOG and Shiftec's small lightweight controllers, fast, powerful and accurate control of multiple hydraulic actuators is possible across multiple line pressures.

The system has been used to control the likes of braking, steering, ride height, gearshift, clutch and active aerodynamics. The system is completely sealed once bled and can therefore be packaged easily within a vehicle. The patented low-pressure accumulator and intermittent duty cycle of the system allows for a significantly lower hydraulic volume to be used, with no need for a conventional reservoir. Using a single power unit, it offers significant packaging, power density

and weight advantages when dealing with multiple actuation systems compared to direct drive electronic systems.

Evolution Measurement

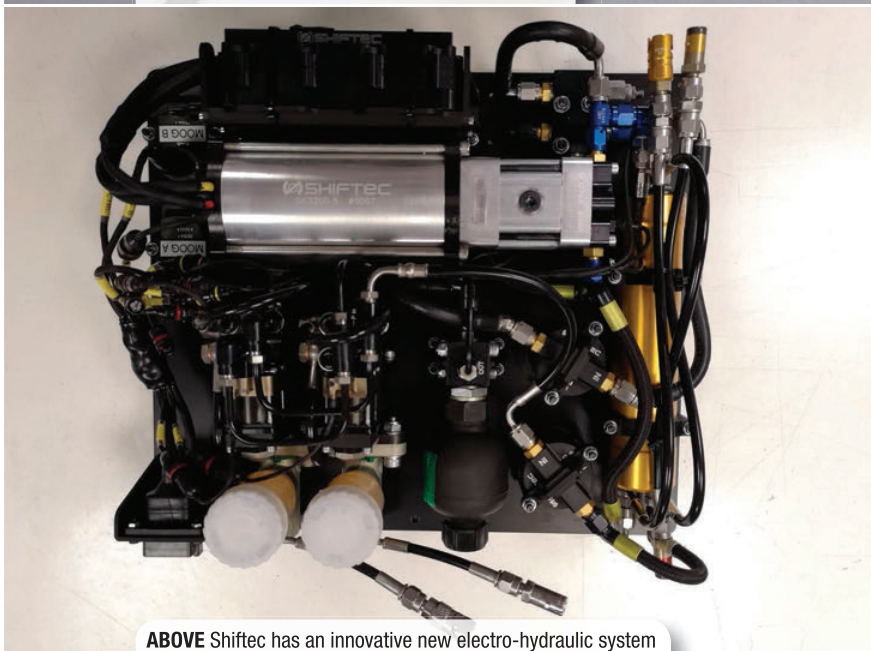
Nominated for its EvoScann P-Series pressure scanner

Evolution Measurement's new pressure scanner platform is a game-changer in achieving highly accurate, fast-response measurements in a compact package. The EvoScann P-Series is unique in enabling users to make critical measurements in previously inaccessible areas.

Pressure scanners are essential in aerodynamic testing of a wide range of ►



ABOVE The FIA has officially homologated the EvoScann P-Series pressure scanner for on-car use



ABOVE Shiftec has an innovative new electro-hydraulic system

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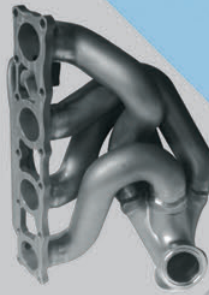
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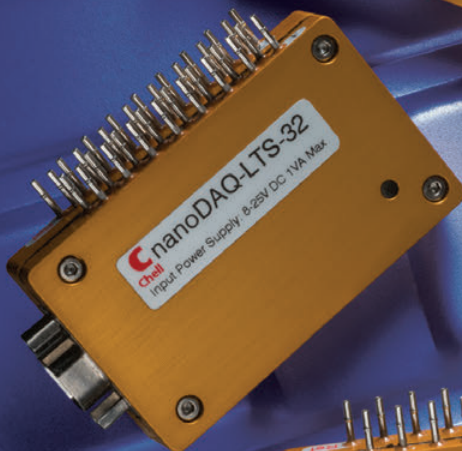
Embedded web server setup

Rugged IP67 construction



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items from wind turbine blades to aircraft wings and to Formula 1 cars. The challenge is in making the measurements as close as possible to the test article and gathering data as quickly and accurately as possible. Often the scanners are mounted inside the model, but this poses a major challenge where space is limited.

In consultation with many customers in the motorsport world, the need was identified for a scanner that could measure pressures accurately and quickly in very confined spaces, that are also often subjected to high temperatures and much vibration. Evolution Measurement responded to the challenge and through careful design and extensive testing, a rugged scanner has been developed that can operate in such arduous conditions.

Weighing-in at less than 15g and fully encapsulated in carbon fibre, with a single communications and power lead, the EvoScann P-Series is ideal for a wide range of applications, often being inserted directly inside an aerofoil section where it provides no disturbance to the airflow.

"F1 teams, and other aerodynamic research customers are excited about the new EvoScann product platform, as it allows them to measure in places that have previously been inaccessible or not cost-effective to measure in," says Paul Crowhurst, Evolution Measurement's managing director. "The product is so compact that it finds uses not only in the wind tunnel but is also rugged enough to be used on-car, one of the most challenging of environments."

Bosch Motorsport

Nominated for its electric coolant pump ECP 160

The Bosch Motorsport electric coolant pump ECP 160 flows 240 litres per minute open and an impressive 160 litres per minute at 1.5 bar. The device is very small, measuring just 110 x 105 mm and weighing less than 1,000g, which includes the electronic box, while producing a maximum pressure of 2.4 bar.

Its mechanism is a semi-axial design and, as such, creates a pressure rise over a much smaller area than a radial design. The patented aluminium alloy impeller design, as well as that of its housing and brushless motor, gives the pump a claimed overall efficiency of 60 per cent, twice as much as conventional road car pumps.

The ECP 160 is designed to replace

ABOVE Bosch Motorsport's electric coolant pump ECP 160

mechanical pumps in combustion engines, but it can also operate in other applications such as battery, electric motor or inverter cooling. The installation point is flexible because it is no longer limited by packaging restrictions like previous belt-driven coolant pumps. The pump is driven by a brushless electric motor that is integrated in the pump housing. It can therefore also be used in electric cars such as Formula E.

The pump capacity and performance can be regulated through needs-based use. The control unit of the ECP 160 can be configured so that under hard acceleration the power consumption of the coolant pump can be reduced, which leaves additional crankshaft power for the drive wheels. Under braking conditions when there is

excess crankshaft power, the coolant pump can be configured to increase output. The independence from engine rotation allows cooling even after switching off the car.

Bcomp

Nominated for its natural fibres

In February this year, Bcomp, a Swiss innovation company in renewable fibre composites, signed a two-year contract with the European Space Agency to participate in the ESA Clean Space programme in which two of its natural fibre materials, AmpliTex technical fabrics and PowerRibs reinforcements, are being tested under conditions comparable to ►



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ABOVE & INSET Bcomp's AmpliTex fabric and PowerRibs reinforcements were harnessed for Vanina Ickx's Gillet Vertigo to become the first natural fibre-bodied car to race in the Pikes Peak International Hill Climb

those in Low Earth Orbit.

Tests will include resistance to extreme temperatures from -150°C to +150°C and the UV radiations found in the earth's orbit. Other tests, conducted in plasma tunnels, will determine if the materials will completely burn up in the atmosphere once the mission is over. With time, those ranges of natural materials might be used for building satellites both technically performing and more environmentally friendly.

The resulting parts can replace carbon fibres and are up to 20% stiffer at equal weight, up to 30 per cent more cost-efficient, and significantly safer without the sharp shattering of carbon fibres, with three times the vibration damping. They are also nicer and safer to work with and can simply be burnt for heat together with normal waste at the end of its life cycle.

These same materials are now being offered for motorsport applications. For the first time since carbon fibre entered the motorsport market 37 years ago, there is an alternative material for bodywork, and clearly a step to prepare motorsport for the future and to attract new generations. It has become a partner of the Tesla-based Electric GT Championship, as well as supplied its fabrics and PowerRibs reinforcements for making lightweight body parts on the Gillet Vertigo that Vanina Ickx drove in this year's Pikes Peak.

Öhlins

Nominated for its MotoGP carbon fibre front fork

Öhlins has produced hybrid carbon fibre and aluminium front forks that it supplies to MotoGP, firstly with Ducati, but now many teams are running them. It is the first time carbon fibre has been integrated in such a way into the front forks.

The basic problem is that the more a bike

is leant over, the more feel a rider needs to go fast, but the trigonometry of the situation means that less of the forks' suspension abilities are used as they only move up and down, failing to give enough feedback. One of the biggest advantages of carbon fibre is that the amount of flex can be controlled to a high level of precision by using different weaves and construction techniques to tune enough flex into the fork tubes. Because the bike also loses a lot of weight which is higher and more forward, so it becomes easier in ►



LEFT Öhlins found huge performance gains with its carbon fibre and aluminium front forks for MotoGP

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the change of direction.

It was a couple of years ago that Öhlins saw the opportunities that carbon fibre presented and partnered with Ducati to develop carbon fibre fork tubes. This was of particular importance to the bike manufacturer as it was suffering from flex problems and the carbon fibre forks looked to be a very good solution.

In addition to solving the flex problems, another great advantage is that they are lighter. "We have achieved a weight reduction of 400 grams, equal to around 10 per cent of the weight of the forks," says Mats Larsson, Öhlins MC Racing manager.

The carbon fibre tube used to cost around £3,000 per tube, with long delivery times hampering the supply to teams. With the new design, cost is lower, performance of the tube is better, it's easier to manufacture and more robust to handle the inevitable crashes that happen in racing. Whilst more costly than a conventional tube made out of aluminium, it is now reasonably affordable for racing use.

Öhlins doesn't rule out the possibility of CF tube technology one day being made available to other disciplines, but for the moment all of its effort is towards MotoGP.

rFpro

Nominated for its Digital Circuit Maintenance Contract

rFpro has submitted its 'Digital Circuit Maintenance Contract', a unique concept as it saves customers money without requiring them to first make a huge up-front investment.

The Digital Circuit Maintenance Contract allows customers in the major series such as Formula 1, NASCAR, the World Endurance Championship, IMSA, Formula E, Super GT, IndyCar and V8 Supercars to share the costs collectively of circuit updates through rFpro.

Every year most circuits change, be it new kerbs, re-profiled corners, resurfacing the tarmac, changing or moving barriers, new grandstands etc. And every year rFpro updates the circuit models and its customers get the changes for a fraction of the cost, benefiting from the large numbers of teams pooled together using rFpro.

Customers also benefit from continuously improved quality. Every year rFpro brings out new features that improve the rendering quality and visual appearance of the models. These updates are then rolled into every new

circuit upgrade.

While it provides a rather dull, prosaic, unexciting, financial benefit, it's made almost all its customers very happy, their budgets now going further and their investment in driving simulation now won't go out of date due to the updates for a fraction of the real cost.

Greaves 3D Engineering

Nominated for its WiFi-enabled fuelling system

Greaves 3D Engineering has developed a WiFi enabled fuelling system, which connects to networks within the garage to provide quick and efficient transfer of data from the fuelling stops to the engineer.

The fuel rig also supplies the refueller himself with all the information he needs on an LCD screen on the timing device, which can also record all sorts of useful data such as the time of the pit stop, the temperature of the fuel and the weight of the fuel that is put into the car. The accuracy of these readings then enables a very precise fuel fill.

This accuracy also means the system is perfect for a 'splash-and-dash'-type pitstop. ►



CLOCKWISE FROM TOP LEFT rFpro updates: Updated kerbs at Yas Marina; Zurich Formula E chicane straight across the tram lines; repaving at Monza with new astroturf and drains; new anti-cut kerb at COTA; new temporary kerbs at Monza's Parabolica; updated kerb at Road Atlanta; more Zurich FE; moved DRS board at Silverstone; updated baguette kerbs at Spielberg; Baku's reprofiled chicane; and, in centre, a final hurrah for Baku, now lost from the calendar



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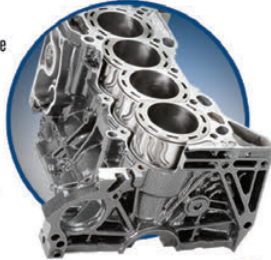
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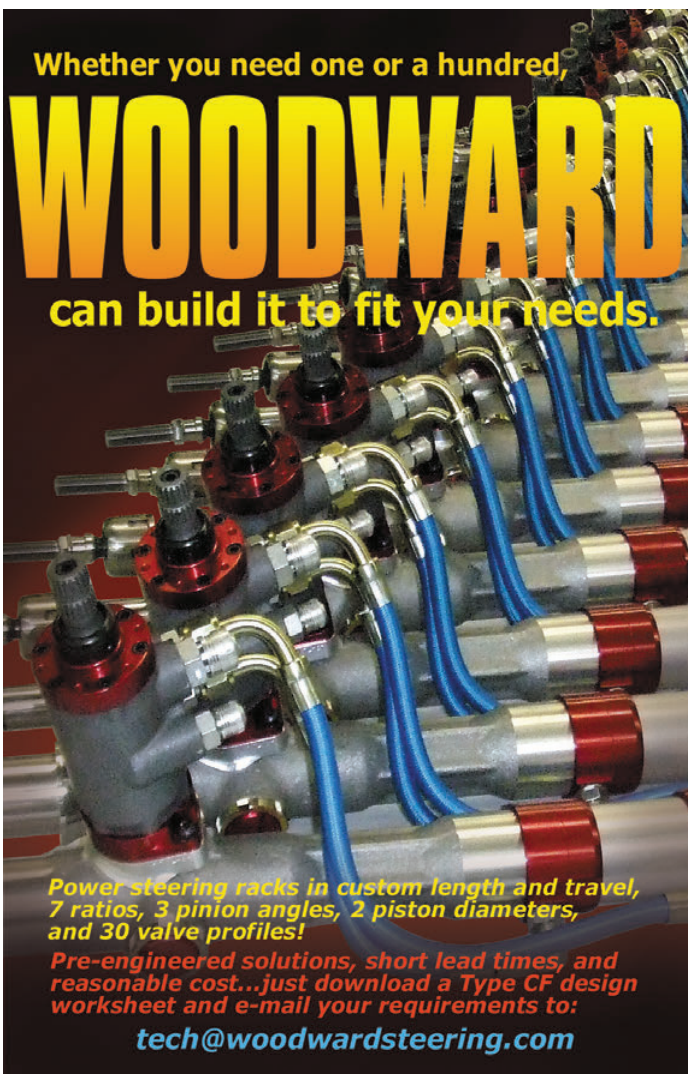
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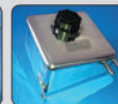


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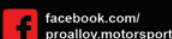
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Once the fuel couplings are connected, the rig's countdown timer starts and alerts the refueller when it is time to disconnect. As soon as this happens and the fuel hose is returned, the rig recognises the hose is docked, and then sends information straight through the network to the engineer.

"They get the information almost instantaneously after the pitstop," explains managing director Jacob Greaves. "So, the benefit of the system is that it records a log in an excel spreadsheet both on the timer itself and on an engineer's computer. That information is then given to the engineer quicker than any other system that's available on the market at the moment. There is no requirement for information to be transferred manually from the fuel rig to the engineer; it's all done electronically and accurately."

The system brings other features to the racetrack too, such as a dead man's switch, which enables a team to make sure the fuel dead man, the handle on the bottom of the tank which opens the fuel flow, has been opened fully during the fill, and has been held open at the right angle and for the right amount of time. From that it calculates the fuel flow rate, and so is good to check that there aren't any problems with any part of the system. If something is amiss and there is an issue, it can be identified quicker than using other fuel systems, which means problems can also be solved more quickly.

The fuel rig also integrates with Greaves' fuel bowser, which the teams use in the garage to pump fuel in and out of the car. The bowser uses the same technology as the rig, so is also able to quickly provide information to the engineers in the garage. Additionally the bowser has a direct link to the timer, so teams are able to look in the fuel rig through the bowser screen.

"So, maybe after a session, when you've been using the fuel rig and someone hasn't refilled it, you can be using the bowser and see immediately that you need to go and top up the rig. They communicate to each other to make sure that the fuel systems are correctly filled and all correctly assembled for each session," says Greaves.

"It's a complete foolproof system. It gives a very accurate controlled way of measuring the fuel in and out of the car, and then from that you obviously get more accurate data on all fronts, from the garage side of things, and from the pit lane. You've got the best data for the race and you can manage the process while the actual race is happening."

The advantages of the system were quickly being seen in competition, with several teams in multiple series running the system. In the ELMS Nielsen Racing uses Greaves' system, as does Racing Engineering, which utilised the technology to take its first victory at Paul Ricard this year. **IT**



ABOVE & BELOW The bowser uses the same technology as the fuel rig; the rig's display makes the refueller's job easier





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SAFETY products are a necessary evil in the sense that they are no more than ballast until they are called into action, which hopefully is never. However, they are under constant development to meet the demands of the FIA or the SFI in the US, while at the same time companies are striving to produce ever more efficient and lighter products at a cheaper price.

One such company at the forefront of motorsport fire suppression systems is **Lifeline Fire & Safety Systems**, which dominates the market in the UK and Europe. Never resting on its laurels, though, it has developed a brand new 8865 fire suppression system that will be launched at the PMW Show. 8865 is the FIA standard for plumbed-in and hand-held fire extinguisher systems.



ABOVE & BELOW Lifeline Fire & Safety Systems will launch its brand new 8865 fire suppression system, the 0275, and a new range of seatbelts

WHY WEIGHT FOR BETTER SAFETY?

William Kimberley finds that weight considerations are guiding safety innovations, as they are all other areas of racecar design, as he looks ahead to some of the latest products launched for the show season

Called the 0275, it will weigh about 2.6 kg with a filled cylinder which is half the weight of anything in the marketplace. It incorporates 300g of Monnex, the world's most trusted high-performance dry chemical powder for high risk firefighting applications that was originally developed by ICI in the UK, on one side of the bottle. In the other side is 0.7 litres of Coldfire, an American product that's effectively a fuel neutraliser.

"Traditionally we've used AFFF (Active Film Forming Foam) but that's now coming under serious environmental issues because of damage it does to the watercourse,"

says Jim Morris, Lifeline's managing director. The concerns centre around the potential negative impact on the environment from the discharge of foam solutions, the combination of water and foam concentrate. The primary issues are the toxicity, biodegradability, persistence, treatability in wastewater treatment plants and nutrient loading of soils.

"Some countries such as Australia and the Netherlands are already starting to ban it, which means that things like our 025 systems are on a short lead at the moment," says Morris.

The modern FIA test replicates three fires

in a World Rallycar cockpit. Each fire is a tray with two and a half litres of fuel with a plastic medium over the top, which then has a towel draped over it so that it masks the fire as well, so it's quite intense and hot. There's a pre-burn time of one minute and the fires are extinguished within seconds with 300g of suppressant.

Another novel feature is that the nozzle, currently nicknamed the "petal", is located on the transmission tunnel between the seats, going away from the traditionally high mounting in the car. "It was feedback from Volkswagen when doing the R5 programme," explains Morris of the reasoning behind the mounting. "They told us that they'd prefer the nozzle as low as possible."

It's a dual outlet nozzle with one directed toward the front of the car while the other sprays into the back. The suppressant streams out in the arc dictated by the nozzle shape, almost making a blanket but keeping the driver clear. If it's fitted to a GT or Touring Car it can be located where the passenger seat would be and still work as efficiently.

"We are using bladders inside the system, but we've come up with a new way of pressurising to make the bladder even more efficient," says Morris. "One of the things that have always precluded people from ▶



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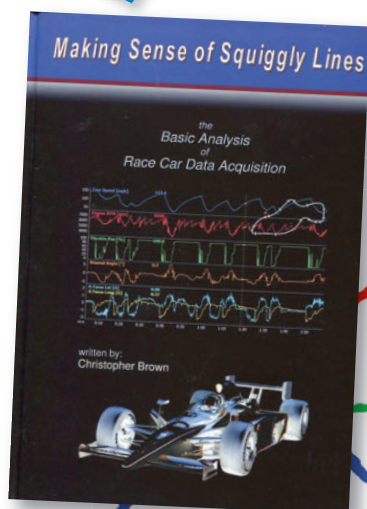
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"It will be the lightest and the cheapest 8865 system on the market as we're looking for a price point under €1,000."

Another core product for Lifeline is the quick-release steering wheel, but it has been losing market share to rivals and Morris felt it was time to upgrade Lifeline's offerings. The result is a new quick-release mechanism that is far more efficient.

"We've always had a strong market for these products but it's changing because with the prevalence of the long-distance GT cars, driver changes become more and more critical, as does time," says Morris. "One of the issues we had with our traditional spline quick-release is realignment. If the driver comes into the pits and the wheels are not dead ahead, then the driver who gets in can lose precious seconds fitting his wheel to the column, so we have come up with our own design of three spigots replacing the spline that allows the realignment to take place up to 100 degrees, which means that it's really fast. No matter the wheel alignment, the driver will just find it and it will then centralise itself. It's also very light."

A brand new product for Lifeline is its FIA harness line, something it has been working on for the last 18 months and which is being manufactured completely in-house. It has even created its own sewing facility on site with a CNC sewing machine.

"Our stats show that with our fire suppression systems we enjoy 85% of the UK market, around 60% of Europe; the US is a growing market and I think we're going to get to the stage where we can't do any more," says Morris. "Because the FIA has launched this new standard for safety harnesses, we thought it would be a good opportunity to have a go at it."

"We are launching three sets of belts at PMW, an entry-level steel adjuster belt in two and three-inch hands and non hands and a higher level belt that's totally adjustable, interchangeable ends, lightweight aluminium, lap straps, that sort of thing, while the buckle is of our own design but which conforms to FIA regulations. Overall weight is really critical and we're quite anal over it and follow the same mindset as we do with the extinguisher systems."

Sabelt will also be introducing its first seatbelt developed expressly for endurance competition. The new LMP seatbelt is based



ABOVE & BELOW Sabelt is introducing its first seatbelt developed for the demands of endurance racing

on Sabelt's SH.006.16-T-6 model already used worldwide by GT teams and also Hyundai and Citroën WRC teams. However, the new belt being previewed at PMW has been introduced in the market to satisfy the specific needs of endurance drivers.

The 8853-2016 FIA homologated seatbelt is a standard configuration, with a range of accessories, including handles for simple strap regulation, Velcro sections, a new fixing system with intercom and hydration, lap straps with pull down adjustable tongues, and a new buckle with quick link.

The new endurance buckle is based on the aluminium one as used by Audi and Porsche in LMP when they were competing in it, but developed in a different material to suit the

budget of the GT teams while still offering the same performance. Patented with a new structure, it is fitted with a quick-link system to help tongue insertion and new ejectors that optimise the driver change time.

Another safety-related item that will be on display at the show is **SST Technology's** Titanium Driver Protection System (DPS-ProTi) – the only system of its type manufactured in the UK. It has been designed to achieve conformity to FIA Standard 8869-2018, and can be supplied with the Additional Frontal Protection Halo (AFP-Halo) for Formula 1, Formula 2 and Formula E. Furthermore, it is manufactured to be at the lower limit of ►



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the weight tolerance stipulated by the FIA. Extremely tight material control, production parameters and dimensional tolerances ensure an accurate fit of the assembly onto the chassis, and allow it to meet the extremely high load requirements of the structure.

Motordrive will be launching its second series of FIA 8862-2009 seats, offering both four and six-point mounted ultra-lightweight models. Motordrive says it has become the first seat manufacturer in the world to develop both four and six-point mounted FIA 8862-2009 advanced motorsport competition seats. The company can also advise on fitting services and personal branding, world-wide distribution opportunities and how it can provide a competitive edge with new GT3 seating regulations.

CLEVER TEMPERATURE READINGS

Racelogic will be introducing its tyre temperature monitoring system that has been specifically designed to measure the highly transient surface temperature of a

tyre, providing invaluable information for chassis tuning and driver development. Each sensor can measure up to 16 temperature points on an object with surface temperatures ranging from -20°C to 300°C.

Tyre temperature is the most crucial part of the equation as racing rubber is designed to give the highest grip over a certain temperature range. Therefore, to get the best performance, they need to be kept within this operating window.

The traditional way to monitor this is to take a reading from each tyre as the car comes into the pits. However, temperature measured like this is an average of the entire session and while it gives a rough idea, it is not ideal and certainly does not show the whole picture.

The only other feedback available comes from the driver, who will impart information based on their seat-of-the-pants impression of the car's performance while at the wheel; only some drivers are good at this, but it is always subjective.

Recognising the problem, Racelogic has introduced a new feature to its VBOX Video HD2 system that gets past the difficulties of tyre setup and allows for

ABOVE SST Technology's Titanium Driver Protection System is as light as the FIA permits

precise measurement of temperatures while the car is moving.

VBOX infrared sensors, mounted in the proximity of each wheel, measure the temperature across the width of each tyre and the information is then recorded and overlaid in real-time on the video as a heat map. Consequently it is now possible for HD2 users to understand exactly what is happening to their rubber at all points of the circuit. As this information is available on the video, it is extremely easy to interpret and see precisely what is happening.

Until you have seen the data, it is difficult to appreciate how much information can be gained from watching what happens to the surface of the tyre as the various loads change during braking, cornering and acceleration.

Take brake bias as an example. This is traditionally adjusted by driver feel and takes a fair amount of experience and car sensitivity. With the fast reacting temperature maps overlaid on the video, it can instantly be seen which tyres heat up first during the braking phase, and the front to rear balance tweaked to even them out. As a driver, it is often difficult to work out if the tyres lock up, but by watching the heat maps on the video, it can be seen when it happens and on which tyre. This gives really useful data for setting up the suspension as well as the brakes. ►

LEFT Motordrive launches its second series of FIA 8862-2009 seats



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ABOVE & BELOW Now tyre temperatures can be examined through Racelogic's VBOX Video HD2 system



As an example, Team Racelogic was testing its Fun Cup race car at a chilly Oulton Park earlier this year, with a track temperature of only a few degrees Centigrade. They were still struggling for front end grip, despite the fact that hand-held measurements indicated that the front tyres were reaching optimal operating temperature.

Watching the video proved it was very much the opposite: when the car was out on the circuit, the surface of the tyre was being cooled by the cold track and at high speed by the air. As the car slowed down and came into the pits, the surface of the tyre quickly heated up due to the heat soak from the main body of the tyre and the hot brakes, so static readings didn't show the problem. After adjusting the pressures by a significant amount, the video showed the tyres retaining their temperature out on the track, resulting in less understeer and an instant lap time improvement of 0.3 seconds.

This kind of data is invaluable when the brakes, tyres and suspension of the race car are being set up, especially as all it takes is just watching a video to work out what is happening extremely quickly and

make simple adjustments to improve the performance of the car.

BOOSTING PERFORMANCE

French company **Rotronics** claims that Hubscanit is the most versatile dyno to boost all racing applications. Due to its long experience in asynchronous and eddy current chassis dyno design for more than

25 years, and understanding that some vehicles are tough to test under special conditions, it has added a direct hub coupling dyno to its product range. It now means that a range of vehicles such as rally cars, single-seaters, off-roaders, four-wheel and two-wheel drives can use this dyno that features direct hub connection and includes accurate wheel force and speed measurement.

Two strong eddy current brakes per axle allow a superfast and accurate change of the load and while not claiming 3,000 hp like some of its competitors, the emphasis is on accuracy and repetitiveness.

To allow high-speed testing, a field-proved process with auto-centring feature is available that makes possible one axle mounting in less than five minutes and, claims Rotronics, is as easy as changing a flat tyre. It has also designed generic flanges to maximise the number of vehicles that can be managed.

Driven by a smart electronic board, loads are finely adjusted on each wheel a hundred times per second. It not only allows testing the vehicle under road load simulation, but also under linear acceleration or sweep test. Furthermore, a strong software suite allows data from the vehicle to be accessed via OBD and CAN while it can also measure the mean time weather conditions and Lambda. On demand it can even force some speed offset (F/R or L/R) to check differential behaviour.

The concept is ready for electrical or hybrid vehicles and some motoring capabilities could be added as an option using a couple of AC motors. The dyno can also be moved from one location to another. It has also already been tested on some VIL (Vehicle In the Loop) concepts. ►



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ABOVE 920E is following its F1 breakthrough by developing a range of GT products

The Expo will see the European debut of a new model of GT monobloc callipers from **920E**, alongside a range of entry-level motorsport and high-performance callipers, actuation products and discs. Following on from its success in Formula 1, 920E is developing a range of GT products due for completion in early 2019. Closely following on from this rear calliper, but not quite in time for the show season, will be a 6-piston front GT3 monobloc calliper along with brand new front and rear discs and 920E brake pads. A range of master cylinders will also be available, all of which will provide a full brake system offering for the GT market with more to come in the future.

On the same stand, sister company **Shiftec** will be showcasing its range of pneumatic and hydraulic products, as well as control systems and brushless motor controllers that are used across the motorsport industry by various teams and race series, from autonomous racing to Formula 1 and GT. Taking centre stage will be Shiftec's Air Power Source (APS) unit, which was designed to minimise space by utilising an in-built air compressor and accumulator, thus removing the need for extra pressure vessels and hoses.

Shiftec has an innovative new Electro Hydraulic control system that combines the benefits of the energy storage and the small actuator size of a hydraulic system coupled to an independent electric powerpack. Using high-precision proportional valves and Shiftec's small lightweight controllers, fast, powerful and accurate control of hydraulic actuators is possible. The system can then be used to control systems such as braking, steering, ride height, gearshift, clutch and active aerodynamics. The system is completely sealed once bled and can therefore be packaged easily within a vehicle. The patented low-pressure accumulator and intermittent duty cycle of

the system allows for a lot lower hydraulic volume to be used with no need for a conventional reservoir, saving weight and improving packaging.

Bosch Motorsport will be showcasing a number of new motorsport products from ECUs to water pumps. Its Vehicle Control Unit (VCU) is a powerful processing unit for customisable functions. The customer software development process is based on MATLAB/Simulink to allow for fast algorithm development, helped by the automatic code and documentation generation. The VCU features an integrated logging device with high-speed logging capability of up to 100 kHz and it offers real-time Ethernet functionality to exchange data between devices with a guaranteed latency time of 1ms.

Also featured on Bosch's stand will be its e-GoKart powertrain, which is a ready-to-use solution that combines future-oriented technology with traditional karting technology. The system consists of a motor-generator normally used in a car's mild hybrid system, two 48V batteries, a control unit, an HMI, sensors, a wiring harness and several power electronic components.

Taking centre stage on the **Cosworth** stand will be the Antares ECU that is making its debut at the expo. This next-generation ECU is a step forward from its successful predecessor – the MQ12Di – thanks to an increase in processing power and a step change in logging and custom code creation capability. A key new feature is the cylinder pressure monitoring.

In addition to the new ECU, Cosworth will showcase its full range of updated electronics solutions. This includes the new CDU7.0, its latest full-colour, fully configurable 7" display unit, and the IPS32 Mk2, an IPS power management platform. The latter provides PWM capability on all outputs, improved reaction time for output shutdown, auto-zeroing of outputs on start-up and fully synchronous, high rate output current measurement.

ZF needs no introduction, but its latest TCR suspension system might. Already homologated for use in the TCR versions of the SEAT Leon, Audi RS3 and VW Golf, the ZF Race TCR Suspension is a lightweight bend-proof and sturdy strut design made from high-strength aluminium. It allows



ABOVE ZF is showing its latest damper for the TCR market

for two-way adjustment of shock rebound and bump, as well as ride height, without either one interfering with the other. Shock absorber adjustment is very precise, with 20 even clicks.

ZF has integrated an additional damping valve to obtain the best compromise of high damping pressure and low gas filling pressure, for the best possible response. They can also be further optimised for a specific application by ZF's dealer network. **RT**

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ABOVE It's the category's fifth season but the Gen2 car is, insists Rinland, still only the early days of the Formula E story



The designer who worked on the early iteration of Formula E – long before it even had a name – offers his verdict on the category's Gen2 revamp

A BIG STEP IN THE RIGHT DIRECTION

AS the comedian George Carlin used to say: "I like people!" I say, "I like Formula E!" Of course I do: I was involved with the concept before it even became Formula E, working with Lola and Lord Drayson on the first iteration of the FIA's all-electric category in 2011. So, I am an early adopter.

After only four years of it being around, it has shut up many 'non-believers'. When it started, I was still thinking like a typical race car designer: I wanted to design the whole car. When Alejandro Agag announced at the EEMS conference in Birmingham in 2014 that "this is not a formula for aerodynamicists" (meaning car designers), I was not happy. My discipline had been withdrawn. This prompted me into specializing in electric powertrains and simulation, eventually realising what Alejandro meant.

FE has developed from a control formula in year one and two to then opening up to develop motors and transmissions in years three and four. It has been slowly opening the door for development, which means engineers have a go. Always keeping a lid on the energy and power provider, the batteries, where big money can be spent if let loose. That concept is not dissimilar to what we have been advocating for

motorsport regulations: control power output. In opening motor and transmission development, the constructors have to concentrate on improving efficiency and weight – the two areas that contribute to improve range, EVs' biggest challenge.

Many people laugh at the thought of changing cars in the middle of the race because the mandatory batteries would not have enough energy for more than half the distance. After the first season, many of them were excited by the prospect of the strategy and the complication of it, to the point that

“If F1 panics and tries to copy what FE does, that will be the end of it”

now they are sorry the practice has gone. I always thought it sent the wrong message about EVs, but it survived!

That is the rate of battery development: in only four years it has nearly doubled the energy capacity for the same power and weight. Not Moore's Law, but not far from it. And we are only at the beginning. With solid state batteries being developed as we speak for the automotive industry, it is not too adventurous to think that in four or five years' time we could see more than one hour of

racing, close to Formula 1!

Should Formula 1 be concerned? If they do their homework right, they should not fear. Beyond the effect of a reduction in the share of the revenue from the automotive industry, Formula 1 and Formula E are two very different things and should remain as such. If F1 panics and tries to emulate or copy what FE does, that will be the end of them.

The new FE cars look much better. A bit too many wings and winglets for my taste, but it is a big step in the right direction. There is a lot of talk of AWD for the next generation after this, which was my original concept as far back as 2011. If and when that is introduced, I would like to see no more front wings (and dramatically reduced downforce) and let the improved traction capabilities take care of tyre performance. After all, that is where the automotive industry is going and for very good reasons.

By now Formula E has attracted seven major OEMs. Only a few have not jumped on the bandwagon – notably FCA, Honda, Toyota and Ford – but it is only a question of when, not if. FE offers a great marketing platform for all these manufacturers who are taking the bold step into full electrification. Also, it could be used as a good engineering training ground and possibly for development of some components and methods. Even though the needs of the racing environment are very different to those of road cars (as, indeed, is the case with ICE cars), it will surely contribute to the developments of first and second tier suppliers' components and selected technologies.

Other than its looks, 85% more energy from the batteries and 25% more power – not forgetting, of course, the new 'Hyperboost' strategy tool – FE V2.0 will

feature a technology which will change driving techniques completely: Brake by Wire. This allows the ERS/friction brake balance to be managed automatically. Is that a bad thing? I don't think so: drivers will be able to concentrate on other techniques and skills and the move will also help in the development of a technology that is necessary for road cars. Was the constantly changing brake balance to adapt the energy recovery facility a necessary skill? No more than changing gears with an H-pattern lever. **RT**

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