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PUBLISHING DIRECTOR
Soheila Kimberley

RACE TECH
Motorsport Engineering

841 High Road, Finchley
London N12 8PT
Tel: +44 (0) 208 446 2100
Fax: +44 (0) 208 446 2191

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Behind the scenes: all hands on deck!

2019 has been what I would call a year of consolidation. For the enthusiast, it's a variation of the same cars across every major series fighting it out for wins and championships – little different from 2018. Behind the scenes, though, it's all hands to the deck! 2020 will start to see a trickle of what's to come, but come 2021 and certainly 2022, that's when the tsunami hits and we will learn just what every manufacturer and team in every major championship has been working on.

When it comes to Formula 1, we can look forward to a radical new design philosophy. The renders you see in this magazine are the results of the governing body's unprecedented use of a team of aero experts, working with CFD and in the wind tunnel, to combat the drawbacks of what have become the most complex aero cars in F1 history.

The 2021 cars will have a striking new look with sweeping bodywork, simplified front wings, larger rear wings, increased underbody aerodynamics, wheel wake control devices, simplified suspension and low-profile tyres with 18-inch rims. Although aesthetics was a major consideration, the changes aren't just cosmetic: over several years, both Formula 1 and the FIA have been working tirelessly to design cars that can race more closely. One of the goals was to find a solution to the loss of downforce that the current cars experience when running in another car's wake. Running in dirty air behind another car, a 2019 machine could lose more than 40% downforce. However, with the 2021 car design, this drops to around 5-10%, with airflow coming off the new cars both cleaner and directed higher, meaning it has significantly less impact on drivers following, giving them the chance not just to overtake, but to battle.

Formula 1 has also announced its plan to become carbon-neutral by 2030 and for all race events to be sustainable by 2025. The aim is to eradicate its carbon footprint of activity at racetracks as the sport attempts to burnish its green credentials to appeal to commercial sponsors and younger fans.

All this is to be applauded and was a spur for us to present our inaugural GREEN TECH award. I have often argued that motorsport has always been about being Green from the very beginning, although the word Efficient is probably more appropriate. Unfortunately, the word Green now tends to denote just battery electric power, and while it has an extremely important place due to deadly urban air quality issues, it's not the one and only solution. That will, I am sure, be an issue investigated at the World Motorsport Symposium on 3/4 December at the Institution of Engineering & Technology in London.

We will also be finding out whether the internal combustion engine still has a future, and learning more about the arrival of new and more sustainable fuels, hydrogen fuel cell technology and of course battery electric cars. The keynote speech on keeping motorsport relevant is being given by Lucas di Grassi, a Formula E champion, Environmental Ambassador to the UN, and Roborace chairman. He will also be presenting the GREEN TECH award at our Awards dinner on the evening of the 3rd December. It should be a really invigorating and thought-provoking couple of days.

William Kimberley
EDITOR

Daimler AG

ABOVE The ambition is for F1 to become a laboratory for environmentally beneficial innovation

Formula 1's carbon neutral plans announced

F1's ambitious sustainability plan has been more than 12 months in the making. **William Kimberley** reports

FORMULA 1 has announced its plan to become carbon neutral by 2030 and for all race events to be sustainable by 2025.

The aim is to eradicate its carbon footprint of activity at racetracks as the sport attempts to burnish its green credentials to appeal to commercial sponsors and younger fans. The initiative includes road and air transport of staff and equipment to the events and follows 12 months of talks with the FIA, sustainability experts, F1 teams, promoters and partners, all of whom are on board with the scheme.

It was calculated that the sport's total carbon emissions in 2018 was 256,551 tonnes – not including fans' transport to races – which is the equivalent of providing energy to approximately 30,000 homes for the same period. It comprises:

- Logistics (road, air and sea freight) 45%
- Personnel travel 27.7%
- Factories and facilities 19.3%
- Events 7.3%
- Total F1 car emissions including all race and test mileage: 0.7%

F1 says it will "move to ultra-efficient logistics and travel and 100% renewably-powered offices, facilities and factories". It will offset emissions that cannot be cut through a combination of replanting trees and using the engineering know-how in the sport to develop new technologies that can capture carbon from the atmosphere.

Its first step is to begin carbon-reduction projects immediately and make all events "sustainable" by 2025. This includes eliminating single-use plastics and ensuring all waste is reused, recycled or composted. Those emissions that cannot be eliminated will be matched by offsetting measures such as carbon sequestration or planting trees. Additionally, race organisers will provide incentives and tools to offer fans a greener way to reach events. The race calendar will also be changed so teams fly less between events.

With F1 engines having a thermal efficiency rating of 50% compared to the 30% or so of a production road-car petrol engine, F1 is hoping to work with the automotive industry to apply the lessons of F1's engines to create "the world's first net-zero carbon hybrid internal combustion engine". The current engines will continue until the end of 2025, but F1 is looking at ways of ensuring that whatever specification of engine is used from 2026

takes another step forward in efficiency.

F1's plans to reduce its footprint include running cars on fuels generated from household waste or algae, saying it will work with suppliers such as Royal Dutch Shell, ExxonMobil and Petronas, to produce enough biofuel to run its race cars fully by the end of the next decade.

In-depth conversations with OEMs on this area have not yet begun but they will focus on the development of synthetic fuels, which use carbon captured from the air, farm waste or biomass. In 2021, rules will demand that the petrol used in F1 has a biofuel content of at least 10%.

F1 says all have signed up to the project and some have already started working towards this goal. Reigning World Champions Mercedes, for example, says it has been powering its two F1 factories in the UK entirely by renewable energy since early October. It is on target to have net-zero carbon emissions by the end of next year, through a combination of reducing CO2 emissions and offsetting.

Six-time champion Lewis Hamilton has also pledged to ensure his life and business activities are carbon-neutral by the end of the year. Praising the virtues of a plant-based diet in reducing greenhouse gas emissions, he is working with Mercedes to make relevant changes. After selling his private plane last year, after being accused of hypocrisy because of his role in F1 and the number of flights he has to take as part of his job, he admitted the subject was "not easy but that doesn't mean you should be afraid to speak out for positive change."

> *"The world's first net-zero carbon hybrid internal combustion engine"*

Chase Carey, the chairman and chief executive of F1, said: "Over its 70-year history, F1 has pioneered numerous technologies and innovations that have positively contributed to society and helped to combat carbon emissions. From ground-breaking aerodynamics to improved brake designs, the progress led by F1 teams has benefited hundreds of millions of cars on the road today.

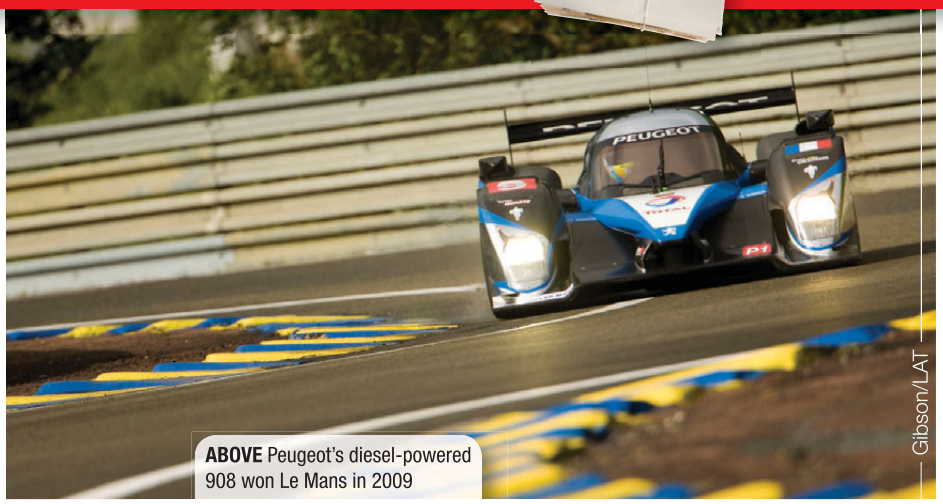
"Few people know that the current F1 hybrid power unit is the most efficient in the world, delivering more power using less fuel, and hence CO2, than any other car.

"We believe F1 can continue to be a leader for the auto industry and work with the energy and automotive sector to deliver the world's first net-zero carbon hybrid internal combustion engine that hugely reduces carbon emissions around the world."

"This strategy is in line with initiatives started some years ago by the FIA with the creation of the Environmental Accreditation Programme, more recently with the FIA Environment and Sustainability Commission, and researches on renewable racing fuel," said FIA president Jean Todt. "With the involvement of the teams, drivers, F1's numerous stakeholders, and crucially the millions of fans around the world, the FIA and Formula 1 are committed to driving development and ensuring motorsport grows as a laboratory for environmentally beneficial innovations."

BELOW Total emissions from the actual races make up a fraction of the sport's carbon footprint

Red Bull



ABOVE Peugeot's diesel-powered 908 won Le Mans in 2009

Peugeot boost for WEC hypercar revolution

VELIZY, France: Peugeot Sport's announcement that it is to return to endurance racing, in the 2022-2023 season, has delivered a huge boost to the FIA World Endurance Championship's hypercar revolution.

Until now, Toyota and Aston Martin had been the only confirmed manufacturer participants – although Glickenhaus and ByKolles are also planning enter the 2020-21 season. Peugeot's announcement that it will race an as yet-to-be revealed hybrid-powered hypercar does much to steady the nerves of all who have worked on the new ruleset.

"Peugeot's arrival in the new Hypercar category, alongside Aston Martin and Toyota, can only encourage more manufacturers to commit to the top level of endurance racing," admitted Gérard Neveu, CEO of the WEC.

"What great news this is for everyone involved in endurance racing," agreed Pierre Fillon, president of the Automobile Club de l'Ouest (ACO). "Peugeot has made history in terms of endurance racing and the 24 Hours of Le Mans, winning the event certainly, but also always producing spectacular machines, particularly appreciated by spectators. I can't wait to see the French racing car that will take over from the winning 905 and 908."

The French automotive giant has a long and proven pedigree in endurance racing, and most recently won the 2009 24 Hours of Le Mans with its 908 HDi FAP diesel LMP1 machine. It had developed a hybrid version of the car before abruptly cancelling its LMP1 project on the eve of the inaugural WEC season in 2012.

Further details of the hypercar programme will be revealed early next year, although speculation has suggested that ORECA and Rebellion could be involved in the project.

PSA motorsport director Jean-Marc Finot said: "I am very excited at the prospect of channelling the skills and passion of my team into this project.

"It is a new challenge and I know our experts will rise to it with another demonstration of their will to win with teams financed by the [PSA] Group's brands, fuelled by their long experience of top-flight FIA championships and hunger for success." RT

Green light for F1 2021 rules package

AUSTIN, TX: The long-debated rules package that will bring sweeping changes into Formula 1 in 2021 has finally been approved by the World Motorsport Council, before being formally presented ahead of the USA GP.

Formula 1 set several key objectives for the rules package, such as: working to ensure that cars would be able to follow one another more closely, allowing for more exciting racing; encouraging more balanced competition on track; and ensuring that success is determined by how wisely a team spends its money, and not simply how much it spends.

To achieve these aims, Formula 1 conducted a detailed analysis of current F1 cars, and refined ideas through the use of both CFD and wind tunnel testing.

"After more than two years of intense research and development… the FIA is proud to publish today the set of regulations that will define the future of Formula 1 from 2021 onwards," said FIA president Jean Todt at the announcement via video link.

"It is a major change in how the pinnacle of motor sports will be run, and for the first time, we have addressed the technical, sporting and financial aspects all at once."

Sustainability was another priority of the FIA in shaping the future of F1, with the renewable content of fuel increased to 20% for 2021, and further initiatives set to be revealed at the *Race Tech* World Motorsport Symposium in early December. RT

ABOVE Brawn, Tombazis and Carey present a mock-up of the new car

F1 2021: see p28-34

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IndyCar and Indianapolis Motor Speedway sold to Penske

INDIANAPOLIS, IN: The current owner of IndyCar and the Indianapolis Motor Speedway has revealed that it is to be bought out by a subsidiary of global transportation and motorsports outfit, Penske Corporation.

The sale will see Penske Entertainment acquire all Hulman & Company principal operating assets, including the Indianapolis Motor Speedway, the NTT IndyCar series and IMS Productions, and is set to be completed as soon as standard approvals are received.

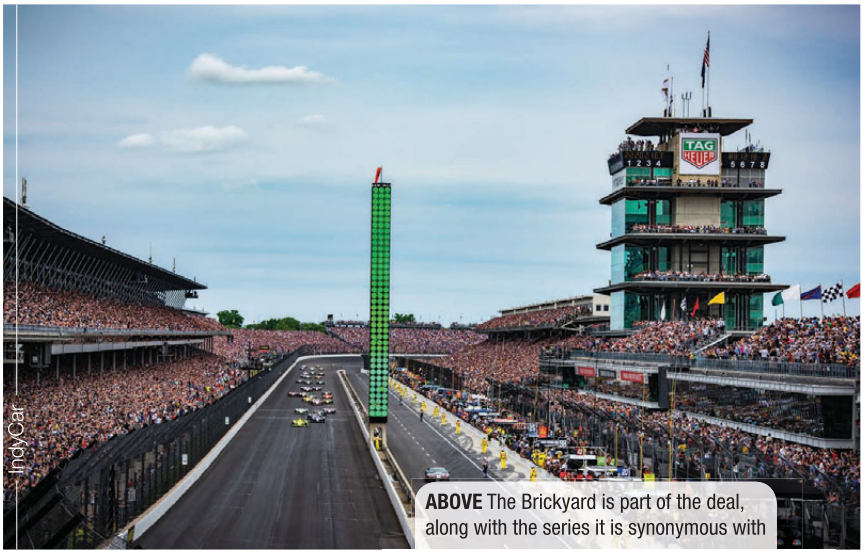
"We recently approached Roger Penske and Penske Corporation about this opportunity and began working to put an agreement in place," explained Tony George, chairman of Hulman & Company, in a statement. "The Indianapolis Motor Speedway has been the centrepiece and the cathedral of motorsports since 1909 and the Hulman-George family has proudly served as the steward of this great institution for more than 70 years. Now, we are honoured to pass the torch to Roger Penske and Penske Corporation, as they become just the fourth owner of the iconic Speedway."

The move will introduce a potential conflict of interest into the series, given Penske owns a team that competes in IndyCar and will also own its biggest race. However, Penske was adamant he understands "the integrity issue". "I know what my job is," he added. "Hopefully I've got enough credibility with everyone that we can be sure that there is not a conflict, and I'll do my very best to be sure there isn't."

Others involved in the sport echoed this sentiment. Meyer Shank Racing co-owner Michael Shank said that he would "actually sleep better at night knowing Roger is at the helm.

"There are so many ways you can monitor performance in IndyCar, and we have so many smart people working behind the scenes on teams that monitor data and information from other teams," Shank said. "If you even consider taking any sort of advantage, that ruins everything he's just worked 50 years to make, so in my opinion, I don't think there's any possible way he'd risk his new stewardship to win two more races or another 500. There's too many people watching him and too much to lose."

Penske said he is yet to create a firm to-do list, but has not ruled out exploring new ideas to draw more events to IMS such as persuading F1 to return, or attracting a 24-hour race. Penske also mooted the possibility of an IndyCar-NASCAR weekend doubleheader at the Speedway. "We've got to break the glass on some of these things, don't we," he added. RT



ABOVE The Brickyard is part of the deal, along with the series it is synonymous with

Chevrolet to campaign new Camaro in NASCAR

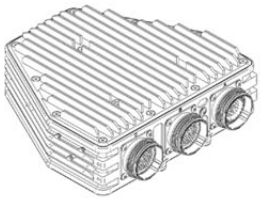
DETROIT, MI: Chevrolet has revealed that next year it will switch to the new Camaro ZL1 1LE in the NASCAR Cup Series, taking over from the Camaro ZL1 which made its debut in 2018.

The 1LE is based on what Chevrolet claims is the most track-capable Camaro ever, and will make its debut at next year's Daytona Speedweek in February, which opens the 2020 season. It has been prepared for racing by Chevrolet's motorsport engineers, who focused on the car's aerodynamic performance, and used CFD simulation and wind tunnel testing to optimise the car for competition.

ABOVE Chevrolet hopes that the development work gone into to the ZL1 1LE will pay dividends on track next year

"The ZL1 1LE is the highest performer within the Camaro production-car line-up," said Jim Campbell, US vice president of Performance and Motorsports. "We took lessons from the production car and applied them to the new 2020 Cup car."

As well as racing in the NASCAR Cup series, the new 1LE will also join the Camaro SS in the NASCAR Xfinity Series, in which it has won 76 races since its debut in 2013. RT



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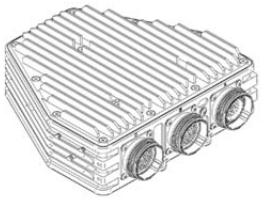

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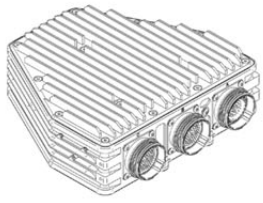

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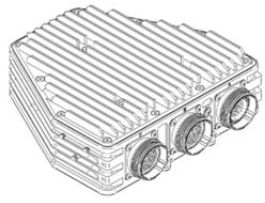

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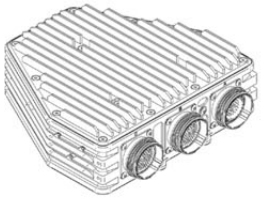

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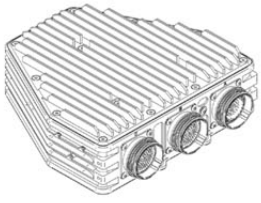

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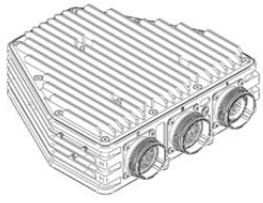

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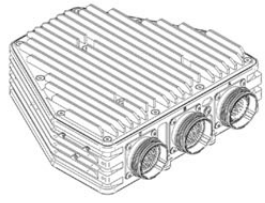

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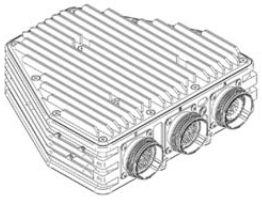

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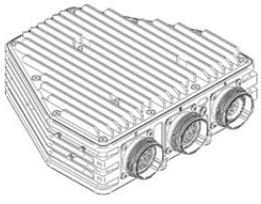

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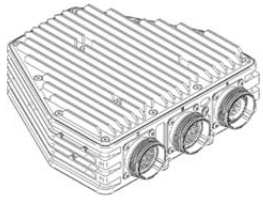

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2019

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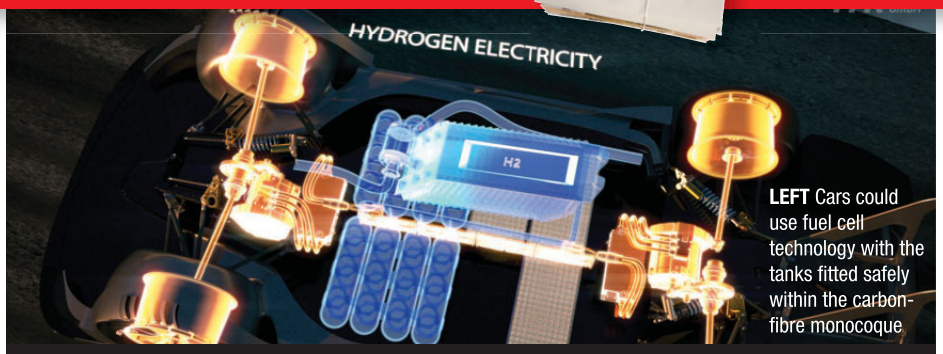


LEFT Cars could use fuel cell technology with the tanks fitted safely within the carbon-fibre monocoque

DTM reveals concept for all-electric support series

STUTTGART, Germany: DTM promotor ITR has revealed a spectacular vision of how it thinks touring car racing could evolve in the coming years, as it transitions to electric vehicles.

In the concept unveiled by ITR, the race cars could use either batteries or hydrogen fuel cells to store energy on board. With the adoption of these technologies, ITR envisages pit stops featuring large industrial robots carrying out the tasks which pit crews complete, such as changing the wheels, as well as other jobs such as replacing a car's battery pack or hydrogen tank located in the underbody. By using a high-performance electric powertrain, the futuristic race cars would be able to output more than 1,000 bhp for brief periods of time and achieve speeds in excess of 300 km/h.

ITR chairman Gerhard Berger praised the "courageous and innovative" concept. "You have to look far ahead if you want to shape the future of motorsport and offer racing with alternative drive systems that inspires the fans. It is obvious that manufacturers who want to become involved in motorsport are increasingly focusing on alternative drive concepts," he said.

The series would, at least initially, appear in a supporting role to DTM. It continues the German category's trend of becoming more environmentally friendly, from the shift to efficient, high-performance, four-cylinder turbo engines for the 2019 season, to the trials of greener fuels and plans for the introduction of sustainable drive technologies, such as hybridisation, in 2022.

To make the proposed series feasible, the necessary technology would have to be delivered through a collaboration with a single-source supplier. This would not only ensure parity between racers, but also help control costs, which could be shared by all entrants. Development costs would be kept in check thanks to largely standardised units.

This cost control is one of the factors that ITR hopes will make the concept series attractive to manufacturers. In addition, the promotor argues that it would also mean that carmakers could enter race cars that resemble their electric road-going line up; something not currently possible in electric categories. The series would also offer manufacturers an R&D opportunity, giving them the chance to explore and develop technologies for their road cars.

Berger added: "The cars showcased in our conceptual study offer something completely different. Here, we're talking about high-performance racing cars which – just as in DTM – are fast, spectacular, and able to race wheel to wheel. Another benefit is the fact that these cars will look like the cars you can buy at a dealership: they'll be recognisable and distinct to each brand manufacturer."

There is no guarantee that the concept will make the jump to reality, with several technical and financial feasibility questions yet to be answered. However, Berger notes that ITR is "talking with a significant number of automotive manufacturers and suppliers who would like to become more involved in motorsport", and that the proposal is at least a "first look at something tangible". RT

R-Motorsport ends DTM association with HWA

NIEDERWILL, Switzerland: R-Motorsport has announced that it will no longer use engines supplied by HWA in its Aston Martin race cars after a single difficult season.

HWA, which managed Mercedes-Benz's DTM entries until the German marque pulled out of the series at the end of last year, was heavily involved with the four Aston Martins fielded by R-Motorsport this season. The outfit reportedly offered to continue supplying engines for the cars, but this approach was turned down.

A split had been rumoured on at least one occasion, with poor reliability hampering the squad's fledgling DTM effort. However, R-Motorsport team principal Dr Florian Kamelger had previously stated he believed in HWA's ability to resolve any issues.

Since then, the companies have parted ways, leaving HWA without any involvement in DTM for the first time in decades.

"Regrettably, we have been unable to establish any consensus for further collaboration with HWA AG in regard to fulfilling our commitment to the DTM, so that the only option for us now is to terminate our partnership with HWA in the DTM and to focus on the future," explained Kamelger.

ABOVE R-Motorsport's Aston Martins will continue to be a presence at DTM races, but HWA will no longer be behind them

"Despite the termination of our collaboration with HWA, however, we still plan to continue our involvement in the DTM, and we will reorient ourselves in 2020 under these changed circumstances in coordination with Aston Martin."

The team's commitment to DTM was also reinforced by Aston Martin chief executive Dr Andy Palmer, who added: "Aston Martin will continue to be supportive of R-Motorsport's DTM programme with the Vantage DTM race car and their wider plans to compete in race series governed by Class 1 regulations, such as the Super GT in Japan and in Asia." RT

Ferrari launches 488 GT3 Evo

MUGELLO, Italy: Ferrari has unveiled a new version of the 488 GT3, which will compete in the main international GT championships from 2020 onwards.

The new Evo package is a refinement of the original, successful 488 GT3. It applies innovative ideas derived from the experience and feedback of the teams competing with the original to improve aerodynamics, vehicle dynamics, ergonomics, safety and reliability.

Ferrari's engineers honed the Evo's aerodynamics, particularly at the front end, to boost the car's stability. These changes saw more than 18,000 hours of calculations, CFD simulations and wind tunnel testing go into the design of a new bumper with a reduced frontal section under the headlights. This made it possible to introduce a pair of downforce-generating flicks, which improve stability, without affecting the car's balance thanks to turning vanes inside the splitter.

Other areas also underwent aerodynamic development. The vents on top of the wings are larger than the current model, while the front section of the door is now more tapered to efficiently channel lateral flows. Additionally, the vents on the rear wings have also undergone a redesign.

No engine components have been switched or modified, but a new engine management system has been used, which offers smoother, more precise torque delivery, as well as better reliability. More significant changes have been made to improve vehicle dynamics, such as an increase in wheelbase to optimise tyre use, reduce tyre wear, and facilitate conversion from GT3 to GTE, which also has a longer wheelbase. Ferrari's engineers also focused on reducing the car's weight, which means that more ballast can be used to reach the minimum weight, reducing its centre of gravity.

Inside, the evolution benefits from a new seat, which meets the FIA's latest regulations. It was developed jointly by Sabelt for both the GT3 and GTE, and is not only more rigid and robust, but also 2.4 kg lighter thanks to new belts and a new buckle.

The new components used in the 488 GT3 Evo, are also available to existing customers as an upgrade package.

ABOVE Ferrari hopes that a remodelled front end, as well as a longer wheelbase, will ensure the continued competitiveness of its GT3 racer

MissionH24 achieves new technological milestones

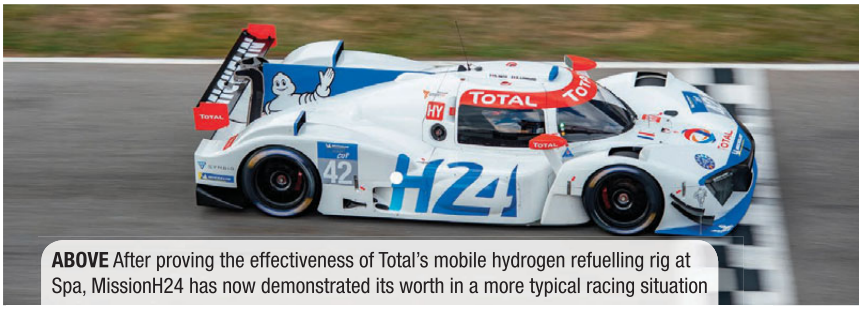
PORTIMAO, Portugal: The MissionH24 LMPH2G enjoyed a successful run in free practice ahead of the Michelin Le Mans Cup, and in doing so achieved all of its end-of-season objectives.

Following its first participation in a race weekend at the Spa-Francorchamps round of the Michelin Le Mans Cup, the hydrogen fuel cell-powered racing prototype returned to action. As well as continuing to validate several technical solutions that had been developed in private testing, the outing in Portugal also gave the team the chance to make a motorsport first: the pitlane refuelling of a hydrogen-powered racing car.

Unlike Spa, where the car had to leave the pitlane to reach the mobile refuelling rig developed by project partner Total, at Portimao, the car was able to refuel in the entry to the pit zone, while other teams were also active in the pit lane.

Another first achieved at the test was that Total's engineers have now equipped the hydrogen refuelling station with an infrared link that connects the station to the car so that the filling of its tanks, including the temperature, pressure and quantity is handled automatically. Now the only human intervention required during a refuelling stop for the LMPH2G is connecting the coupling connector and monitoring the automatic refuelling procedure to make sure that nothing goes wrong, and then disconnecting the device.

"After our entry for a weekend's racing for the first time at Spa Francorchamps five weeks ago, our return to the track here in Portimao for the last round of the 2019 Michelin Le Mans Cup was important," noted H24Racing team manager, Jean-Michel Bouresche. "As scheduled, we began the process of racing development at the end of the season and we had to take full advantage of each event on the calendar."



ABOVE After proving the effectiveness of Total's mobile hydrogen refuelling rig at Spa, MissionH24 has now demonstrated its worth in a more typical racing situation

ABOVE Hyundai is ramping up its assault on the R5 market

Hyundai rocks WRC and plots R5 push

ALZENAU, Germany: Hyundai Motorsport has reaffirmed its commitment to top-flight rallying by completing the shock signing of newly-crowned World Rally Champion Ott Tanak from Toyota. The squad then secured the WRC Manufacturers' title when the final round at Rally Australia was cancelled due to fires in New South Wales.

The marque has also committed to introducing two new versions of its i20 R5 category machine in the next 18 months. An evolution version of the current i20 will be homologated in time for Rally Monte Carlo in January, while a totally new machine, based on the Korean manufacturer's new road car, will hit the stages in mid-2021.

The updated version of the car, with revisions to chassis and engine, will be called the i20 R5 '20. The revised machine will have new MacPherson struts with three-way adjustable dampers for both gravel and Tarmac, along with a revised steering system. While standard on newly-built R5s, the upgrades will be available as a kit to update existing machines to the latest specification.

In the 1.6-litre turbocharged engine, new pistons and liners have been adopted, to give an increase in power and torque throughout the power band.

Externally the car will use new door mirrors, a reprofiled roof scoop, new cooling ducts for the Ricardo five-speed sequential gearbox and four-pot brakes, with 300 mm vented discs for gravel, 355 mm for Tarmac.

"The R5 category is incredibly competitive, and in order to keep our customers at the front of rally championships around the world we need to almost continuously develop the package that we offer," said Hyundai Motorsport Customer Racing senior sales associate, Andrew Johns. "The Hyundai i20 R5 '20 represents the largest single upgrade to the car since it was revealed at the end of 2016.

"The first tests we have completed show a good increase in performance, and the feedback from our drivers on the handling and balance has been very positive. We will continue to work to finalise the exact specifications of the new parts, but I am already confident that the updates will make the i20 R5 '20 a very strong contender for national and international rallying." RT

BTCC announces rules tweaks

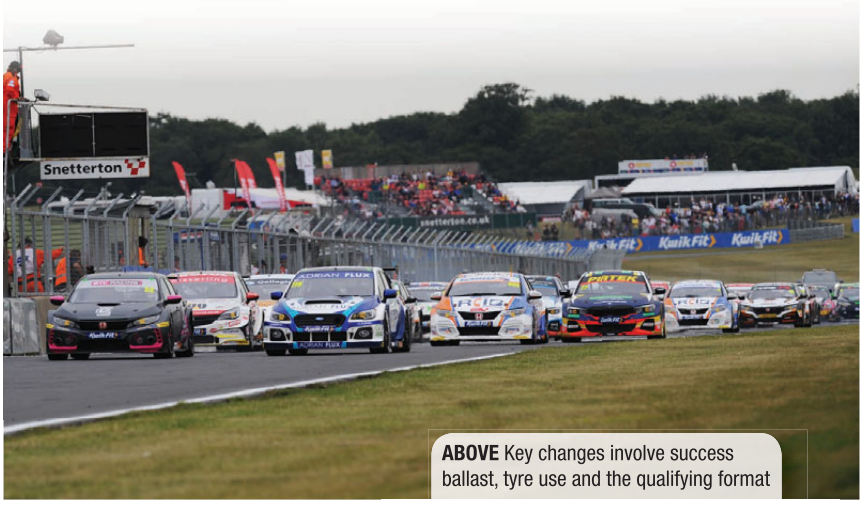
BRITISH Touring Car Championship promotor TOCA has introduced a number of minor rule changes to tyres, success ballast and qualifying ahead of the 2020 season.

At both the Snetterton and Croft rounds, drivers will use all three Goodyear tyre compounds – hard, medium and soft – across the three races. To enhance the strategic battle, teams will now also be able to decide when to use the 'option' tyre (which must be used in one of the three races) during race day, instead of having to nominate prior to qualifying.

A new qualifying format will also be trialled at Snetterton. Replacing the usual 30-minute session, drivers will have 25 minutes to set a time, before the fastest 10 progress to a 10-minute pole position shootout.

The maximum success ballast has been increased to 60 kgs, decreasing in 6 kg increments down to 10th place.

"Clearly, the regulations for the BTCC work tremendously well. That's self-evident from the fantastically close racing and championship battles, but we're always looking at ways in which they can be improved," said BTCC boss Alan Gow. "So whilst these are fairly minor tweaks, they will certainly add some interesting new elements to next season's championship." RT



ABOVE Key changes involve success ballast, tyre use and the qualifying format

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The RACE TECH World Motorsport Symposium has become an institution since it was first established in 2005 both influencing and impacting the politics and development of technology and engineering in the motorsport and the automotive sectors - leading to new series, such as Formula E. These two days in London at the Institution of Engineering & Technology (IET) gather the industry's leaders and influencers to discuss how technology will shape the future of the sport and in turn influence engineering sectors across the globe. A must-attend event for the motorsport and transport community.

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WITH SUSTAINABILITY, VISIONARY and FORWARD LOOKING being the watchwords when it comes to this year's World Motorsport Symposium themes, **Pat Symonds**, F1 Chief Technical Officer, will be revealing some breaking news and expanding on the announcement of the F1 sustainability programme. He will be covering issues such as how ultra-low carbon sustainable fuels are to be introduced to F1 and how the next generation of engine and fuel will be designed to work in harmony to achieve a highly efficient carbon neutral power unit and introducing, for the first time to a forum such as this, some of the visionary projects that will put F1 at the forefront of sustainable sports. Delegates at the World Motorsport Symposium at the IET in London on 3/4 December will be the very first to hear the details in person.

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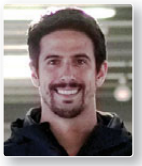

ANNOUNCING OUR KEYNOTE SPEAKER

LUCAS DI GRASSI Formula E champion, Roborace Chairman, Environmental Advisor to the UN

Shaping the future of motorsport

THE CHAIRMEN

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Director, Audi Motorsport Engine Development, Audi AG

JOHN ILEY
Founder and Director, Iley Design Limited

SPEAKERS AND CABINET MEMBERS

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Chief Technical Officer Motorsport Division, FORMULA 1®

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Head of Aerodynamics, FORMULA 1®

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LUCAS DI GRASSI
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Global Business Segment Manager Racing, AVL

BRYN BALCOMBE
Chief Strategy Officer, ROBORACE

DR MARK ELLIS
Managing Director, Advanced Engine Research

PROF. DR WILLEM TOET
Senior Sales Manager & Aerodynamicist, Sauber Aerodynamics

NIGEL FINE
CEO, Institution of Engineering & Technology (IET)

CHRISTIAN FISCHER
CEO & Founder, Bcomp

MARC HILBERT
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Exhibit to promote your technology and services

ABOVE Nikolas Tombazis, the FIA Head of Single Seater Technical Matter, chats to Evolution Measurement founder, Paul Crowhurst, at his stand at WMS18

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AWARDS 2019

RACE TECH's Editor-in-Chief William Kimberley and his panel of industry experts are looking for ground breaking motorsport technology that enables a positive impact on the environment. If you believe that your product should be considered, email a short brief to maryam.lamond@kimberleymediagroup.com.
A member of the team will then contact you for further information.

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- Racecar Aerodynamicist

ABOVE Dialma Zinellia and DALLARA win Racecar Aerodynamicist of the Year, Integral Powertrain win Race Powertrain of the Year & Bcomp Ltd wins the Most Innovative New Motorsport Product of the Year

Nominees and winners will be announced at the World Motorsport Symposium Champagne Drinks Reception and Networking Awards Dinner on the evening of Tuesday 3rd December 2019 at the Millennium Hotel, London Kensington in front of key influential leaders in the motorsport and automotive industry.

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PROGRAMME

Tuesday, 3rd December 2019

Theme of the day: Touring Cars and new engines, GT and Balance of Power, F1's sustainability programme, and alternative fuels.

9:00 – 9:15

- **Opening statement and welcome by WILLIAM KIMBERLEY**

Editor in Chief, RACE TECH Magazine

9:15 – 9:45

- **WELCOME TO THE WORLD MOTORSPORT SYMPOSIUM BY THE CHAIRMEN**

ULRICH BARETZKY, Director Audi Motorsport Engine Development, Audi AG &
JOHN ILEY, Founder & Director, Iley Design Ltd

9:45 – 9:55

- **WELCOME by NIGEL FINE**

CEO, Institution of Engineering & Technology (IET)

9:55 – 10:15

- **KEYNOTE speech by LUCAS DI GRASSI**

Formula E Champion, Roborace Chairman, Special Advisor to Formula E & UN Environment Clean Air Advocate

Keeping Motorsport relevant

10:15 – 10:45 COFFEE BREAK

10:45 – 11:05

- **Presentation by ULRICH BARETZKY**

Director Audi Motorsport Engine Development, Audi AG

The DTM is entering a new era in 2019. What does the new concept of the popular touring car series with turbo instead of naturally aspirated engines promise?

11:05 – 11:45

- **Panel session:** *The new-look DTM cars and what it means for Touring Cars*

11:45 – 12:05

- **Presentation by NICOLAS AUBOURG**

Head of Performance & Simulation, FIA

Technical Approach to BoP (Balance of Performance) in GT championships

12:05 – 12:45

- **Panel session:** *Technical Approach to BoP in GT championships*

12:45 – 13:00

- **TECH TALK by MATTHIAS DANK, AVL**

Global Business Segment Manager Racing

Powertrain Efficiency - the next step

13:00 – 14:00 LUNCH BREAK

14:00 – 14:20

- **Presentation by PAT SYMONDS**

Technical Director, FORMULA 1®

The F1 sustainability programme

14:20 – 15:00

- **Panel session:** *The F1 sustainability programme*

15:00 – 15:30 COFFEE BREAK

15:30 – 15:50

- **Presentation by VINCENT BEAUMESNIL & ROMAIN AUBRY**

Sports Director, ACO, Technical Manager, Total Motorsport Division

CO2 and emissions in motorsport. Are hybrid technology, alternative fuels and hydrogen technology the answer to the long-term future of powertrains, and what role can motorsport play in A. developing them and B. marketing them?

15:50 – 16:30

- **Panel session:** *Are hybrid technology, alternative fuels and hydrogen technology the answer to the long-term future of powertrains, and what role can motorsport play in A. developing them and B. marketing them?*

16:30 – 16:45

- **Resume of the day**

Wrap-up from **ULRICH BARETKZY** and **JOHN ILEY** on conclusions from both morning and afternoon sessions

Wednesday, 4th December 2019

Theme of the day: New motorsport road map, robot cars and AI, CFD post processing and the application of machine learning in motorsport.

9:00 – 9:05

- **Opening statement and welcome by WILLIAM KIMBERLEY**

  Editor in Chief, RACE TECH Magazine

09:05 – 9:30

- **WELCOME TO DAY 2 OF THE WORLD MOTORSPORT SYMPOSIUM BY THE CHAIRMEN**

  ULRICH BARETZKY, Director Audi Motorsport Engine Development, Audi AG & **JOHN ILEY**, Founder & Director, Iley Design Ltd

9:30 – 9:50

- **Presentation by STEVE SAPSFORD**

  Managing Director, SCE

  New motorsport roadmap, including IC engine efficiency and low carbon fuels

9:50 – 10:30

- **Panel session:** *The future direction of motorsport*

10:30 – 11:00 COFFEE BREAK

11:00 – 11:20

- **Presentation by BRYN BALCOMBE**

  Chief Strategy Officer, Roborace

  Robots that want to race: Mainstream or Minority?

11:20 – 12:00

- **Panel session:** *Does the conventional racing car face an uncertain future? Will mainstream motorsport go the way of horse racing over the next 20 years due to revolutionary concepts like Roborace and other AI series coming into mainstream motorsport?*

12:00 – 12:15

- **TECH TALK by CHRISTIAN FISCHER, Bcomp**

  CEO & Founder,

  Sustainable lightweighting for motorsport – driving technology for road relevance

12:15 – 13:15 LUNCH BREAK

13:15 – 13:35

- **Presentation by JASON SOMERVILLE**

  Head of Aerodynamics, FORMULA 1®

  2021 F1 Aerodynamic regulations

13:35 – 14:15

- **Panel session:** *2021 F1 Aerodynamic regulations*

14:15 – 14:35

- **Presentation by WILLEM TOET**

  Professor, Aerodynamics Specialist & Senior Sales Manager at Sauber Aerodynamik AG

  CFD Post Processing

14:35 – 15:10

- **Panel session:** *The importance of understanding just what you are seeing when it comes to aero analysis and how it can be applied practically to a physical model*

15:10 – 15:40 COFFEE BREAK

15:40 – 16:00

- **Presentation by MARC HILBERT**

  Team Lead: Machine Learning in Engineering and Production Technologies, Volkswagen AG

  The application of machine learning in assisting the race driver in managing more and more complex drive systems – development, limits and test experience.

16:00 – 16:30

- **Panel session:** *The application of machine learning in motorsport*

16:30 – 17:00

- **Resume of the day**

  Wrap-up from **ULRICH BARETKZY** and **JOHN ILEY** on conclusions from both morning and afternoon sessions

NB. The programme is subject to change

"In 10 years the cars we use today will be viewed almost like carriages!"

William Kimberley talks to Lucas di Grassi, who is giving the keynote speech at the World Motorsport Symposium about his vision for motorsport's future – and whether it has one

PASSION is the word of the moment. Forget the ice-cold, dispassionate era when decisions were made with a calm and cool head; we now live in a world of swirling, red hot passion in every walk of life. However, such passion is to be expected in all sportsmen as it is that which drives them, no matter the skill level.

Lucas di Grassi typifies the latter. He is a driven and passionate man, not just for motorsport, but in all areas of life, including climate change and what motorsport needs to be doing to play its part.

As an official Clean Air Ambassador of the United Nations since 2018, the CEO of Roborace, FIA Formula E World Champion in 2016/17, a member of MENSA and also founder of EDG – a Brazilian technology company that has developed what it claims is the only electric bicycle in the world with a 100 km range – he has become one of the most important mouthpieces explaining why motorsport matters in these revolutionary times. For example, at "Climate Week NYC" that followed the UN Climate Action Summit in early November, he said: "A few years ago, I helped shape Formula E because for me it was clear that the future will belong to electric cars – on the road and on the race track. Advancing new technologies and inspiring people's enthusiasm for the relevance of electric mobility regarding the climate and our health is an important concern of mine."

Di Grassi comes from the Brazilian city of São Paolo that has a population of 20 million people and has terrible air quality. According to a now aged report, in the entire state of São Paulo, air pollution has been cited as responsible for the deaths of nearly 100,000 people from 2006 to

Audi AG

BELOW di Grassi emphasised the role of Formula E in the transformation of electric mobility in a keynote speech in New York City

Audi AG

Dunbar/LAT

ABOVE & BELOW Fast-changing times: the notion of Formula E (above) would have been thought preposterous when di Grassi first tested an F1 car for Renault in 2008 (below)

2011 from respiratory illness. In 2011 alone, 4,655 people died as a result of air pollution. In that same time period, traffic fatalities accounted for 1,556 deaths. The study also points out that pollution contributed to over twice as many deaths that year than both Aids (874) and breast cancer (1,277) combined. It is these numbers that have galvanised di Grassi into speaking up and seeking a role, using his position as World Champion to underline the case for the electric car.

"Electric cars, regardless of what energy source they use, at least don't emit high levels of molecules into the atmosphere," he says. "When I spoke with the UN I said: 'Let's make people more aware of the clean air side of electric cars, and not just the climate change.' To be an ambassador for the UN is to use their credibility and data sources, and they use you to help promote their cause. That's how the relationship works, pushing this idea forward without any vision for profit."

He says governments should push for a faster transition to electric transportation, arguing that even if they don't, it will happen anyway because eventually it will become much cheaper: "Don't forget the combustion engine has been pushed by governments for 100 years and electric only for the last 10 years. In another 10 years we will look back at the technology we use today and these cars will be viewed almost like carriages. It's been happening in our lifetime. I drove a combustion engine Formula 1 car, then a hybrid and now I drive Formula E, which is fully electric. I'm now developing a fully autonomous, electric car. This is how quick things are changing."

Driving for the Audi Sport Abt Schaeffler team is the perfect fit for him as Audi, together with the Volkswagen Group, was among the first vehicle manufacturers to have committed to the Paris Agreement. It set itself the ambitious goal of a successive 30 per cent reduction of vehicle-specific CO2 emissions by 2025, compared to the reference year of 2015 and along the entire product lifecycle. In addition, the company is actively involved in the development of Greenovations – innovations for the protection of the climate and the environment. An example of a promising technology is CO2 capture, a method for extracting carbon dioxide from the air. Audi has already installed such a facility near Zurich. In the long term, it is pursuing the vision of carbon-neutral mobility.

> *"The onboard computer processor is capable of 24 trillion operations a second"*

"We have too many people consuming too many resources," says di Grassi. "What's clear is that we can't continue consuming the way we do and emitting the amount of CO2 per person. So we need to find a way of making the stuff we use more efficiently without affecting people's quality of life. It's easy to say, 'Well, people can go and live in the jungle and eat nuts and apples', but this is not an option. You either replace existing technologies with better ones or start reducing the impact of products like plastic bags by using less of them. Simple stuff that doesn't change the quality of life is the first step."

AUTONOMOUS PIONEER

However, it is not just all about electric cars for di Grassi, because as Roborace CEO he is actively involved in artificial intelligence (AI) driverless cars as well. The series is currently formulating ideas for its first autonomous racing championship, ▶

ABOVE & BELOW Driving itself using AI technology, DevBot 2.0 completed a run in 66.96s at the Goodwood Festival of Speed

planned for 2021, with new cars that will bring together the best aspects of Robocar and DevBot 2.0.

The AI racing concept is currently midway through 'Season Alpha', the name given to the first year of head-to-head competition between different teams. It will then embark on Season Beta in 2020 with the all-electric DevBot 2.0, before looking to incorporate the technology and acquired knowledge in a more official competitive setting in 2021.

In July, this machine proved a point at the Goodwood Festival of Speed by setting the first ever official timed autonomous run at the event, racing up the 1.16-mile course in just 66.96 seconds – eight seconds faster than an unofficial attempt last year – reaching top speeds of 100 miles/hour.

"It means that there's around 12 seconds left for the AI to find before it can match the best human drivers," says Bryn Balcombe, Roborace's chief strategy officer.

The car's hardware is managed centrally and is the same for each team, meaning that the only differentiator is the AI driver software the teams develop for the competition. It runs on Nvidia's PX2 AI car computing platform when in autonomous mode, using a number of technologies to drive itself, including LIDARs (light detection and ranging), radars, AI cameras, ultrasonic sensors, optical speed sensors, Global Navigation Satellite System (GNSS) positioning and more. The car has a GPS inertial system that's accurate enough for missile guidance.

Both the Technical University of Munich led by Johannes Betz, a post-doctoral researcher, and the University of Pisa are involved in the project. "We started in early 2017, when my professor saw this in a newspaper," says Betz. "Each month, we have to develop our software a little further, and then go to an event like Formula 1."

Each team – electric van start-up Arrival, on a mission to make EVs mainstream, also competes – writes software for an identical racing car, which is capable of speeds over 200 mph (322 km/h). It is guided by six cameras, two radars, 18 ultrasound sensors, and five LIDAR sensors. The onboard computer processor is capable of 24 trillion operations a second.

"The idea is that we have our own competition series in the future, which does not need to be traditional racing," di Grassi told e-racing365 in July. "It could be a competition of obstacle avoidance or it could be a pitch-black night race. Some types of software require computer vision for night-time but with LIDAR you don't. It will therefore be different challenges and not traditional racing that will be a part of it but just a complement to the other things that we do during the season."

Looking to the future, di Grassi is adamant that motorsport as we know it is set to change radically over the next few years. "In the future I would say that apart from classic motorsport, all motorsport will be electric. By the long-term future, not now, it will be cheaper to operate and it will be technically easier to design the car with more performance. Some countries will not accept promotion of combustion racing any more, it will be the same as promoting tobacco today." RT

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EVOLVE OR DIE

As somebody who has spent their career trying to circumnavigate the best intentions of rule changes, our **Expert Witness** – an F1 insider who must retain anonymity – is well-positioned to offer a verdict on plans for F1 2021

SPECIES must evolve and adapt to their new environments or their numbers decline, and they do not survive.

Governing bodies enjoy a degree of control over their own destiny, but the clarity of the correct way to proceed to prosper is never normally simple or obvious. So, as the high-profile pinnacle of world motorsport, Formula 1's latest regulation upheaval for 2021 feels like it will be the critical test of the whole industry's health and prosperity going forward.

Rule changes are nothing new and inevitably they involve an initial investment because different parts and infrastructure are required. This area, cost, is one of the key issues that the rule-makers are finally attempting to tackle. Why? Because 'sport' should be about addressing a challenge with talent and innovation, not buying success by spending two or three times the amount of your opposition.

If costs can be controlled – currently they are pitched in 2021 at £135m per annum with exemptions on drivers, three top executives and marketing – this significantly reduces the margins between the 'haves' and the 'have-nots'. While a cost cap is painful to start with for the three big teams that have invested and grown massively, I don't see what they should be afraid of: they can continue to win by being more intelligent, more efficient and still have a growing healthy grid of opposition.

Who would join F1 in the current climate? What is the cost to benefit ratio? Through no fault of its own, Mercedes GP has dominated the six championships, Drivers and Constructors, since the last major rule change. A powertrain manufacturer at a key moment in how that area of the regulations evolved, it stole an initially 'frozen' march on the whole grid. Though the other manufacturers have got closer over time, that initial lead has never been overturned.

This stagnation of unpredictability is not good for viewing figures. However impressive it is, a sporting event where you already know the winner before it starts is, unsurprisingly, not a draw to the public. Any new arrival in a category in my opinion needs two things: the ability to sustainably afford it, but also, crucially, "hope". Spending a fortune to languish at the lower end of the grid, season after season, makes no sense – particularly for an additional brand-new OEM.

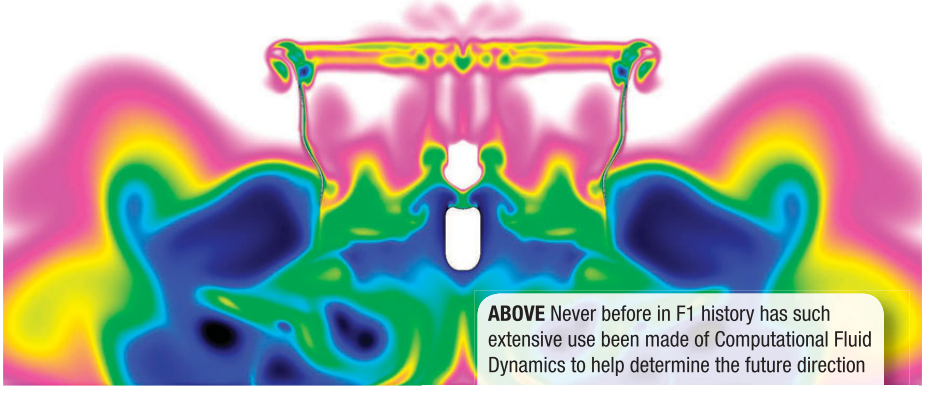
What *does* make the public interested and watch? These are the kind of questions that are now being asked and attempted to be addressed by Liberty F1's new technical structure. One simple answer is to communicate the story better: graphics and access to information the viewers have not seen before, that lets them in and allows them to follow what is actually going on. Teams will be reluctant to share this, but if it adds texture and appeal to the event, it is a small concession and the same for everybody.

But how do you make the racing better, so that anyone and everyone wants to watch, even for the first time? There are both technical and sporting aspects to this.

DISTURBED WAKE

Liberty is keen to maintain the traditional DNA of F1. This is understandable to a point as it is its identity and USP. However, as it has discovered from independent research, initially 12 years ago (FOM) and once again over the last 18 months, a Formula 1 car is not an easy car to follow and overtake. This is based both on its exposed wheel DNA, but also on a whole series of aerodynamic technical regulations that made the cars generate downforce that took significant energy out of the air, leaving a large and highly disturbed wake behind it.

It is a problem massively magnified by all cars being developed in perfect airflow conditions in isolation, all the better to make multiple, small incremental gains. As it sounds, this recipe generates a category of highly aerodynamically sensitive machines unable to run close



ABOVE Never before in F1 history has such extensive use been made of Computational Fluid Dynamics to help determine the future direction

Photos courtesy of F1

ABOVE & BELOW The FIA's armoury of technical, sporting and financial change offers an unprecedented opportunity to capture the public's imagination with the new 2021 car

to the car in front without losing up to 50% of their downforce. Often this loss is predominantly at the front, killing both the following car's balance and tyres.

The difference this time around is that the tools available to the governing body compared to 2008 – the last aerodynamic upheaval on this scale – are considerably more advanced. Furthermore, an aerodynamically experienced Liberty F1 group has been established to manage the program, both in CFD and the wind tunnel. The prime focus has been regulations that will reduce the low energy wake of an F1 car, but also to make a set of car regulation architecture that is much less wake-sensitive. Numbers quoted have this loss for following a car at the same distance dropping as low as 10%, rather than the 50% of 2019.

How can you protect this going forward? In the past teams often found a way of not only getting all the performance back and more, but also in the process circumnavigating the best intentions and producing a dirty wake as bad as before. Well, one way being discussed is by changing a sporting aspect and varying the format of a race weekend. If a qualifying race with a reverse grid with championship leaders starting at the back was introduced, teams may have to make a car with improved overtaking ability for the first time, instead of just assuming it will qualify at the front. A more extreme mechanism may be to create some wake measurement requirements for all competitors: they cannot exceed a certain level, even with an improvement gradient over time.

> *"Any new arrival in a category needs two things: the ability to sustainably afford it, but also, crucially, 'hope'"*

On this last point, improving over time, this was also in F1's DNA wasn't it? F1 2021 has a massive opportunity to showcase not just much improved and exciting racing, cars that are visually much more appealing, but also a more aligned, appropriate and up to date technological story. We're talking about the benefits of its powertrains' efficiency to manufacturers and the environment, biofuels, recycled components, reducing carbon emissions and carbon neutrality.

As the prime flag-bearer for our sector, being sustainable and up to date, with a road map to develop it, is not just about popularity and commercials, but how our product is perceived by the general public. If we don't get this right, there is a danger we could become a dinosaur. And we know what happened to them… RT

AND NOW FOR SOMETHING COMPLETELY DIFFERENT...

The grand unveiling of F1's 2021 regulations reveals a sport looking to fundamentally change the way it works, on track and off. It makes everything that's gone before look like tinkering in the margins… **Matt Youson** reports

ABOVE The shape of the future: how the FIA believes the next generation car might look

IN Austin, at the United States Grand Prix, the joke in the build-up to the release of the 2021 Formula 1 regulations was that the process had a great deal in common with the new *Star Wars* movie: years in the making; a certain inevitability to its arrival; and all the best bits long since leaked to the press. As such, there wasn't anything particularly revelatory in the announcements – but the grand unveil still had the capacity to shock.

The various building blocks of the rules package had been drip fed into the public sphere over the last few years – but only when seeing them assembled into one structure does the magnitude of change become apparent: F1's 2021 redux is gargantuan; revision on a bigger scale than anything that has gone before.

The axis of FIA and Formula One Management, with the teams trailing behind with variable levels of enthusiasm, has decided to institute revolution across the board. Technical and Sporting Regulations are comprehensively overhauled, and joined for the first time by a set of Financial Regulations tasked to introduce and police a cost cap. While the full effect of these sporting and financial regs won't be felt until they kick in, the new technical rules are firmly occupying minds right now, arguably to a greater extent than preparation for 2020.

"When you have such a fundamental change it's tempting just to say, 'You know what, we'll sack off next year, throw everyone on '21, make it as good as possible,'" says McLaren technical director James Key. "… but when you're sat on the pitwall in Melbourne next year, that's actually a very difficult thing to stomach, for everyone. So, you have to figure out the best balance. '21 is such a change, you need to start early.

"We've got a resource split organised and have already been working on the '21 project for months. It is tricky, and obviously the smaller you are, the more difficult that decision-making process gets. I don't envy the teams that have a little bit less resource than us. It is quite a difficult split to make."

> *"2019 analysis has a following car retaining 55 per cent downforce at one car length; the number for a 2021 car is 86 per cent"*

CLOSE RACING

The FIA and FOM released a mission statement consisting of five top-level objectives. The desire for a more competitive field, and some mandated restraint in spending fall under the aegis of the tech regs – but the key point in this regard is 'raceability', and specifically the facilitation of close racing. Given that a resolute defence can often provide as much entertainment as a courageous pass, everyone sticks to the terminology of 'close racing', rather than 'overtaking' but the meaning is very much the same: wake turbulence from the current cars makes overtaking too difficult. The logic of addressing this is self-reinforcing: if cost-cutting and spending caps deliver a more competitive field with a narrower performance window, there needs to be a correspondingly smaller performance advantage required to overtake, lest F1 ▶

ABOVE These will be fundamentally ground-effect cars

return to an era of processional races.

The 2019 technical regulations featured an early subset of these rules, using research already completed to instigate changes, notably to front and rear wings. While this hasn't led to a noticeable uptick in overtaking opportunities, it did achieve the stated aim of preventing the situation getting worse. From 2021, wake turbulence should be greatly reduced, allowing cars to run closer to each other.

Nikolas Tombazis, the FIA's head of single-seater technical matters, is the public face of the aerodynamic research. "We have simplified the front wing to create weaker vortices around it, in this way giving less opportunity to the teams to control the wake of the front wheel," he says. "There's no barge boards [and] the car is fundamentally a ground-effect car. It's got a long diffuser starting from the front of the sidepod, and finishing at the very back.

"This is fundamental for the flow structures that we've sought to achieve. Some areas of the car – not a huge number – are going to be prescribed because there are some areas where there's such sensitivity to control the wheel wakes, we feel if we didn't actually restrict the shapes, we would end up with, potentially, teams finding ways to overcome the key objectives."

This point is of particular relevance: while there is near-universal approval of the new direction, the same people endorsing the changes will also seek to undermine them in the natural course of events. A more restrictive aerodynamic geometry is designed to limit their ability to circumvent the intent, with a greater focus on legality being tackled at source, rather than in the scrutineers' garage.

"The aerodynamic regulations are going to be much more CAD-based," says Tombazis. "We've introduced an X/Y/Z coordinate system, and a lot of the legality of the cars will take place in CAD. Simultaneously, we'll be taking scans of the cars and comparing those to the CAD shapes, in order to ensure the cars are legal in all aspects of the regulations."

The RANS numbers [Reynolds-averaged Navier–Stokes equations] for projected 2021 aerodynamic performance are impressive. A baseline 2019 analysis has a following car retaining 79 per cent of lead-car downforce at seven car-lengths, dropping to 55 per cent at one car length. The comparative numbers for a 2021 concept car are 98 per cent at seven car-lengths and 86 per cent when right on the gearbox.

"The simulations show this should achieve cars being able to follow each other much more closely and be more able to attack the front car, which, ultimately, is what we are seeking," says Tombazis. "Clearly, when teams do their aero-development, this number will reduce a bit – but, we still expect there's going to be a huge chunk more performance for the following car, compared to the front car."

While closer racing is the primary goal, it isn't the *only* goal, with the rulemakers keen to address all sorts of longstanding issues that have plagued the sport. A good example is the regulation specifying the composition of the front floor structure. Regulating this area both prevents teams building floors that flex unduly under load – a perennial bugbear for the scrutineers – but also creates a car that is less prone to kerb-strike damage.

"One small detail is that every race we have one or more cars failing to perform properly because they have bits fall off," ▶

ABOVE LEFT & RIGHT The use of standard parts won't prevent the cars looking different – at least initially!

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BELOW Leclerc's Ferrari drags a damaged front wing endplate around Suzuka. The 2021 cars will be less fragile

explains Ross Brawn, F1's managing director of motorsports. "As soon as they touch the grass, or as soon as they touch each other, bits fall off and their performance is degraded. These cars have been designed to be much more robust, so we won't suffer those problems."

SUSPENSION CLAMPDOWN

From an aesthetic point of view, these aerodynamic changes will fundamentally alter the shape of a Formula 1 car, with everything from the nosecone all the way back to the rear wing endplates affected. As such – and thanks to some funky 3D renders released along with the roll out – it's these changes that have captured the imagination of the outside world.

There is, however, a lot going on below the surface. The technology below and around the bodywork is undergoing just as significant a revision. Some of this ties into the notion of closer racing but much more is tasked to cost saving and regulatory adherence. Suspension, for example, will be more straightforward, with fewer opportunities to fall foul of the rules proscribing moveable aerodynamic devices.

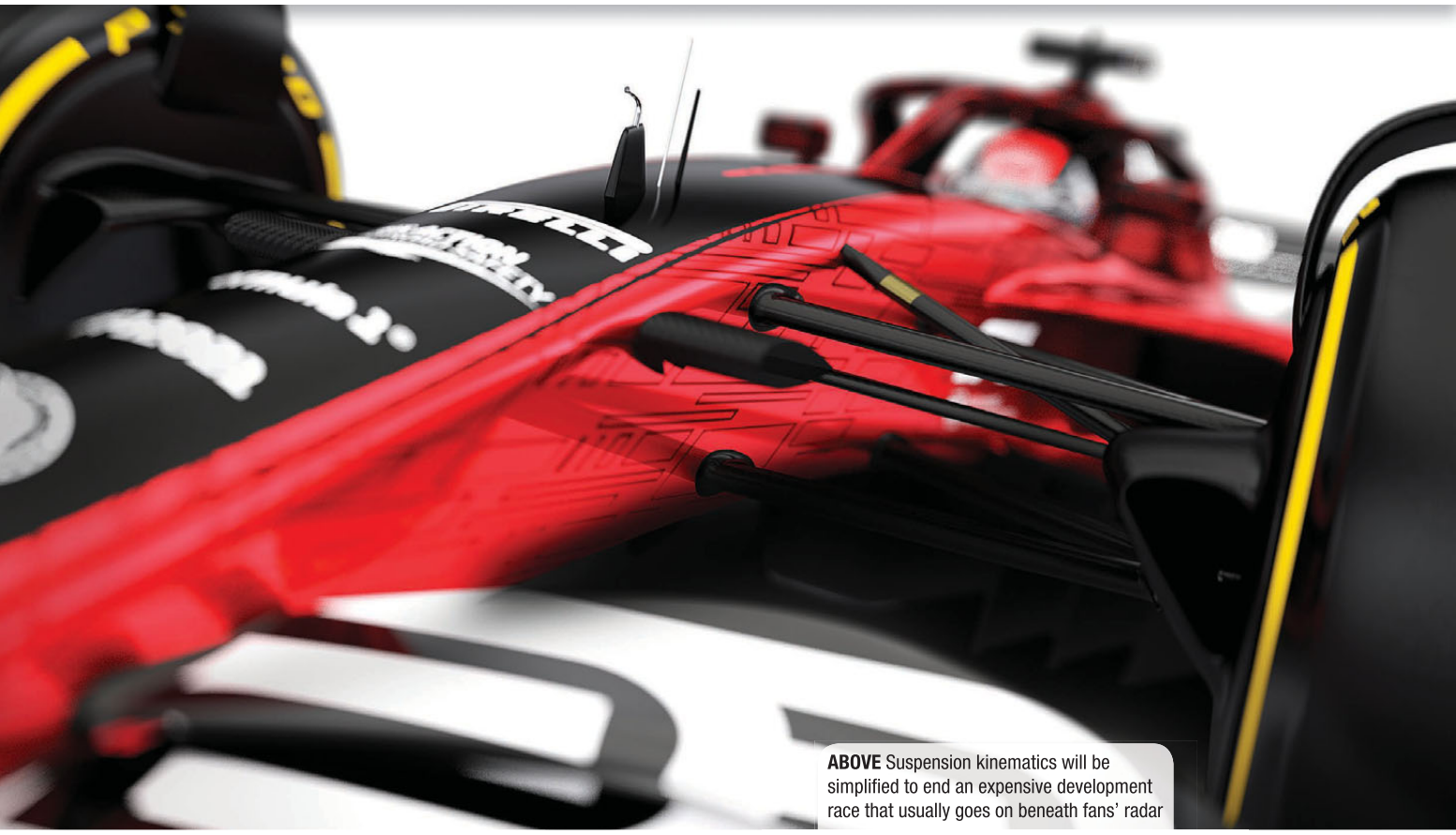
"It's quite a lot of change on the suspension," concedes Tombazis. "We are simplifying, massively, that area; we are banning the hydraulic suspension that we feel has no real relevance to road cars and is leading to ultra-complicated systems. We are simplifying, also, the in-board part of the suspension, in terms of springs and dampers. We are going to be banning inerters, which don't bring anything to the sport: it's something everyone has and it doesn't really create anything positive for us. We are simplifying the kinematics: there will be the obligation that the outboard suspension points will be inside the volume of the wheel rim and not sticking outside, which we feel will simplify some of those areas."

POWER GAMES

The principal area of the car studiously avoided by the updated regs is the power unit, the manufacturers having lobbied successfully to stick with what they have, rather than write-off several billion dollars of R&D. There are, however, small changes, including an increase in minimum weight. Overall, the car goes up from 743 kg to 768 kg, through a combination of bigger wheels, heavier safety components and some standardised parts. An extra 5 kg in the power unit is designed to allow manufacturers to lower costs by building simpler, more robust components.

The power units will also face some material restrictions, with a slightly nebulous reference to 'commercially available' materials, and an intriguing non-exclusivity clause, demanding suppliers of, for example, turbochargers cannot enter into an exclusive supply relationship with one outfit. Engine ancillaries receive further attention, with greater standardisation coming into play. While this is being billed as a cost saving measure, as with front floor geometry there exists a belief that specifying standard parts – high pressure and primer pumps, standard piping, and approved collectors and some internal components – will limit teams' ability to circumvent the spirit of the regulations. ▶

BELOW The rules reset is being used as an opportunity to stop cars being designed to flex unduly under load



ABOVE Suspension kinematics will be simplified to end an expensive development race that usually goes on beneath fans' radar

WHAT TO DO?

The sheer scale of change for 2021 is a talking point in itself. Items such as the gearbox freeze, or the switch to 18-inch wheels would, in most years, dominate the conversation. While not exactly relegated to the footnotes, they're simply bullet-points on a much longer list this time around. It presents teams with an unusual set of problems: not simply what to do but rather what to do first? There simply aren't the resources available to work across the board on everything.

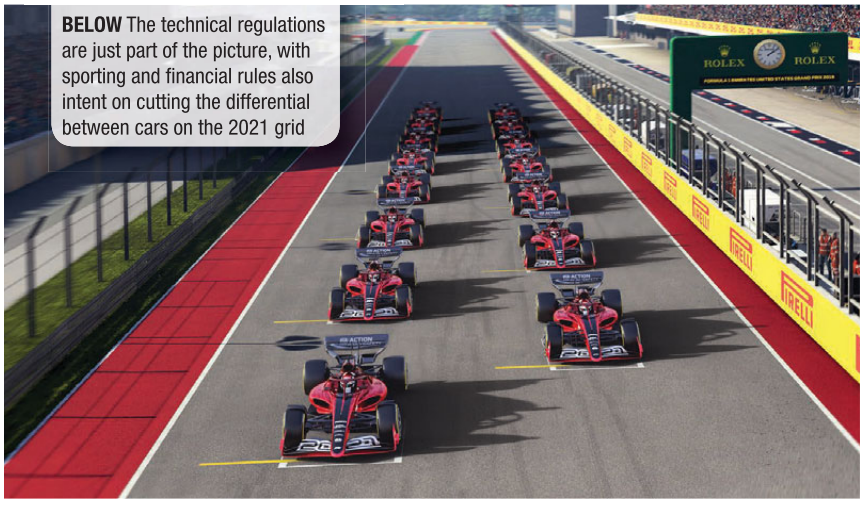
"The question is: what are the big performance differentiators on these cars? That's what we've really got to establish," says Key. "I love new regs, because it presents all of those challenges – but you're always terrified you're going to turn up and find that you've gone with a low front wishbone set-up and everyone else turns up with a massively high one, and you've missed something… or maybe you didn't and it's going to be mega!

> *"You're always terrified you're going to turn up with a low front wishbone set-up and find everyone else turns up with a massively high one!"*

"We're thinking: 'How much scope do we really have to investigate here?' I don't think it's really any one thing at the moment. It's more about the concepts you come up with and whether they're the smartest ones – or not. I think this is the good thing with 2021: it will encourage smartness. The more restrictive things get, the more innovative you've got to get to have a little bit of an advantage. That's the challenge we've got in the short-term."

As Key, and his peers say, work on the 2021 project is well underway; the announcement of the new regulations being the formal green light to work that has been several years in the making. And while there's the small matter of a 2020 season to get through first, the scale of change makes that seem like something of an encumbrance.

The last two significant regulation changes, for 2009 and 2013, both resulted in the teams that did their homework best retaining their advantage all the way through the cycle. While the 2021 regulations have been written to prevent the creation of another hegemony, history isn't on their side – though there is considerable optimism that, on first analysis, we're looking at a blockbuster rather than a flop. RT



BELOW The technical regulations are just part of the picture, with sporting and financial rules also intent on cutting the differential between cars on the 2021 grid

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PHOTOGRAPHY
LAT

ART EDITOR
Paul Bullock

ACCOUNTS MANAGER
Vikki Amour

COMMERCIAL DIRECTOR
Maryam Lamond

MANAGING DIRECTOR
Adrian Goodsell

PUBLISHING DIRECTOR
Soheila Kimberley

GREEN TECH Motorsport Engineering

841 High Road, Finchley
London N12 8PT
Tel: +44 (0) 208 446 2100
Fax: +44 (0) 208 446 2191

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THIS year, for the first time, we will be presenting the GREEN TECH Award at Race Tech's World Motorsport Symposium.

If the word 'Green' is substituted for the word 'Efficient', that is what motorsport has always been about from the very first time two cars competed wheel-to-wheel with each other. The aim of motorsport engineers has always been to make their car faster than the competition. The obvious way to achieve that is in the pursuit of better efficiency.

There are, for example, in the region of 16,000 parts on a Formula 1 car. That's 16,000 chances to gain the edge over rivals by being more efficient. Those gains are usually found through a combination of things, but would include: aerodynamics, lubrication and fuel, lightweighting, driveline performance, electronics, silicon carbide applications for power modules, miniaturisation, packaging, wheels, tyres – in fact, anything that might make their car go faster.

Over the last few years, though, the term Green has tended to be associated with electric racing cars. Their role is undeniably essential in highlighting the killer air quality in many cities, but as such it begins and ends there. The battery electric vehicle is definitely an answer and the more we can improve them, the better. However, the GREEN TECH Award is for innovative solutions such as proprietary lightweighting, innovative fuel that improves the CO2 balance and things like that. It might even be for innovative battery solutions as well – anything goes.

The next few years are going to see a revolution in motorsport power units, with the advent of hybrid technology coming to NASCAR, IndyCar and IMSA, joining Formula 1, in 2022. This is quite a big decision to have made, especially with the traditional NASCAR fan wedded to the growling and rumbling V8, but if these series are to have a future, then they need to move with the times.

2022 is also the year earmarked for the World Rally Championship's transition to hybrid technology, and the date that Peugeot Sport will be joining the FIA World Endurance Championship. Its new hybrid-powered hypercar will compete alongside Aston Martin and Toyota, so that series is also shaping up very well.

However, DTM promotor ITR has revealed an even more spectacular vision of how it thinks touring car racing could evolve in coming years, as it transitions to electric vehicles using either batteries or hydrogen fuel cells to store energy on board. With the adoption of these technologies, ITR envisages pit stops featuring large industrial robots carrying out the tasks which pit crews already complete, such as changing the wheels. They would also remove and replace the battery pack or hydrogen tank located in the car's underbody. By using a high-performance electric powertrain, the futuristic race cars would be able to output more than 1,000 hp for brief periods of time and achieve speeds in excess of 300 km/h.

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AN ELECTRIC ODYSSEY

Chris Pickering examines an electric racecar that was devised to highlight climate change and help create a low-carbon future powered by renewable energy

IT'S five and a half years since Formula E made its debut. During that time, the electric championship has gone from an object of curiosity to one of the world's most important race series, boasting as many road car manufacturers in its ranks as Formula 1 and LMP1 put together. That's quite a feat. But for his next project, Formula E creator Alejandro Agag is getting really adventurous.

The Extreme E series will be off-road racing's answer to Formula E, with rally raid-style events held across the globe. In an environmental twist, the rounds will be based in regions that are at risk from issues such as climate change, including the edge of the Sahara desert, the Amazon rainforest, the Himalayas, the Pacific islands and the Arctic.

The competitions will follow a point-

"A wheelbase 100 millimetres shorter than Formula E: quite a challenge when you have to squeeze two complete drivetrains into that space"

ABOVE Odyssey 21 testing at Chateau de Lastours in the south of France. The car will race at some of the most remote corners of the planet, highlighting the climate change challenges faced by different ecosystems

to-point format, with teams racing through a series of virtual gates, taking in a combination of off-road tracks and open ground. Unlike traditional rally raid events, however, the distances involved will be quite short, with stages of around 10 km in length. The drivers will also be alone in the cockpit, with no navigators to help them out.

It's no surprise that Agag and his team have once again partnered with Spark Racing Technology, the French company that has produced all the chassis for Formula E since the series' inception. The car they have developed, the Odyssey 21, will form the basis of a 'spec' package to be used by the Extreme E competitors, although some areas will be open for development.

The project began with more or less a blank sheet of paper, explains Theo Gouzin, chief engineer at Spark Racing Technology: "Alejandro [Agag] explained that the series would be based around short races with a high power output, but almost everything else was open for discussion at that time. We started with a very broad remit, looking at different ways to design a car to go off-road."

Alongside the option of a rally raid-style vehicle, the Spark engineers initially considered something along the lines of a Safari-spec WRC car. But as the discussions progressed it became obvious that Agag and his team were planning to race in very, very remote locations. What's more, they weren't just looking at rough roads, but proper off-road terrain, with significant obstacles to negotiate.

From that point onwards, Gouzin and his colleagues turned to the most obvious starting point: the FIA's rally raid regulations. Elements were also drawn from the regulations for the WRC and GT racing, picking what they believed to be the best aspects from each category.

"We followed the Dakar Rally regulations quite closely," he recalls. "The spaceframe design, for example, is slightly different to that of a rally raid car because we needed extra space to package the battery, but the rest is very similar."

In the spirit of this 'cherry picking' approach, the Spark engineers loosely followed the Dakar's four-wheel drive regulations, but dropped in some of the concessions that are normally offered for two-wheel drive vehicles. The wheels, for instance, are giant 37-inch (940 mm) alloys shod with balloon tyres, which are ▶

BELOW The use of RMS Helena as a mobile hub for the series will reduce the carbon footprint for the logistics operation by a factor of three compared to using aircraft

ABOVE The series has been designed to raise awareness of climate change and inspire action

normally reserved for two-wheel drive cars. Likewise, at 380 mm, the wheel travel is around the same as a two-wheel drive rally raid car (while 4X4s are limited to 280 mm). This, combined with the torque of an electric drivetrain, should give the cars phenomenal obstacle-clearing ability.

Laying down the drivetrain specifications was fairly straightforward, we're told. Right from the start, the organisers were keen to provide some degree of commonality with the technology used in Formula E. As such, the Extreme E cars will effectively combine two identical Formula E motors (rated at 200 kW in race mode) to give a total of 400 kW and four-wheel drive. "The torque and efficiency optimisation is a little different for Extreme E, but most of the fundamentals can be carried over," notes Gouzin.

DOWN TO DETAILS

The battery specifications were harder to define. Gouzin and his colleagues set about analysing the requirements for the system, while Williams Advanced Engineering, which had previously supplied the first-generation Formula E battery, was brought in to handle the design and production.

"When we started Formula E, we were dealing with cars on a normal circuit, so we could simulate the power consumption quite accurately based on the weight, tyre performance and aerodynamics," comments Gouzin. "With Extreme E it's a lot more complicated, because the grip levels and the terrain vary a lot. We used our experience to come up with a good estimate and then we added some margin to that."

The end result is a battery capacity of 54 kWh – the same as the current Formula E battery (which is an unrelated unit made by McLaren Applied Technologies and Atieva) and similar to the Tesla Model 3 road car. That's designed to allow the car to do two Extreme E stages (circa 20 km) before it requires recharging.

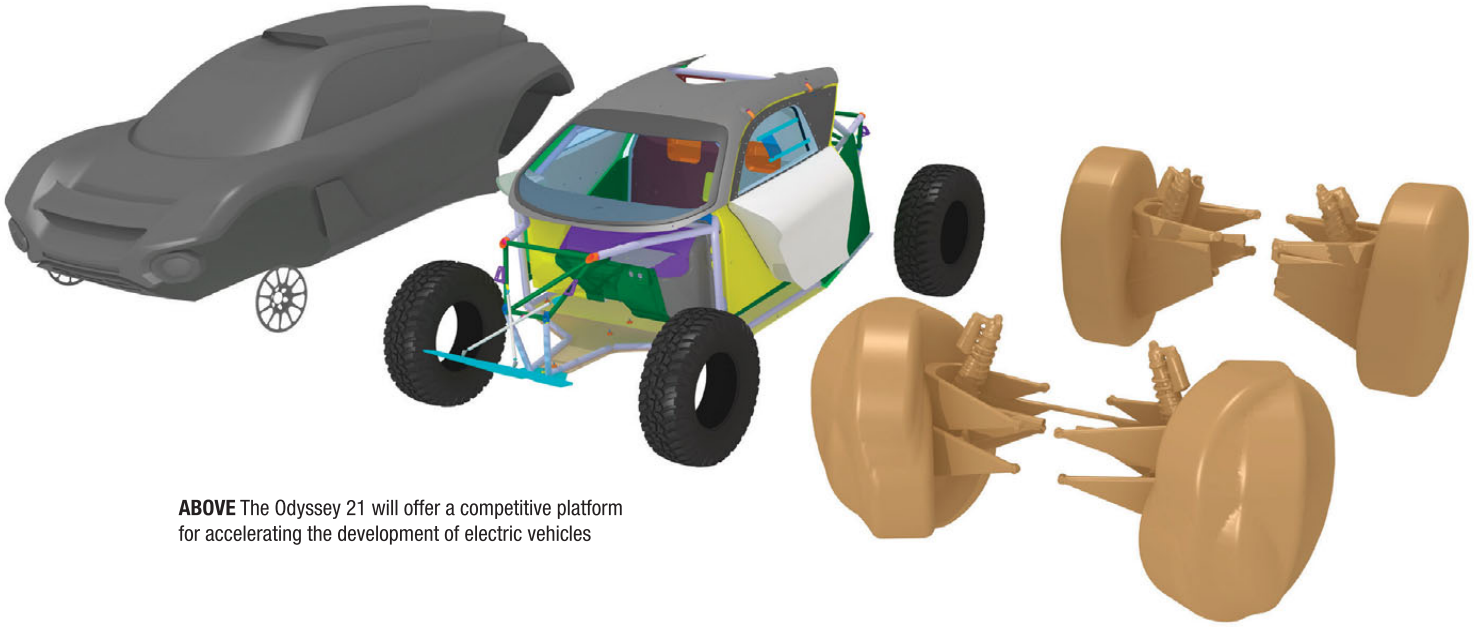
"In testing, we can run the car for around half an hour at a time, so it's a lot closer to World Rallycross [than the Dakar] in terms of race duration," Gouzin notes. "In the future we may be able to further optimise the battery. If we find that we can recharge after every session then it's possible that we might reduce the battery capacity a little bit to decrease weight, but our target for the beginning was to have a reliable car with a degree of future-proofing."

As with the motors, the gearboxes are identical front and rear. The two drivetrains operate completely independently with no physical connection, although conventional mechanical differentials are used to split the torque across each axle.

"We wanted to keep the manoeuvrability of the car as high as possible, so we reduced the wheelbase to 3 metres – 100 millimetres shorter than Formula E," Gouzin notes. "That becomes quite a challenge when you have to squeeze two complete drivetrains into that space."

To make the most of the available space, each drive unit is stacked vertically, with the motor directly above the axle and a single-speed reduction gearbox beneath it. The width of the transmission is also significant, Gouzin points out: "One constraint that comes up on every rally raid car is the angle of the driveshafts. Every millimetre that you can reduce in the size of the differential gives you extra wheel travel."

The suspension systems use double wishbones at both ends with a single damper used on each corner for cost reasons (in contrast to the twin damper setups commonly seen on rally raid cars). Likewise, the brakes feature conventional ▶



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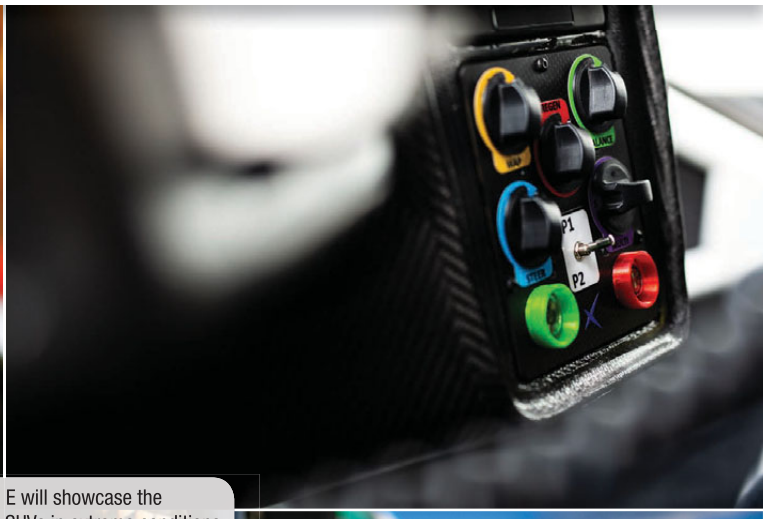

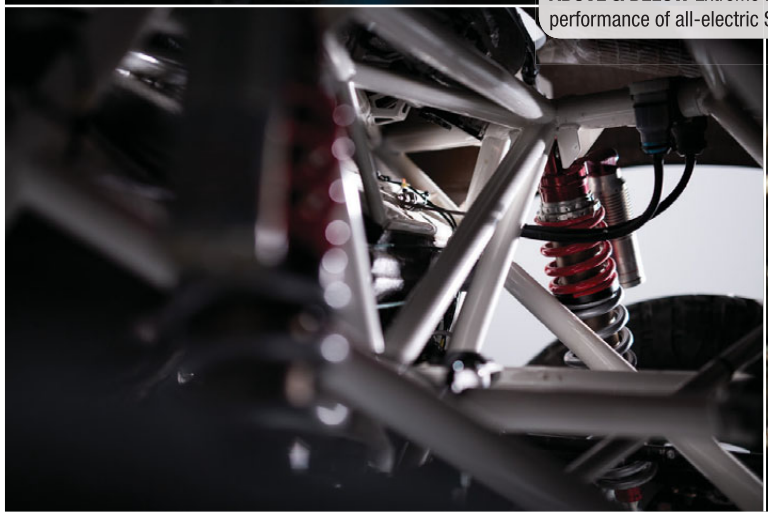

ABOVE & BELOW Extreme E will showcase the performance of all-electric SUVs in extreme conditions

air-cooled callipers (unlike some rally raid cars, which use water cooling). Here, the sheer size of the wheels helps by providing the space to run large diameter discs. It's also worth bearing in mind that the Odyssey 21 actually tips the scales at several hundred kilos less than a fully-laden rally raid car, so there's not as much energy to dissipate.

"We're not using a great deal of regenerative braking at the moment as we want to limit the battery's duty cycle, but that's something we might look at in the future," says Gouzin. "One of the things we learnt in the first season of Formula E was to ensure that the transmission was mounted transversely [without the need for a crown wheel and pinion] and that the gears were symmetrical so they could transfer torque equally well in either direction."

The stage lengths are dramatically shorter than those of traditional rally raid competitions, which are frequently measured in hundreds of kilometres. There's no doubt that this will change the character of the event somewhat, but it may actually be a good thing for TV audiences. Similarly, it brings a number of engineering benefits. Dakar cars not only carry hundreds of litres of fuel, but also a fairly comprehensive stock of spare parts and large emergency water tanks in case the crews find themselves stranded a long way from rescue.

The short-range format of Extreme E eliminates the need for much of this equipment, which makes the cars lighter and simpler. In theory, it should also make them faster, thanks to more power and less weight. Spark claims a 0 to 100 kph (0 to 62 mph) time of around 4.5 seconds and the ability to scale gradients of up to 130 per cent (52.5 degrees).

EXTREME ENVIRONMENTS

The shorter distances involved might make things more manageable than a conventional rally raid, but the terrain and the environmental conditions in Extreme E promise to be every bit as challenging. One of the first things that springs to mind when you talk about electric vehicles plunging through river crossings or sitting axle-deep in mud is sealing. In some respects, though, the situation is actually simpler than it would be on a combustion-engined car. Electric motors don't have many seals, the transmission is far simpler and the batteries already have to be very well sealed to meet the safety regulations.

In theory, the technology used in Formula E should already be robust enough for these environments, but Gouzin admits he took some convincing: "I remember the first time we tested the new car off-road. It came back covered in mud, so I took it to the workshop to clean it with a pressure washer and I thought for a second 'should I really do this?' Even though you know it's designed for that, there's a moment of hesitation the first time you put it to the test!"

Another major challenge in extreme environments is typically cooling. You might imagine that this would be a particularly serious concern for electric vehicles, which can sometimes struggle with battery performance in extremely hot or cold conditions. Perhaps surprisingly, the short distances involved mean that the Odyssey 21 doesn't actually require any onboard battery cooling at all. Instead, an external device will be plugged in before and after each stage to manage the battery temperature. ▶

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Eliminating the need for an onboard cooling system theoretically also means there's one less thing to go wrong, which is a paramount concern when you're operating in remote locations, Gouzin explains: "Battery rebuilds were quite common at the beginning of Formula E. Even today, it's not unusual to need to change a fuse or a contactor somewhere. That will be a lot more difficult in Extreme E [due to the environments the series will operate in] and it will take a lot longer to ship the batteries back to Europe if they can't be fixed on-site, so reliability becomes even more important."

BELOW Gouzin says Spark's creation blends elements of Formula E, Rally Raids, WRC and GT racing

In fact, servicing in general poses something of a problem when you're operating somewhere like the Arctic or the Himalayas. There's the physical challenge of getting people and equipment out to inhospitable places, but there's also a cost element to consider. One of the first targets laid down in the project was that the teams would be limited to just six trackside personnel. (In contrast, the Formula E regulations allow up to 20 people, while the head count for a manufacturer LMP1 team could be upwards of 60.)

Again, the solution is to design a robust package that will require minimal servicing. Gouzin says he's hoping it will be possible to go for an entire season without changing things like wishbones or driveshafts. In fact, the plan is to avoid any servicing at all during the course of an event, so the team can focus on setup and car preparation.

The code used in the car's ECU will be fixed, but the teams will be able to adjust calibration parameters like the front-to-rear torque split to suit the conditions and the drivers' personal preferences. This is a new system that's been developed specifically for the Odyssey 21's four-wheel drive setup, although it does take some inspiration from Formula E when it comes to things like the status indicators that display whether or not the electrical systems are isolated.

Even before the crews can begin work on the setup, however, there's the logistical challenge of how to get the cars to the start line. Here too, Extreme E has come up with a novel solution. Rather than send everything by air freight, the organisation has acquired an ex-Royal Mail transport ship, the RMS Helena, which it is re-fitting to act as a 'floating paddock'. This is said to reduce the carbon footprint for the logistics operation by a factor of three in comparison to using aircraft. On top of that, the organisers are looking at converting the ship to run on biofuel and they are also investigating some more unconventional solutions, such as using giant kites to assist with the boat's propulsion (the latter may sound outlandish, but it's an established idea in the shipping industry).

The plan is to dock the boat at the nearest port and then use a road convoy for the remaining distance. Part of the brief was that the cars should be road-legal with things like lights and indicators, so it's even possible that they may be driven to the events.

A BIG ADVENTURE

Much like Formula E, the plan is to open up areas of the design so the individual teams can apply their own technology. For the time being, the only hardware aspects they will be able to develop are the motors and the inverters, but it's likely that this could change in the future.

Aside from those areas, almost no physical parts will be carried over from the single-seater series (the only exception is the collapsible steering column, which will be used in both). The main reason for this, Gouzin points out, is the vastly different specification of the two cars – in particular the weight, which at 1,650 kg (unladen) is getting on for twice that of a 900 kg Formula E machine.

Nonetheless, the Spark engineers have certainly benefitted from their experience in Formula E. "One of the nice things about doing this now that Formula E is established is that we already have a contact at all the major suppliers," Gouzin comments. "We've not had to spend anything like as much time explaining what we plan to do. The project began in September 2018, but we had a complete car running in time for the Goodwood Festival of Speed at the start of July [2019]."

Since then, the emphasis has shifted onto testing, he explains: "We studied the design of some existing rally raid cars at the start of the project to try to understand what approaches people are using for the chassis and suspension. On top of that, we also carried out a lot of simulation. In the end, though, I think the best you can do in off-road racing is to test your car and see what breaks. We've done over 300 km and things have gone very well so far."

Of course, the acid test will come in 2021, when the Extreme E series makes its debut. To some, its unconventional format, short-range races and overt environmental message might seem a little contrived. But much the same argument could have been applied to Formula E when it first appeared in 2014. Don't be surprised if Alejandro Agag's difficult second album turns out to be another big hit. RT

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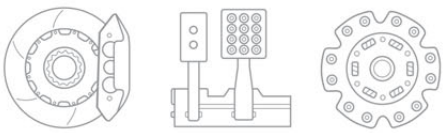

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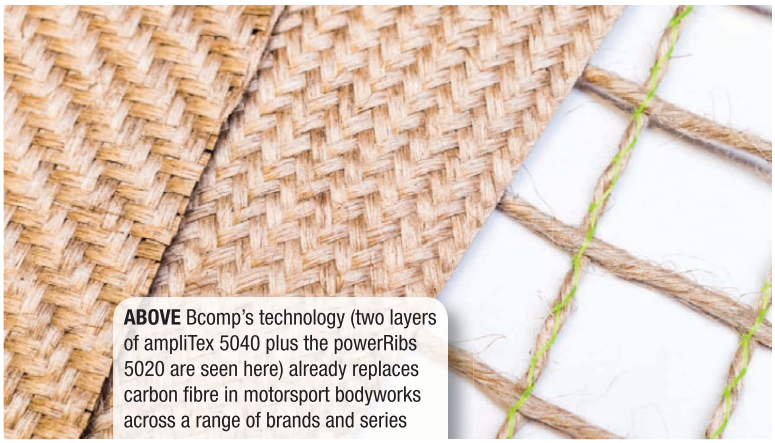


ABOVE Bcomp's technology (two layers of ampliTex 5040 plus the powerRibs 5020 are seen here) already replaces carbon fibre in motorsport bodyworks across a range of brands and series

William Kimberley introduces the contenders for Race Tech's exciting new award category

Bcomp
Nominated for its powerRibs

BY applying the latest lightweighting and composites knowledge to natural fibres, Swiss clean-tech firm Bcomp has developed proprietary lightweighting solutions. The powerRibs is a natural fibre reinforcement grid inspired by the thin veins on leaves, providing maximal stiffness at minimal weight. It is used on the B-side of thin-walled shell elements and can be combined with natural fibres or other engineering materials.

For high-performance applications such as motorsport bodywork, the powerRibs matches the performance of carbon fibres while cutting costs by 30% and reducing the CO2 footprint by 75%. In addition, it improves human safety without toxic carbon dust, splinters and sharp carbon shattering – which could damage tyres – and has five times higher vibration damping. At end of life, parts can be ground down into a new base-material or incinerated for heat within the standard waste management system.

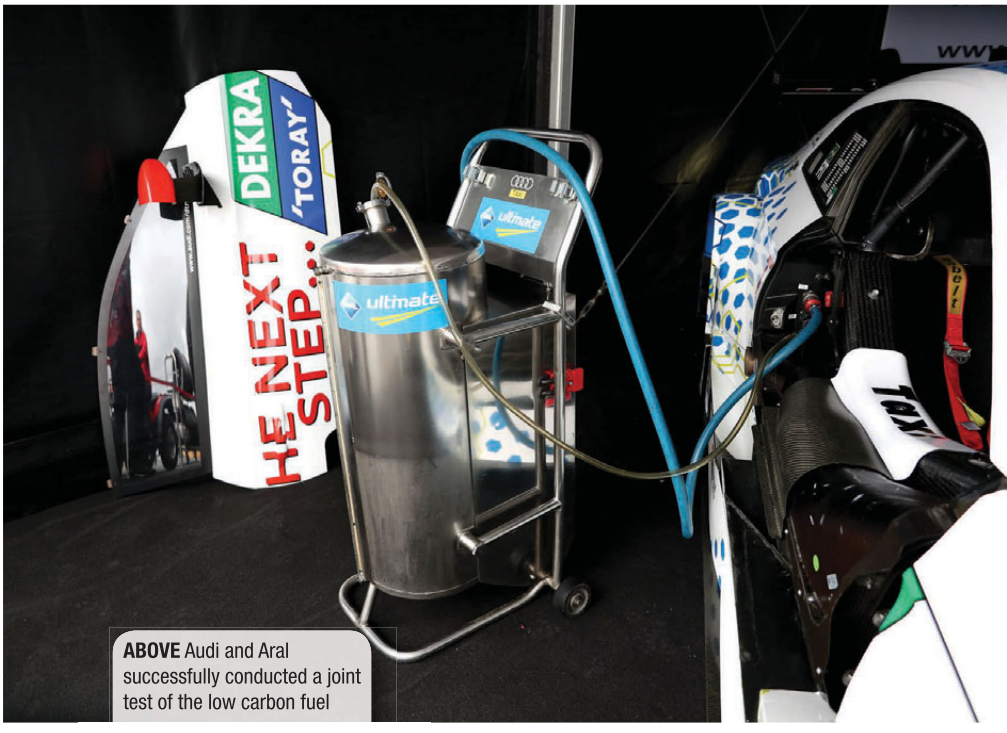
powerRibs have earned a range of innovation awards and Bcomp was a JEC Innovation Award finalist in 2019 as a partner of Porsche for RTM serial production of natural fibre bodywork for race cars. Over the last year, powerRibs have been well tested in both production and on the race track by several series and brands around the world, proving to be a viable solution rather than simply a nice concept.

Audi and Aral
Nominated for low carbon fuel

WITH the introduction of highly efficient turbo engines, the DTM has achieved a significant CO2 reduction in the 2019 season. At the DTM finale at Hockenheim, Audi, together with series promoter ITR and its technology partner Aral, made the next major move: for the first time, both Audi RS 5 DTM race taxis were using innovative fuel that improves the CO2 balance by 30% compared to gasoline purely based on mineral oil. It has a composition of 50% being made up of high-quality renewable components derived from waste materials. Even so, in terms of its properties, it meets the quality standards of the "Aral Ultimate 102" fuel that has been prescribed in the DTM since 2005.

"We did not have to make any modifications to the DTM engine and have not had the slightest problem on the test bench so far," says Ulrich Baretzky, head of engine development at Audi Motorsport. "Consequently, we are proving that low carbon fuels are also suitable for racing engines."

Audi has also been researching alternative fuels for road car production for several years. The company is working independently on projects for the production of e-gas, e-diesel and e-gasoline. ▶



ABOVE Audi and Aral successfully conducted a joint test of the low carbon fuel

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ABOVE Total has developed the world's first mobile hydrogen refuelling station

Total
Nominated for its modular hydrogen filling systems

IN the face of climate issues and the evolution of technologies and uses, surface transports must also make the ecological and technological transition. There is no one single energy that best meets the needs, but a mix of optimal solutions depending on their location and uses.

Hydrogen, says Total, is one such alternative. Running cars and buses while only rejecting steam – nothing is impossible for the smallest atom, which is also the most abundant element in the universe.

If the fleet of hydrogen vehicles is still modest, Total innovates in pilot projects to prepare the mobility of tomorrow. The hydrogen car presents serious assets as it combines the benefits of electric vehicles in terms of emissions and those of conventional thermal vehicles in terms of range and charging time.

Total has been working alongside the ACO since 2018 as fuel supplier to the World Endurance Championship, and the European and Asian Le Mans Series. It was therefore only natural as an energy supplier to get involved in MissionH24. The technological and sporting aims of the programme are perfectly aligned with its strategy and commitment to a sustainable future and responsible energy. This partnership has also given Total the opportunity to break new ground in designing and developing safe, efficient modular hydrogen filling systems.

To meet the needs of the MissionH24 programme and the LMPH2G's introduction into a race environment, Total has developed the world's first mobile hydrogen station. This station can refuel the prototype with hydrogen, safely and reliably.

The H24Racing team can transport it from circuit to circuit, whenever the car undergoes private testing or races at tracks that are yet to install hydrogen refuelling facilities.

Ricardo
Nominated for its 2019 Formula E transmission

RICARDO has developed a number of core building blocks within a systems approach to electrification. This includes supplying the transmission deployed in the double championship-winning DS Performance Formula E team's E-Tense FE19 car used in the 2018-2019 season.

With typical 0-100 km/h acceleration of 2.8 seconds and motor speeds of up to 30,000 rev/min, gearbox weight and durability optimisation are crucially important. With drivetrain efficiency being so vital to race success, the rapid development of transmission technology has been a key element of the Formula E story.

To meet the requirements, Ricardo used its cutting-edge design and analysis methods, testing facilities and world-class advanced manufacturing technology to deliver to the DS Performance Formula E team an extreme performance and high efficiency transmission.

"The ABB FIA Formula E Championship represents the pinnacle of electric motorsport performance and Ricardo is proud to be part of its development, especially given the record of the competition in driving innovation to benefit the entire electric vehicle sector," said Ricardo Performance Products MD Martin Starkey. "Ricardo's involvement in Formula E is part of our own commitment to developing the performance of electrically-driven vehicles in all aspects of mobility, and we look forward to continuing success in the coming 2020 Formula E season.

"Ricardo is proud to extend our relationship with DS Performance to include Season 6 of Formula E, the world's premier electric racing series. Efficiency is the watchword in this formula, which places great emphasis on excellence in driveline performance, and we are pleased to have played our part in this by providing the transmission for the 2018-2019 DS Performance double championship-winning car."

ABOVE Efficiency is a key performance differentiator in Formula E. Ricardo's powertrain was used by the double-title-winning DS Techeetah squad

Formula E

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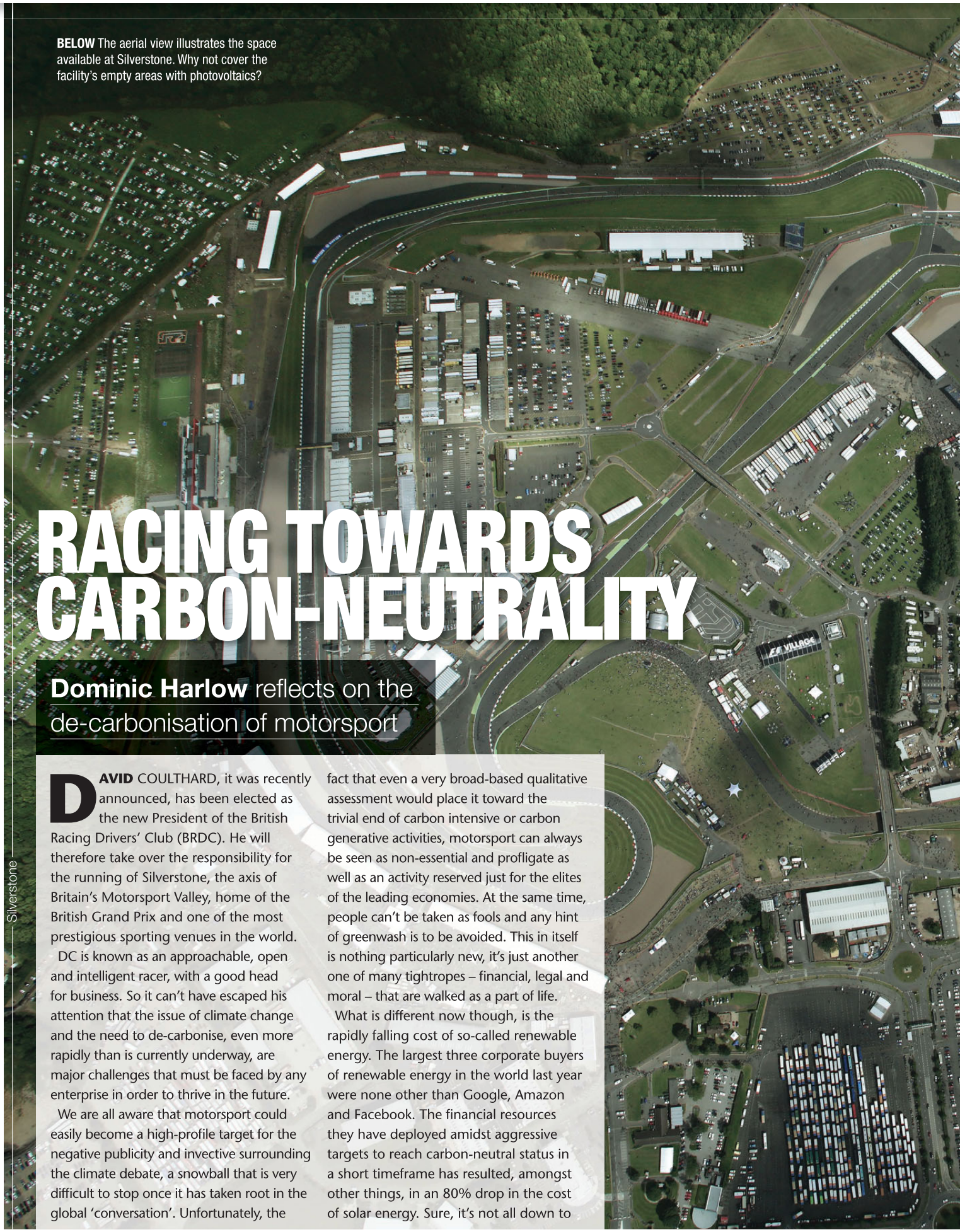
RACE TECH's Editor -in-Chief William Kimberley and his panel of industry experts have been looking for ground breaking motorsport technology that enables a positive impact on the environment. Join the RACE TECH World Motorsport Symposium Champagne Drinks Reception and Networking Awards dinner on the evening of Tuesday 3rd December at the Millennium Gloucester Hotel, London Kensington to find out the GREEN TECH shortlist and winner as well as the winners of the Most Innovative New Motorsport Product, Race Powertrain award and Racecar Aerodynamicist award.

ABOVE Dialma Zinellia and DALLARA win Racecar Aerodynamicist of the Year, Integral Powertrain win Race Powertrain of the Year & Bcomp Ltd wins the Most Innovative New Motorsport Product of the Year



BELOW The aerial view illustrates the space available at Silverstone. Why not cover the facility's empty areas with photovoltaics?

RACING TOWARDS CARBON-NEUTRALITY

Dominic Harlow reflects on the de-carbonisation of motorsport

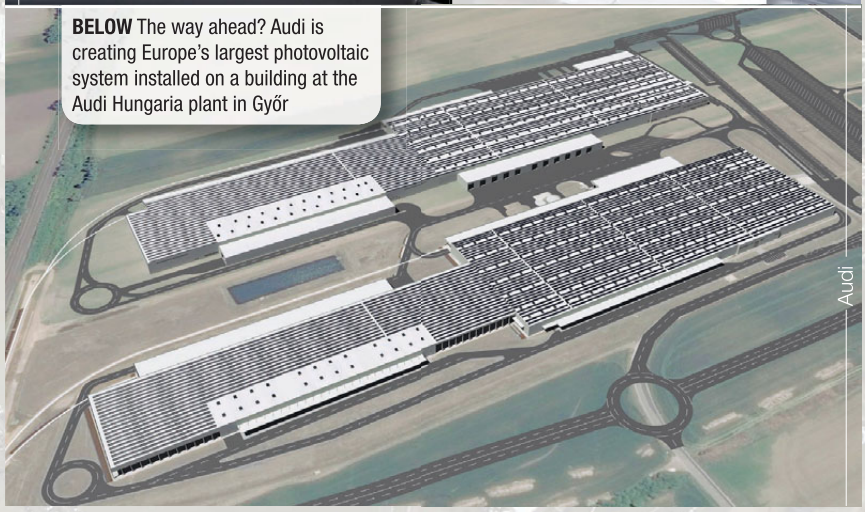
DAVID COULTHARD, it was recently announced, has been elected as the new President of the British Racing Drivers' Club (BRDC). He will therefore take over the responsibility for the running of Silverstone, the axis of Britain's Motorsport Valley, home of the British Grand Prix and one of the most prestigious sporting venues in the world.

DC is known as an approachable, open and intelligent racer, with a good head for business. So it can't have escaped his attention that the issue of climate change and the need to de-carbonise, even more rapidly than is currently underway, are major challenges that must be faced by any enterprise in order to thrive in the future.

We are all aware that motorsport could easily become a high-profile target for the negative publicity and invective surrounding the climate debate, a snowball that is very difficult to stop once it has taken root in the global 'conversation'. Unfortunately, the fact that even a very broad-based qualitative assessment would place it toward the trivial end of carbon intensive or carbon generative activities, motorsport can always be seen as non-essential and profligate as well as an activity reserved just for the elites of the leading economies. At the same time, people can't be taken as fools and any hint of greenwash is to be avoided. This in itself is nothing particularly new, it's just another one of many tightropes – financial, legal and moral – that are walked as a part of life.

What is different now though, is the rapidly falling cost of so-called renewable energy. The largest three corporate buyers of renewable energy in the world last year were none other than Google, Amazon and Facebook. The financial resources they have deployed amidst aggressive targets to reach carbon-neutral status in a short timeframe has resulted, amongst other things, in an 80% drop in the cost of solar energy. Sure, it's not all down to

ABOVE F1's newly-launched sustainability initiative is indicative of increasing momentum in this area



BELOW The way ahead? Audi is creating Europe's largest photovoltaic system installed on a building at the Audi Hungaria plant in Győr

renewables but according to the National Grid, Friday 21 April 2017 was the first working day in the UK without coal power since the Industrial Revolution.

I have been fortunate to have quite a few hours of experience flying, sometimes at relatively low altitude, in the skies above Silverstone and the surrounding countryside. Two things have stood out which, I have come to believe, may offer an interesting opportunity for DC and the Silverstone team to take a step forward in de-carbonizing. Firstly, there are a lot of disused or re-purposed former WWII airfields in this part of the UK, (a statement of the obvious maybe, since Silverstone itself is one); secondly, many of them have been covered in solar panels.

SOLAR PARK

In fact, Silverstone's closest neighbour and former satellite airfield, Turweston, as well as nearby Westcott, another wartime home to Wellington bombers, both now house solar parks. The logic is obvious: these sites have space (Silverstone included), a lot of which is not intensively used; they are usually higher than the surrounding land; they are relatively flat and with an open aspect to the south-west (the preferred landing direction in the UK since it aligns with the predominant wind). So why not cover Silverstone's empty areas with photovoltaics? Use the car parks, the infields, the remaining runways, the roof of the grandstands and so on. Could the power generated then be used to offset the fossil fuels being used on track and allow the venue to claim a level of carbon-neutrality?

Turning to the excellent reference, *Sustainable Energy without the hot air*, by David JC Mackay, it's possible to examine the prospect in more detail using some data.

The power of the sun, per m^2 of land area in Britain, correcting for the angle of the sun, seasonality, effect of cloud cover and averaging over the hours of daylight, is around 100W. The most efficient PV panels are reaching 25% efficiency, and probably won't get above 30% in such an application. Now on track, during the British Grand Prix, 20 cars burn fossil fuel for 90 minutes and release CO_2 in a similar way to an oil or gas-fired power station, albeit slightly more efficiently. So, if we wanted to channel our solar-generated electricity back into the grid (or maybe directly to the Silverstone Technology Park to power those businesses), what area of panels would be required?

Obviously, this depends how quickly we want to offset the Grand Prix. If we want to do it 'instantaneously', then it will be necessary to match the 110 kg (at 100 kg/hr maximum) of fuel powering the cars for the hour and a half, with a calorific value of 46 MJ/kg. That equates to 18.75 MW – incidentally, Turweston solar park has a quoted power of 16.7 MW and cost around £15m, including land, around five years ago – and we're going to need 625,000m^2 or 154 acres.

Silverstone's total site area is 850 acres, so whilst it might not be practical to achieve that kind of coverage, given the track is not used anywhere near 100% of the time or by 20 F1 cars, the numbers appear to add up. It is also worth just dispelling one 'mythconception' that PV panels require more power to manufacture than they harvest in their lifetime: in fact, they can have a yield of five times that energy over their lifetime.

If this is indeed the case, then why not roll this model out to more circuits? Motorsport Vision owns almost all the remaining large UK venues with paddock, offices, garages and so on, and so perhaps the entire site energy consumptions could be offset this way? Perhaps F1 should require new circuit developments to include this kind of element, particularly given the often sunnier regions in which they are built. Some progress seems really possible. Okay, perhaps not Monaco...

It seems surprising that this entire topic has not been more widely considered. I mean, anyone who has ever been knows Silverstone is also quite windy – those airfields again. In one possible glimpse of the future, I have recently noticed that I parked under a large solar array in the visitors and staff car-park of one Alfa-Romeo Sauber F1 team. Switzerland, like Germany, is fairly advanced in the adoption of renewables, and clearly there are a few electrons trickling back into the grid to offset the wind tunnel and CFD clusters chugging away next door. It's not as fashionable to say it, but the difference is likely to be in many quiet, incremental changes like this. RT

F1'S BATTLE TO RETAIN SIX APPEAL

The sixth straight double title haul for Mercedes doesn't do justice to the ferocity of the fight beneath the surface. **Craig Scarborough** explains

CLOSE competition on track has not necessarily been a distinguishing feature of F1 in recent years. But, beneath the daunting headline of a sixth consecutive double world championship haul for Mercedes, 2019 was an incredibly close-fought season. At the front, the champions had to repel challenges from both Ferrari and Red Bull. Behind, there was a tense six-way battle between the midfield teams.

Aero and tyre changes over the winter had been aimed at improving overtaking. Whilst a tiny gain compared to those planned for 2021, anecdotal evidence suggests these objectives were met. This left many areas of the car's design unaffected by the rule changes and teams capitalised by seeking a competitive advantage in power unit and suspension design.

ADVANCING AERO

The revised aero regulations, featuring simpler front wings, a deeper/wider rear wing and lower height for the bargeboards, presented the major design challenge for 2019. Of these, it was the front wing philosophy that split the grid, with two basic variations to produce both downforce outwash and feed the bargeboards/underfloor with airflow.

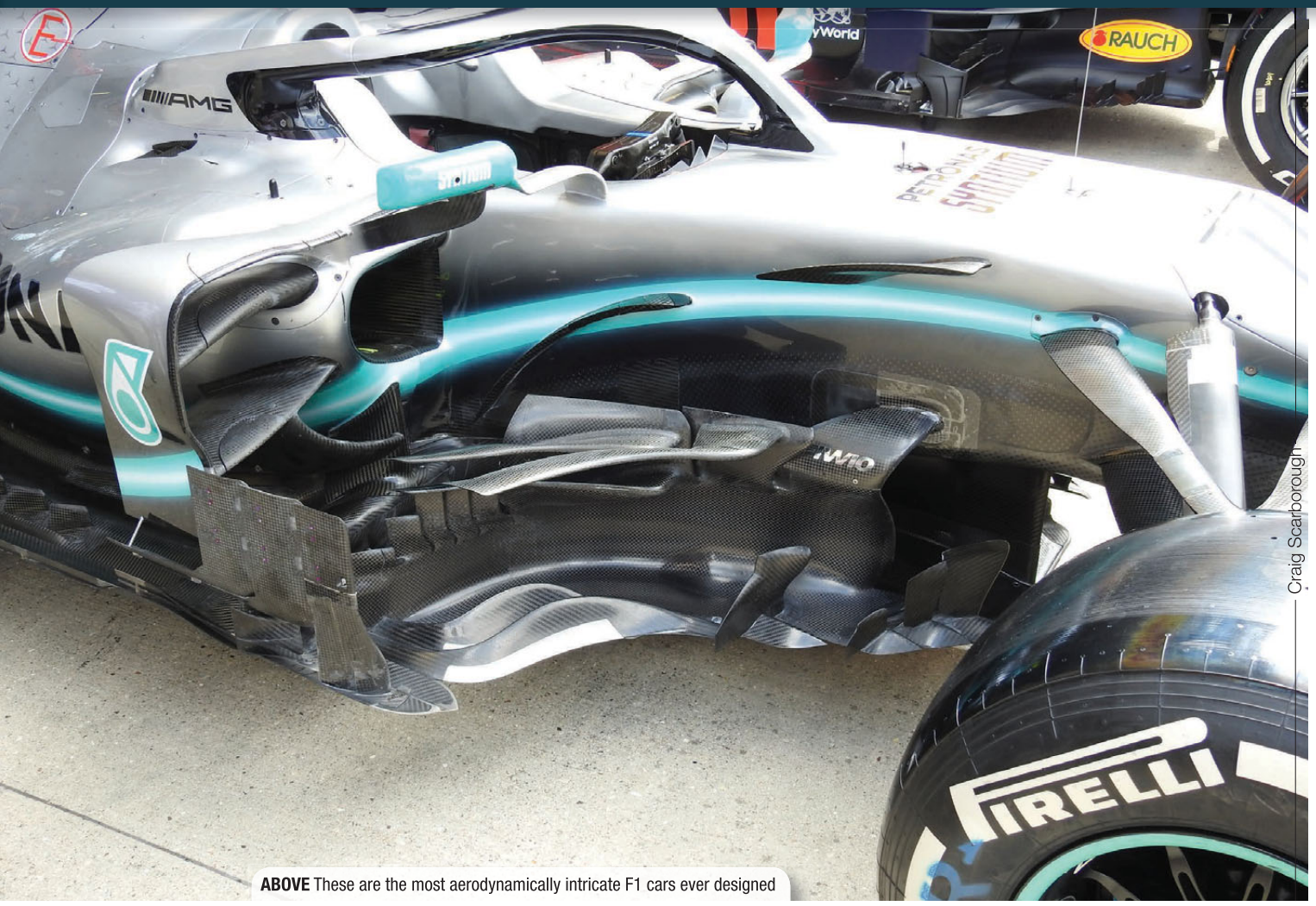
With the pre-2019 front wings, the basic approach was to load the outer tip of the wing. This gave the front axle its downforce and the airflow spilling from the wing, endplate and cascade winglets all pushed airflow outwards to keep the front tyre wake away from the rear of the car. This left the rear of the wingspan free to direct airflow in between the wheel and chassis. Some of this, known as the Y250 vortex, swept outwards to further manage front tyre wake and clean airflow was maintained to the ever more intricate bargeboards.

Now faced with just five wing elements, no cascade winglets and a highly constrained endplate geometry, teams such as Mercedes and Red Bull retained the outboard loaded philosophy through into 2019. This kept the strong airflow to the bargeboards and still created the balancing downforce required from the front wing, but with the compromise in outwash at the wing tip.

Ferrari and Alfa Romeo took the extreme opposite approach, flattening the wing's angle of attack at the outboard tip to expose the endplate for a greater

Mauger/LAT

ABOVE This was a pivotal moment in the season, with Vettel penalised for pushing Hamilton towards the wall in Canada. The battle between Mercedes and Ferrari revolved around their contrasting approaches to the new front wing regulations



Craig Scarborough

ABOVE These are the most aerodynamically intricate F1 cars ever designed

outwash effect. This theoretically helped the car's net drag, as the front tyre wake was better managed downstream, but its compromise was the airflow to the bargeboards, which in turn hindered airflow control around and under the car, costing downforce.

As the season started, both approaches had their attractions, somewhat steered by the teams' previous area of peak development. Mercedes, with the most complex bargeboards and peak power output, wanted to continue to exploit the bargeboard performance and had the engine power to pay the drag penalty.

Ferrari had been chasing to keep up with Mercedes on the straights in 2019, so drag was a greater penalty. Equally, it had a far less developed bargeboard package.

From the first race, the field was equally split between inboard and outboard loaded wing designs. Both Mercedes and Red Bull soon exploited a cut out section in the endplate to expose the front wing flap tip, the tip vortex being useful to create an outwash effect. But the sharp wing tip imperilled the tyres of competitors, thus the teams were forced to smooth the exposed wing tip to the detriment of its performance.

Then, as the teams matured their designs and researched alternative solutions, the Ferrari-esque inboard loaded design started to gain favour with other outfits. It's unusual for teams to switch a major aero philosophy mid-season – even rarer for this to occur very early on in the campaign – but both McLaren and Racing Point switched from outboard to inboard loading on their front wings. The incremental development throughout the year saw most teams ease off the loading at the outer wing tip, and instead adopt a conservative approach to Ferrari's inboard ▶

Craig Scarborough

ABOVE The under-nose 'cape', first developed by Mercedes, was widely adopted across the rest of the grid this season

ABOVE The high outboard expansion front wings were costlier in drag but could produce more downforce

loaded solution.

Such a widespread adoption of this idea suggests that the detrimental airflow in the Y250 and bargeboard area was overcome with detail airflow management with the inner wing tips and the nose/front wing pylons. In addition, an under-nose vane known as a cape, first developed by Mercedes, was widely adopted up and down the grid. The swooping horizontal surface offered a useful means to control airflow downstream, with tip vortices spiralling from its trailing edges.

Bargeboard development also continued apace. The enforcement of a cap on their height still left the vertical and footplate sections free for ever more complexity, with additional vanes and slots being added to every surface. Such incessant splitting of surfaces has led to these being the most aerodynamically intricate F1 cars ever, surpassing even the excesses of 2008.

PROBLEMATIC PIRELLIS

If the aero changes challenged the design office at each team's factory, then it was the tyres that stressed the race engineering department.

Under the post-2017 aero rules, the wider cars and greater downforce increased cornering speeds, leading to more lateral stress on the tyres. Pirelli took steps in 2018 to manage the tyres in fast turns, and for some races elected to run with less gauge on the tread surface. The thinner rubber at the contact patch generates less heat and reduced the blistering that blighted previous seasons.

For 2019 the entire dry tyre range featured this thinner gauge. Certainly the top teams, with their higher cornering speed, benefited from this change. However, the midfield, with lesser cornering loads and limited resources, struggled.

Although designed to have high degradation to meet the FIA's objectives, Pirelli tyres are also sensitive to working temperature. This peaky nature leads to problems, with teams managing the tyre temperatures, both throughout the weekend and from track to track, especially ▶

Haas F1 Team

BELOW Haas' struggle to get the most from its Pirelli tyres left it "a sitting duck" against the opposition

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with different ambient temperatures.

Generally speaking, the rear tyres tend to run too hot; the front ones struggle to gain temperature. Thus any sliding of the tyre from lack of downforce, or running under their working temperature, sends the surface temperature rocketing. If the teams aren't able to get the tyre up to its working range from the off, then the sudden increase in temperature from sliding pushes the tyre over its working range, leading to still less grip. Some squads coped with this relatively consistently through the season, but others really struggled. Haas, in particular, could not find the right balance between qualifying and race and this occurred at most tracks.

With new tyres for 2020, albeit from the same thin gauge family as in 2019, there will continue to be an issue for the mid-grid teams striving to extract the best from their rubber.

ABOVE The ability of cars to follow each other closely is a key focus for the rules upheaval — Pirelli

POWER UNIT PROGRESS

In contrast to the chassis regulations, the power unit rules were left largely unchanged over the winter. The most notable exceptions were an additional race fuel allowance, with a 5 kg increase to 110 kg, and further restrictions on oil consumption.

Although intended to allow flat-out racing from lights to flag, the increase in race fuel had little impact. Race pace tends to be tyre-limited, so the extra fuel was only used at high consumption races. Indeed, a lighter race starting weight was judged to be of more benefit than the ability to run the engine harder for longer.

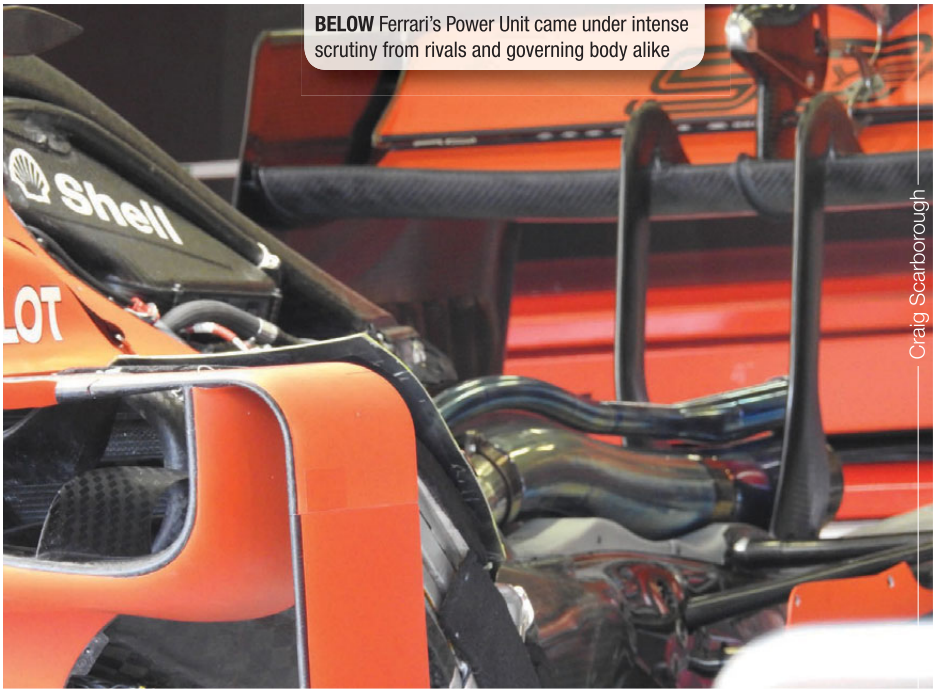
Coming on the back of an in-season technical directive to cap the use of oil as a combustion aid, the reworded 2019 regulations on oil consumption and storage were largely aimed at stamping out the use of high-power 'party modes'. Prior to this, oil was ingested into the inlet tract to introduce additives (not allowed in the fuel formulation) into the cylinders to boost power.

The development curve of the current 1.6-litre hybrid power units has certainly risen steeply: from maybe as little as 800 peak hp in 2014, to over 1,000 hp today. Development of the IC engine in particular has been at a startling pace. Yet with these 1,000 hp, 50% thermal efficiency engines, there remains little fanfare from the FIA, manufacturers or teams that such progress has been made.

The performance between the four manufacturers has converged over the years. Mercedes has always been higher up the hp scale and more consistent since 2014, with the engine bettering rivals in both party-mode and race-mode. Ferrari, from an initial poor response to the new power units, has caught and perhaps surpassed Mercedes on peak output. Renault and then Honda, which introduced its PU a year later, have both struggled to come to terms with the big two on performance, packaging and reliability.

2019 was perhaps the season when the four PUs were finally really very close on performance. Honda, in particular, has made huge strides in the past two years, with its fledgling relationship with Red Bull. There may now be only 10 hp between the engines in race mode.

While it's the PU's race mode and reliability that win points, its high power 'party mode' for qualifying certainly grabs the attention. The fans and, consequently, the media desire to know the most powerful engine, even if peak power alone is not the most accurate barometer for a good racecar engine. Focus has thus ▶



BELOW Ferrari's Power Unit came under intense scrutiny from rivals and governing body alike — Craig Scarborough

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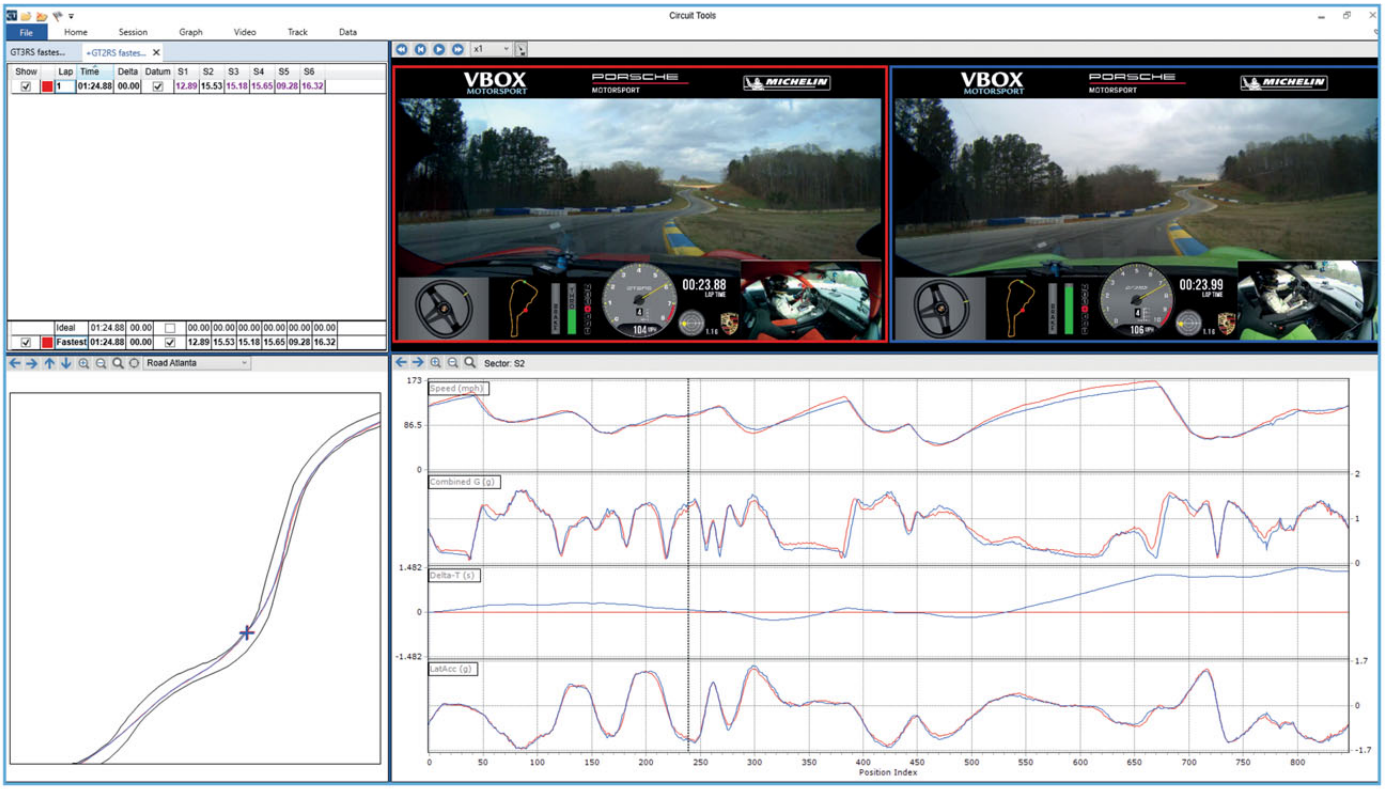
Peter Krause, Professional Racing Coach, Virginia International Raceway.



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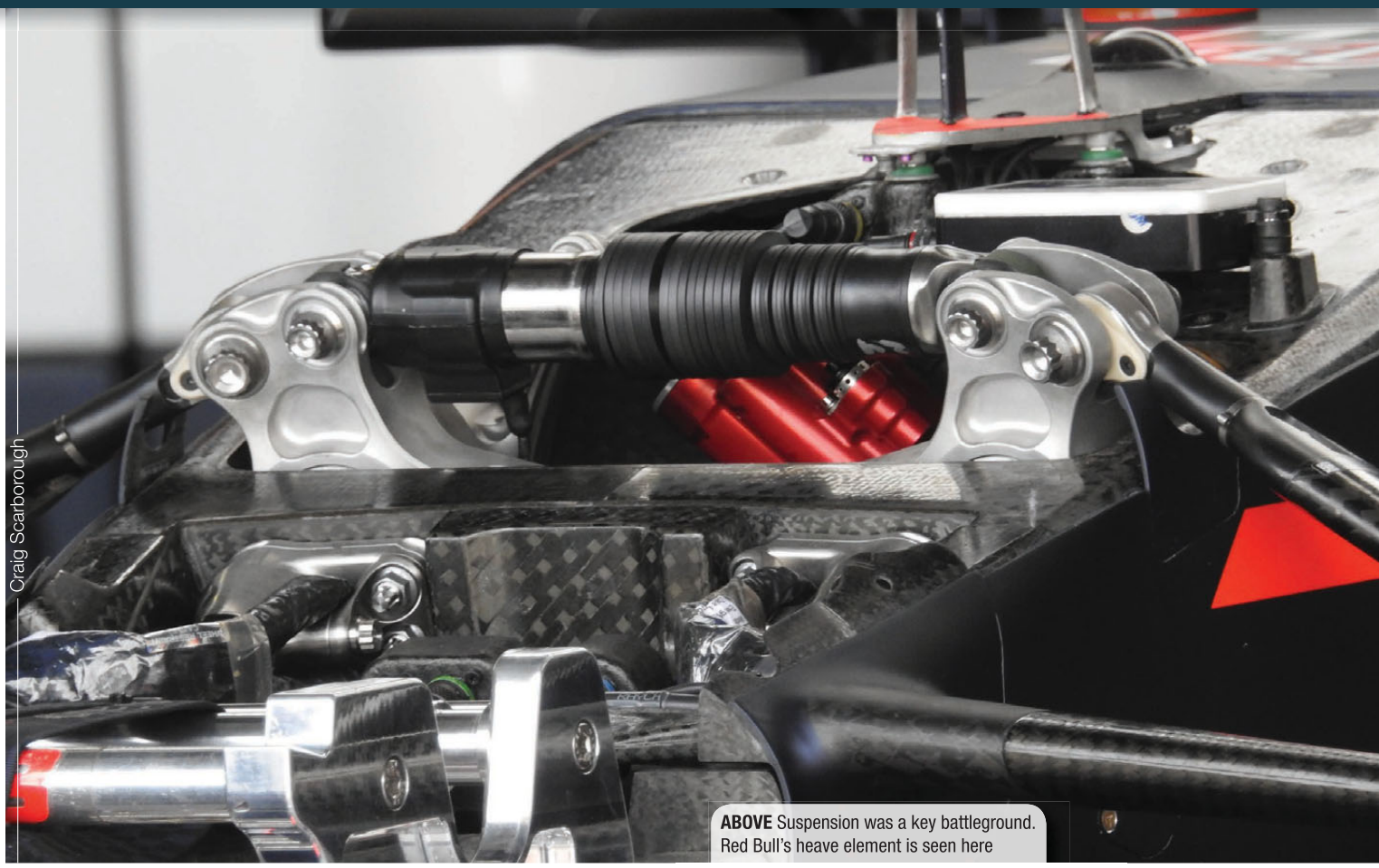
Craig Scarborough

ABOVE Suspension was a key battleground. Red Bull's heave element is seen here

been drawn to straight-line speed and qualifying performance.

In the first five years of this engine formula, it was Mercedes' chart-topping performance that saw it viewed as the most powerful engine. Its list of pole positions is testament to that fact.

Ferrari, however, has caught up this year, but not without controversy. Boasting straight-line speeds well above any rival and a string of power-boosted pole positions, has the Scuderia found something that the other teams don't have?

The evidence is certainly there. The Ferrari shows a higher performance on power-limited sections of nearly every track. Anecdotally, its acceleration in the lower gears is similar to its rivals, but the car continues to gain speed mid-straight, after its rivals' Vmax is reached. This could be partly explained by the car's lower drag aero philosophy: running less downforce and thus less drag to gain top speed is a well-known race engineering option. This is backed up by the FIA data showing Ferrari being relatively weak through corners.

Yet for many it's clear Ferrari has an ability to go faster and especially turn the engine up for qualifying, in a similar fashion to the advantage Mercedes has enjoyed for so many years. But Ferrari being Ferrari, the fingers are pointing to Machiavellian methods to achieve this, rather than the acceptance of it being any sort of pure engineering advantage.

Last year, it was Ferrari's split battery set up that drew negative attention from its rivals, albeit a solution run since 2014. Teams pressed the FIA to investigate the hybrid systems, as they were believed to be part of the boost in PU performance.

This year, with the split battery being discounted and oil burning capped, the focus for the paddock doubters has moved to other areas. Earlier in the season, questions were raised about energy transfer from the turbo's MHU-H to the MGU-K, but these never came to anything.

Next on the agenda was pre-cooled intercoolers for qualifying, which were equally fanciful. As the campaign drew towards its last races, more accusations were made. Firstly, the IC engine's intercooler. For 2019 Ferrari cooled the charge air with a water-to-air charge cooler, mounted to the front of the V6. Rumours suggested that the fluid in the cooler was able to pass into the charge air, allowing additives into the combustion process in an alternative method to the effectively banned oil-burning.

While it's been known the intercooler used a water-based cooling liquid previously, the suggestion was that the intercooler now used oil as a cooling medium. None of these rumours suggested how the fluid would pass from the intercooler jacket into the charge air. Any valves or opening would be obvious to the FIA, while the coolant pressure could overcome boost pressure and leak through joints, although this would be hard to control. Again, the FIA has been requested to clarify if any of this would be allowed and has issued a technical directive confirming it would not be legal.

The other angle of attack for its rivals suggests that Ferrari beat the fuel flow restriction, capped at an instantaneous rate of 100 kg/hr. This debate revolves around the sampling rate for the spec fuel flow sensor, the inference being that either the signal could be changed with electromagnetic interference, or that the sampling rate could be offset from the sensor's output. An FIA directive was released to the teams to prevent any of these practices, following Red Bull's request for clarification, although the impact on Ferrari's performance was arguable.

There's no conclusion to the question of Ferrari's apparent PU performance advantage, despite protestations from rivals. With a fixed regulatory framework through ▶

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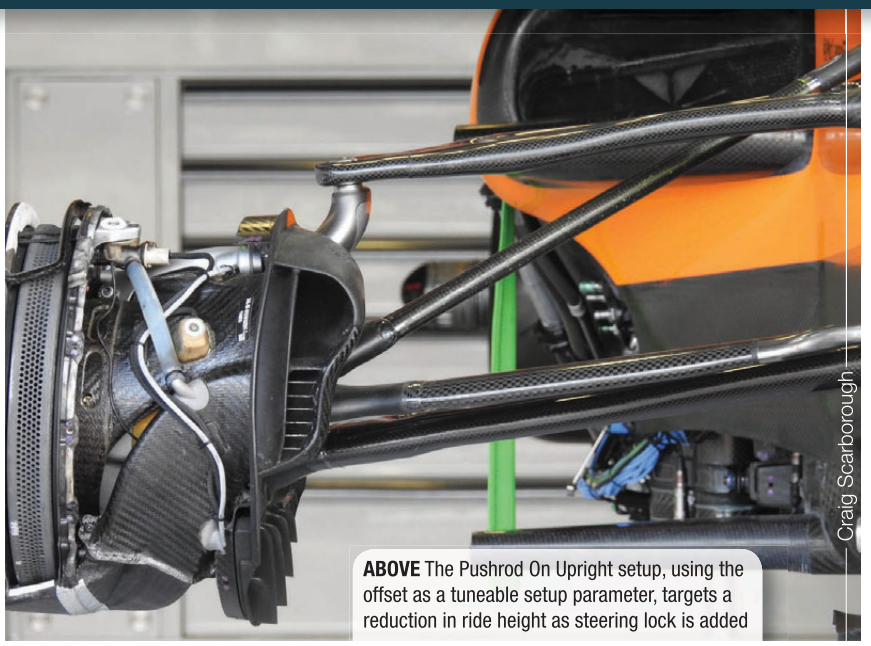
to 2025, the engines are likely to become ever more equal and extreme solutions for boost of power ever more creative.

STEERING AND SQUAT

With the tyre and aero regulation changes, suspension continues to be a primary means of managing the car's performance. This season the aero considerations for the inboard and outboard suspension became more extreme than ever.

Outboard, the double wishbone suspension design is split between conventional and high-mounted wishbones. The latter solution requires a camber plate rising up out of the wheel rim to meet the top wishbone, thus allowing both wishbones to be raised higher from the ground to reduce obstruction to the front wing wake. Given the wider wheels from 2017, the steering axis remains similar to the conventional set up where the outboard wishbone joints are inside the wheel rim. The grid is equally split between both solutions and all teams run pushrods at the front.

It's the steering axis and pushrod that have given us this season's latest trend. For years teams have mounted the pushrod on the upright and offset from the steering axis. Different geometries can offer changes to ride height equal or opposite to left and right. The convention used to be to use the POU geometry to provide lateral weight jacking, but increasingly in the aero-dominated formula it's a net ride height reduction the setup has been targeting: the greater the offset from the steering axis, the greater the effect.



Craig Scarborough

ABOVE The Pushrod On Upright setup, using the offset as a tuneable setup parameter, targets a reduction in ride height as steering lock is added

This became popular in 2017 and was partly banned with an FIA limit of 5 mm ride height change with 10 degrees of steering. But last season Ferrari came up with a geometry, well hidden within the brake duct drum, that allowed more ride height change within this definition.

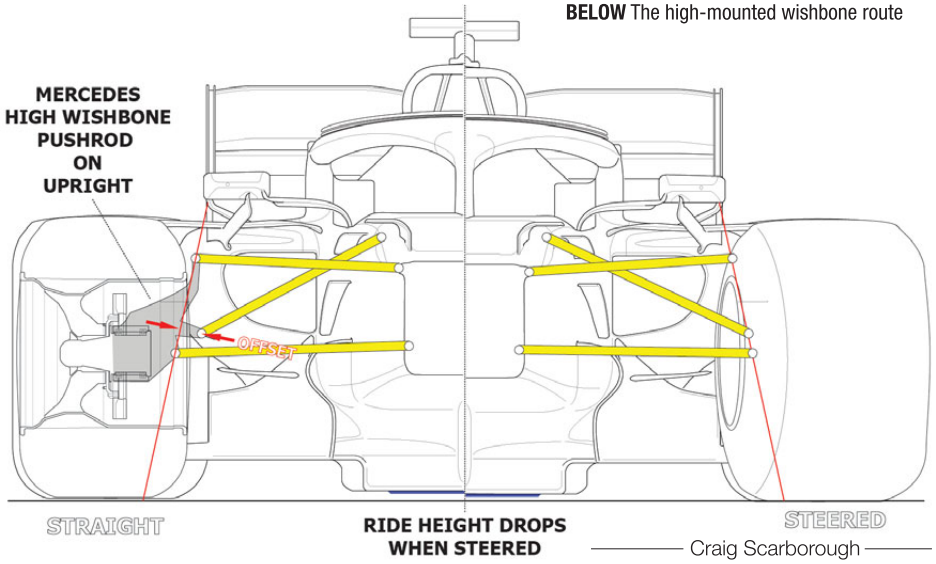
Through 2019 all teams have been returning to extreme POU offsets to gain ride reductions. This is clearly visible at Monaco's hairpin: when the steering lock is applied, the front of the car drops. This places the front wing closer to the track for ground effect. When the brakes are released and the car turns, the POU ride height drop offsets the natural tendency for the nose to pitch up.

Not content with just increasing the pushrod offset, some teams exploited Ackerman in their suspension geometry for a greater steered effect at the wheel. Current F1 cars largely employ parallel steering geometry, such that the wheel turns at the angle for a given input. Mid-season, Mercedes, Racing Point and Williams were repositioning the outer track rod joint (positioned ahead of the front axle) further inboard, effectively creating a reverse Ackerman geometry. This will steer the outer wheel more than the inner wheel, thus increasing the potential ride height drop for the outer wheel. Any other Ackerman steering effect will be lost at the wheel by the downforce and tyre compliance.

On the inboard suspension side, the adoption of gas springs, operated via hydraulic links, continues as much as metal springs and, in Red Bull's case, carbon disc springs. No longer able to be linked front to rear, it's pitch control that is the primary aim with these systems. Ride height control under braking is critical at the front; at the rear, the priority is increased squat at high loads.

These so-called 'collapsible' rear heave units are set to operate normally up to the speeds attained at the fastest corner. To reduce the car's angle of attack for reduced drag and greater top speeds, the rear needs to squat as the car approaches top speed. For these power-limited sections of track (long corners and straights), the aero load on the rear suspension overcomes the valving and the unit spring rates reduce; this non-linear effect allows the team to tune the car between downforce-dependent sectors and the power-limited sections. This solution is adopted throughout the grid and remains, for now, another legal means to use the suspension compliance for aero gain. ▶

BELOW The high-mounted wishbone route



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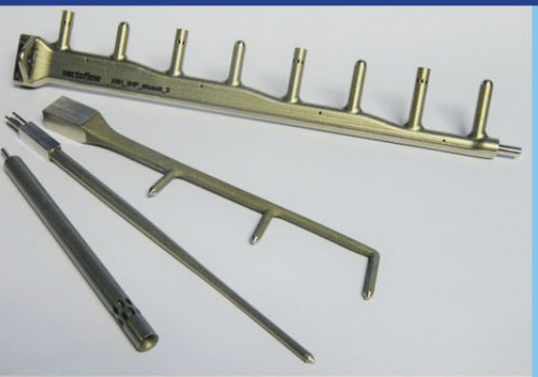

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TEAM BY TEAM

Craig Scarborough assesses the teams' progress or decline

MERCEDES ▶

DOUBLE champion for the sixth successive season. Even though its car was not as dominant as in the previous five campaigns, the team still possessed the benchmark chassis and powertrain by which all others are measured.

The design of the W10 followed its previous strengths, with high drag aero and a long wheelbase generating the downforce. The drawbacks were that the car struggled with tyre and power unit overheating in higher ambient temperatures.

It could be argued that the car was no longer the fastest overall, but it was most consistent, with wins coming from better race strategy and fewer driving errors.

FERRARI ▶

AFTER such a strong showing in testing, the SF72H's shortcomings were soon exposed with poor low-speed corner performance. Yet the car was quick in faster corners and imperious on the straights, the power unit's peak output and the chassis' low drag aero paying dividends.

Car reliability, team organisation and driver consistency were its downfalls against Mercedes. Ultimately, despite a handful of wins, the Ferrari package under-delivered compared to its potential.

RED BULL ▶

IN its first year with the troublesome Honda PU, Red Bull fortunes exceeded expectations. With an initially tricky to drive car and down on power engine, both parties went to work and developed sufficiently to challenge for wins.

Especially in race format, the RB10 Honda was equal to Mercedes and Ferrari, though its qualifying and reliability remained obvious failings compared to its two rivals. Next year it will need to start the season closer in performance to Mercedes and Ferrari to truly carry the fight to them.

McLAREN ▲

THE team's slow decline accelerated during its Honda partnership. But with ex-Porsche LMP boss Andreas Siedl in charge of the technical side, and with the experienced James Key onboard, that slide has been reversed. That much was illustrated by the team out-shining Renault, whose customer engines it was using in 2019, to fight its way to the front of the midfield pack – though still some way short of the top three.

In contrast to many previous seasons, the MCL34 was quick out of the blocks. That performance was further boosted by a strong development push, including a near total redesign of the aero mid-season to follow Ferrari's front wing and Red Bull's sidepod philosophy. Reliability remains a Renault PU issue, sometimes compounded by the talented young drivers' aggressive racing.

RENAULT ▼

AFTER rebuilding the Enstone team following the Lotus period, Renault brought itself back to the front of the midfield in 2018. With the manufacturer taking on top driving talent for 2019, the suggestion was that it was ready to consolidate that position. Instead, it took a step backwards.

The car struggled with downforce and the power unit lacked power and reliability. Equally, not enough progress was made throughout the season, leaving doubt as to where the team goes next.

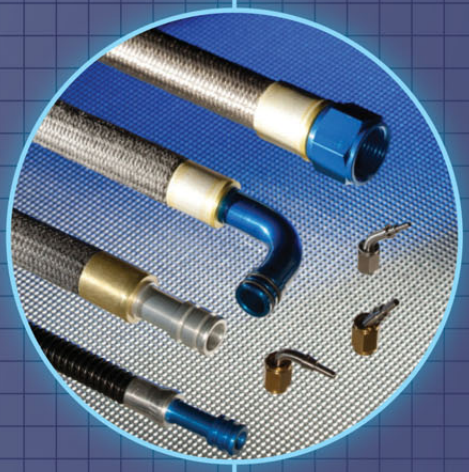
Recruiting Pat Fry and confirming it will focus solely on its own power unit, with McLaren returning to Mercedes power in 2021, are good steps. Yet the team needs to confirm 100% commitment and funding to its F1 future.

RACING POINT ▼

IN the post-2014 regulations, Force India, now Racing Point, built up and consolidated its position as best midfield team. Last season's mid-year ownership change forfeited the outfit its early-season championship points, so the 2018 classification was lower than it ▶

BELOW A rejuvenated McLaren clawed its way to the front of the midfield pack

INTELLIGENCE CONNECTED



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ABOVE Ferrari's ability to deploy its own 'party-mode' disconcerted rivals

should have been in reality.

That interruption also cost the 2019 car its development resources, so the RP01 was based around the older Force India chassis, limiting its performance early in the year. However, the team brought several major updates to the car's suspension and aero, hoisting it back into contention with the top of the midfield.

Despite catching up, it couldn't recover all of the ground lost to the midfield-leading McLarens. That deficit could well be overcome in 2020.

TORO ROSSO ▲

AFTER adopting the Honda engine, a year earlier than its parent team Red Bull, Toro Rosso has been making progress with its performance.

This year the car partly followed the Haas listed-parts approach and has taken key assemblies from Red Bull. Even with a driver switch and taking a string of grid penalties as Honda brought new power unit developments, the STR14 was consistently a mid-grid qualifier and fighting in the races for the last of the points.

ALFA ROMEO ▶

FROM being the tail-enders for a few seasons, Sauber fought back in 2018. Now with Alfa Romeo backing, this trend looked set to continue in early 2019.

The complex-looking C38, with its Ferrari powertrain, promised to be a considerable step forwards in the first part of the season. But as development seemed to slow, the car drifted once more towards the rear of the grid. Despite some moments of real pace, the team and car were too inconsistent over the course of the campaign.

HAAS ▼

ENTERING 2019 off the back of its best season to date, the Haas VF-19 looked to be another step up in performance for the team. Yet, despite its Ferrari underpinnings, the car soon struggled on its tyres.

It's clear the car has pace, but the team was unable to get the tyres into the ideal operating window in qualifying or races. The conundrum detracted from aero development, with mid-season aero parts rolled back to Melbourne spec.

"We cannot do anything about it. We are sitting there like a lame duck," admitted team principal Gunther Steiner. "It's like having a football team with 11 defenders and no strikers, and everyone attacks you. You cannot do anything."

WILLIAMS ▼

FROM a spectacular season in 2014, Williams has been in decline despite its Mercedes Power Unit. 2019 turned into the team's low point, struggling by some margin to keep up with the last of the midfield runners.

The campaign started badly with a late debut for the FW42 and not enough parts to equally equip both cars. Further production issues meant the need to run the cars with split specifications. Even when the new components arrived, they failed to elevate the package to a competitive level.

Now somewhat adrift, without a big-name technical director after a split with Paddy Lowe, the outlook for the F1 squad isn't an optimistic one. RT

FROM HOCKENHEIM TO "HEAVEN'S GATE"

William Kimberley presents the nominations for Race Tech's technical awards: Race Powertrain of the Year, and Dino Toso Aerodynamicist of the Year

IT could be argued that 2019 has been a year of consolidation, settling down and preparing for the tumultuous future that lies ahead for pretty well all motorsport across the board.

While Formula 1's focus has been very much on aerodynamics, how to enable cars to run in close proximity to each other, it is the issue of hybrid technology that has forced its way onto the radar of nearly every other motorsport category: from IMSA to IndyCar, tin-tops to the World Rally Championship, and, perhaps most notable of all, even NASCAR.

While most championships and manufacturers have therefore been working hard behind the scenes, a number of spectacular results have nevertheless captured our expert panel's attention. Those feats have been achieved in a wide variety of settings. They range from the modern circuits of the DTM, to the 'Green Hell' of the Nürburgring-Nordschleife, the spectacular ascent to 'Heaven's Gate' on Tianmen Mountain and, in the case of the F1 tech team, the computers running CFD simulations.

The awards will be presented at next month's World Motorsport Symposium.

DINO TOSO RACECAR AERODYNAMICIST OF THE YEAR

Volkswagen
Nominated for its ID. R aerodynamics

AT the start of the year, Volkswagen set itself a new challenge with the ID. R, its motorsport ambassador for its new, fully electric range of vehicles, by going to the Nürburgring-Nordschleife instead of Pikes Peak. In other words, a racetrack rather than a hillclimb, comprising full-throttle sections instead of hairpins. Because of this, the fully electric-powered ID. R was continuously developed with respect to its aerodynamics.

On the Nordschleife, it is not primarily about downforce, but low drag as well. Furthermore, the air in the Eifel, which sits about 600 metres above sea level, is much denser in comparison to Pikes Peak, where the finish line is 4,302 metres high. "This ▶

ABOVE Volkswagen's fully electric prototype ID. R set a new benchmark on Tianmen Mountain

results in completely different basic data for the measurements of the aerodynamic aids," says Hervé Dechipre, the engineer responsible for the ID. R's aerodynamics.

As well as an adapted floor and a new spoiler at the front of the vehicle, the ID. R also sported a newly designed rear wing that was much lower than the variant used at Pikes Peak. The new multi-wing rear of the ID. R nevertheless still produced high downforce in the medium-fast turns of the 73-corner Nordschleife.

To further reduce the drag in certain sections, the rear wing deploys technology known as the so-called Drag Reduction System (DRS). During the ID. R's solo-drive, the opening element of the rear wing was used exclusively to preserve the remaining energy reserves. "Between when the rear wing is fully deployed and when it is flat, the difference in downforce is about 20 per cent," explains Dechipre.

DRS was particularly significant when the ID. R reached the 'Döttinger Höhe', an almost three-kilometre-long straight at the end of the Nordschleife lap. "With an activated DRS, the car requires less energy to maintain its top speed over the entire Döttinger Höhe," says Dechipre. "The ID. R reaches its top speed quicker and with a lower use of energy."

Similar to the future production vehicles from the ID family, the ID. R also requires comparatively few openings in the bodywork to allow cooling air to flow. "The electric motors operate with little cooling," says Dechipre. "The ID. R therefore requires fewer air intakes than conventional race cars, which brings with it a great aerodynamic benefit."

As with the preparations for the record-breaking outing at Pikes Peak last year, Volkswagen tested the ID. R's aerodynamics in the wind tunnel, initially with a 1:2 model. The next step was to continue this detailed work with the original-sized racecar. "By doing this, we could simulate the movements of the ID. R when braking or steering, as well as the resulting changes in aerodynamics," says Dechipre.

After establishing the electric lap record at Nürburgring-Nordschleife, the car was then taken to Tianmen Mountain road in China. There, the run to "Heaven's Gate" presented an entirely new challenge: 99 tight corners, some with a radius of just six metres, followed by short sprints, fast winding sections with speeds of up to 230 km/h, and hard braking manoeuvres in extremely narrow tunnels. The car's stunning 7:38.585 run set another new benchmark.

"A new record on a truly spectacular road – Volkswagen and the ID. R have once again shown what the electromobility of the future is already capable of today," said Ralf Brandstätter, chief operating officer of the Volkswagen Passenger Cars brand.

F1/FOM/Liberty Nominated for 2021 aero research

AFTER months of negotiations, F1 made the long-awaited announcement on 31 October that the new regulations for the 2021 season have been unanimously approved. The World Motor Sport Council revealed all 10 teams, the FIA and FOM have come to an agreement over the major revamp for the sport's top tier.

In principle, the 2021 F1 cars will have a radical new design philosophy and striking new look with sweeping bodywork, simplified front wings, bigger rear wings, increased underbody aerodynamics, wheel wake control devices, simplified suspension and low-profile tyres with 18-inch rims. It's also proposed that the wheel rims will be fitted with a rotating LED display panel to provide information to spectators, while a bodywork display panel is also proposed for the same reason.

The switch to low-profile tyres isn't purely aesthetic, says F1. The high-profile tyres currently used tend to move around and deflect a great deal, which has an impact on aerodynamics. The teams with the biggest budgets are able to look at these effects in detail and are better able to deliver solutions that give them an edge over others. A tyre with a stiffer sidewall doesn't move as much, simplifying the aerodynamics and thus reducing development investment.

Although aesthetics was a major consideration, the changes outlined above aren't just cosmetic – over several years, both Formula 1 and the FIA have been working tirelessly to design cars that can race more closely.

One of the goals was to find a solution to the loss of downforce that the current cars experience when running in another car's wake. Running in dirty air behind another car, a 2019 machine could lose more than 40% downforce. However, with the 2021 car design, this drops to around 5-10%, with airflow coming off the new cars both cleaner and directed higher, meaning it has significantly less impact on drivers following, giving them the chance not just to overtake, but to battle. ▶

BELOW A rendering of the 2021 F1 car design that will allow more wheel-to-wheel battles

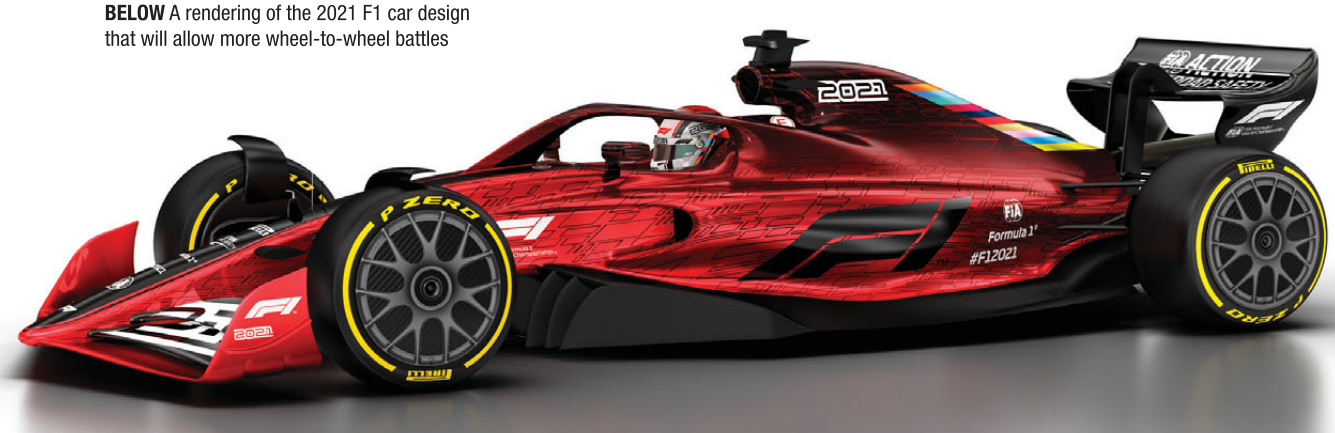


Photo courtesy of F1

RACE POWERTRAIN OF THE YEAR

Audi
Nominated for its DTM engine

THE dawn of a new turbo era marked a watershed year for the DTM – and a glorious one for Audi.

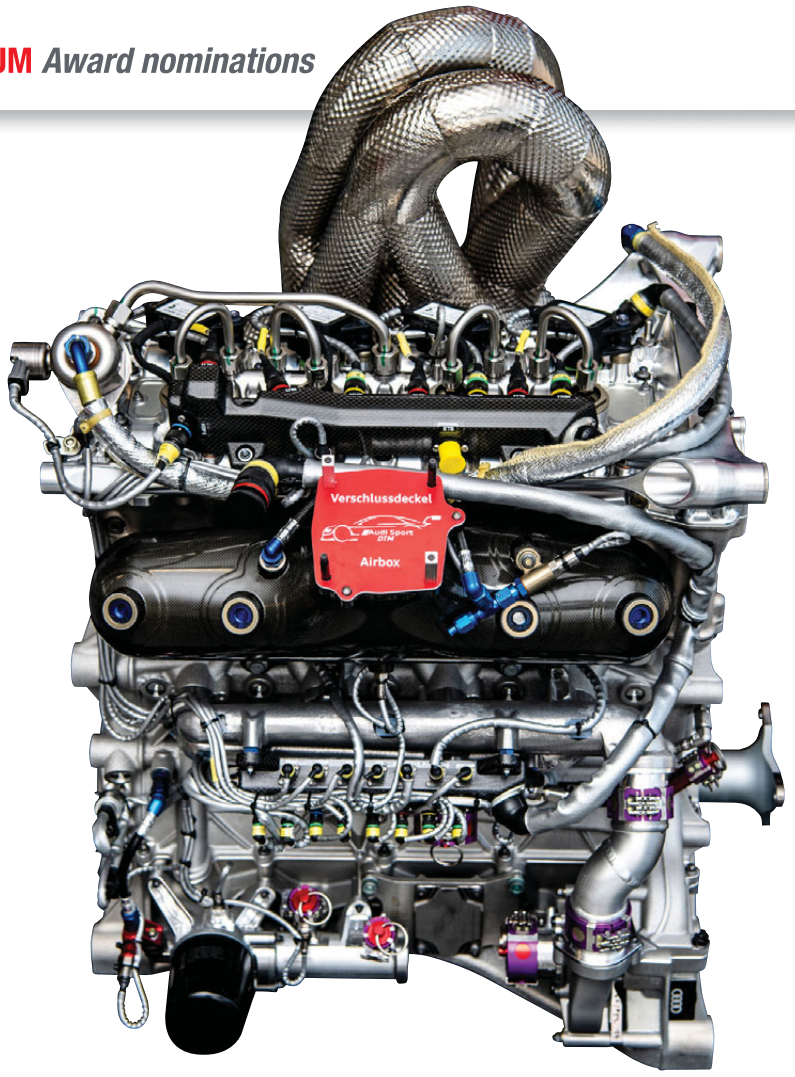
The switch from a V8 to an inline four presented the manufacturers with many challenges, not the least of which were dealing with the vibration and the sheer magnitude of the forces involved.

In its first year of racing, Audi's engineers extracted more than 610 horsepower from a powerplant with just two litres of displacement – around 100 bhp more than its predecessor with half the cylinder count and half the overall capacity.

This was the most efficient and powerful engine in the company's DTM history. The most successful one too: Audi won the drivers', teams' and manufacturers' championships – the latter by a record margin of 582 points.

In terms of reliability, the new engine was instantly exemplary as well: Audi was the only manufacturer to use no more than the allocated number of 1.5 engines per car and therefore did not suffer any deduction of points in the manufacturers' championship. At the end of the season, Pietro Fittipaldi's engine had the highest mileage of more than 5,000 kilometres.

"The fact that this engine concept can be found in a very large number of Audi production models worldwide too, makes this title win all the more valuable," reflected Head of Audi Motorsport Dieter Gass. "The manufacturers' title also belongs to all employees at Audi who work for our brand day in, day out with heart and soul."



ABOVE Audi's new engine racked up a record points haul in the DTM

Volkswagen
Nominated for its ID. R electric prototype

VOLKSWAGEN'S impressive electric racer, the sleek ID. R, has continued to break records at various locations, demonstrating its impressive versatility.

The prototype first made headlines in June 2018, when it broke the all-time record at the Pikes Peak Hill Climb, and dispatched the 156 turns over 20 km in just 7m 57.148s. Since then, the car's twin motors, supplied by Integral e-Drive, have proved that they are a match for more than just that single event.

From the frantic ascents of Goodwood's 1.86 km hill climb, to the high speed attack on the Nürburgring-Nordschleife and the sprint over the rough surface of Tianmen Mountain's tight hairpins, the ID. R's successes have shown that its electric motors can compete in a wide variety of situations.

ABOVE An electric motor from Integral, as used to break records by the ID. R

Romain Dumas, who piloted the ID. R up the Chinese mountain path, explained what a difference the electric motors made on that run. "The little information and testing we had beforehand made it a huge challenge," he said. "The road is incredibly narrow and winding but the drive was unbelievable fun with the electric power of the ID. R. The huge torque was a big advantage on the short straights, while the aerodynamics provided additional traction in the fast sections."

The basis of the car has remained unchanged since those first runs at Pikes Peak almost 18 months ago and utilises two electric motors with a system performance of 500 kW. The ID. R's drive concept has also remained the same, with one electric motor per axle. This, along with the lithium-ion batteries that are used in the prototype, has proved so successful that comparable technology is set to be used in the ID product range: Volkswagen's upcoming production electric offering. RT

SHOW SEASON'S MOST EXCITING RELEASES

The winter chill may be here, but that hasn't stopped many of motorsport's finest names releasing hot new products for the coming year. **Alan Stoddart** takes a closer look at a few that caught his eye

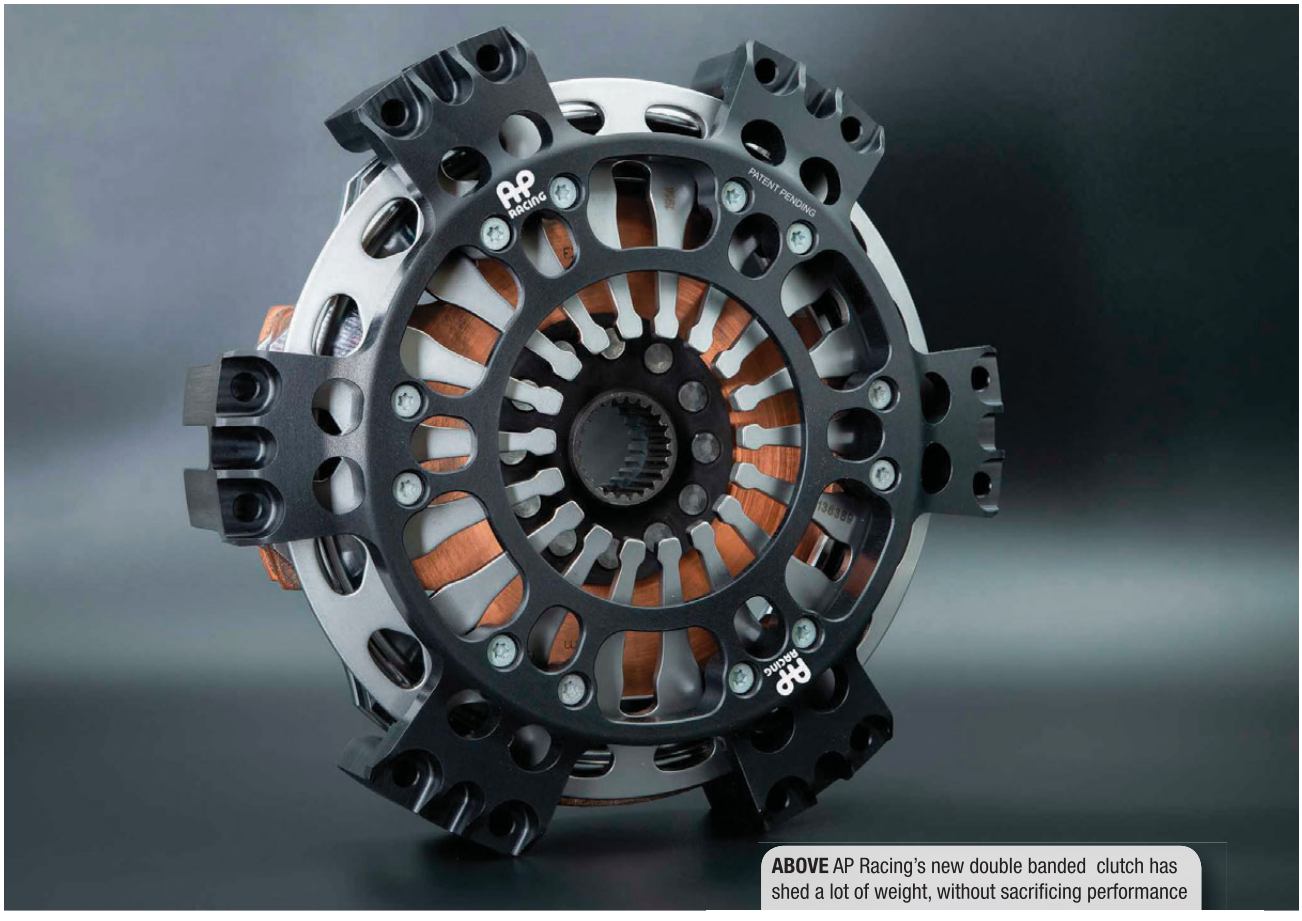
WITH show season well underway and teams and constructors deep into purchasing components that they hope will give them an advantage next season, many of this year's crop of new products have either been released or are in the final stages of approval and will be ready to buy imminently.

Among the companies boasting a number of new products is **AP Racing**. One of its offerings is its new sliding pedal box for use in GT3 cars. In this category, regulations require that the seat is fixed, and that the pedal box moves backwards and forwards to account for different drivers. But ensuring that pedals are light, strong and adjustable is no easy feat.

As such, AP Racing's new pedal box brings a number of features and upgrades over the outgoing model. It is a lot stiffer, and with the rails now located along the centreline rather than at either side as they were before, the stiffness is also concentrated around the brake pedal; exactly where it is needed.

The new design is also modular, and again is based around the brake pedal, with a throttle piece that goes on the right hand side and an optional clutch module that can be omitted entirely if the pedal box is to be used on a car that only needs two pedals, in electric motorsport for example. There is a lot of adjustability in other areas too, to account for driver preference, with the throttle one area where feel can have a big impact for drivers.

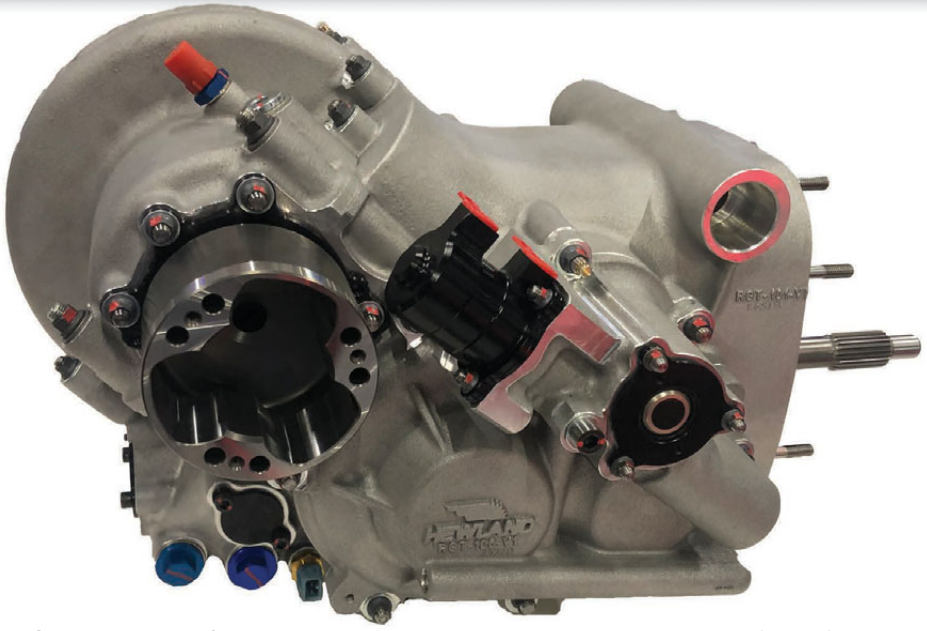
As well as the new pedal box, AP is also bringing out new GT3 and GT4 callipers. These replace an older asymmetric design, which relied on one forging, before undergoing a significant amount of machining. The new callipers, however, are made from two separate forgings, which cuts down on the amount of machining required, which in turn reduces the cost. This is ideal for GT3 and GT4 teams that get a great calliper at a competitive price. Also new on the braking front is the company's ▶



ABOVE AP Racing's new double banded clutch has shed a lot of weight, without sacrificing performance

latest range of discs, which feature a dog drive system between the disc and the mounting bell. This increases the durability of the discs, which is critical when they are being used all over the world, in many different series by drivers and mechanics of varying abilities.

Finally, another new product for the firm is its dual banded clutch. New FEA tools have meant that AP Racing has been able to take a lot of weight out of the clutch, with material being removed from the basket, the cover and even the diaphragm spring, without affecting its performance.



ABOVE Hewland's new RGT gearbox can utilise a less conservative design, thanks to the use of new software

Another company which has used new tools to optimise its products is **Hewland**. Its new RGT transmission is a transverse transaxle gearbox, and while highly specified – it is rated for 670 nm of torque – is also a relatively low cost unit.

To achieve this price point, some compromises were made. The aluminium casing design has not been as meticulously optimised as it is on the top-level models, but despite this it still only weighs in at 55 kg. "We've optimised the oil system," explains James Batchelor, principal engineer – Design & Systems. "There is some new software we have invested in which has allowed us to be more adventurous with what's going on inside the casings. This has meant we can actually put oil galleries inside the casing, rather than adding extra elements.

"It allows us not just to shape the casings based on the constraints of the car, but we can also simulate acceleration, deceleration, cornering – all those loads. Without that you have to be more cautious."

The new gearbox comes with a torsen differential, which can be upgraded to a powerflow differential, or externally adjustable differential options. It also has pneumatic shift actuation built in and is available now.

ABOVE Pipo Moteurs' engine development will next year help the TitanRX series boast sustainability credentials that could even rival Formula E

Elsewhere, **Pipo Moteurs**, the engine builder well known for its prowess in rally and rallycross competitions, displayed its latest innovation: an internal combustion engine with green credentials touted as rivalling Formula E.

The engine is a development of the 2.3 litre Ecoboost unit which powers the Pantera RX6 in the TitansRX rallycross series. What sets the new engine apart is its ability to run on 90 per cent non-fossil fuels.

Pipo has worked closely with Total to test synthetic and biofuels on the dyno, which will then be used in the series from next year. Combustion using these greener fuels is slightly different compared with traditional gasoline, as such some changes have had to be made to the engines. Ethanol used in the sustainable fuel can have a drying effect on some internal parts of the engine, so fuelling must be modified. "We also need to think about some different piston shapes, different ▶

Giorgio Piola

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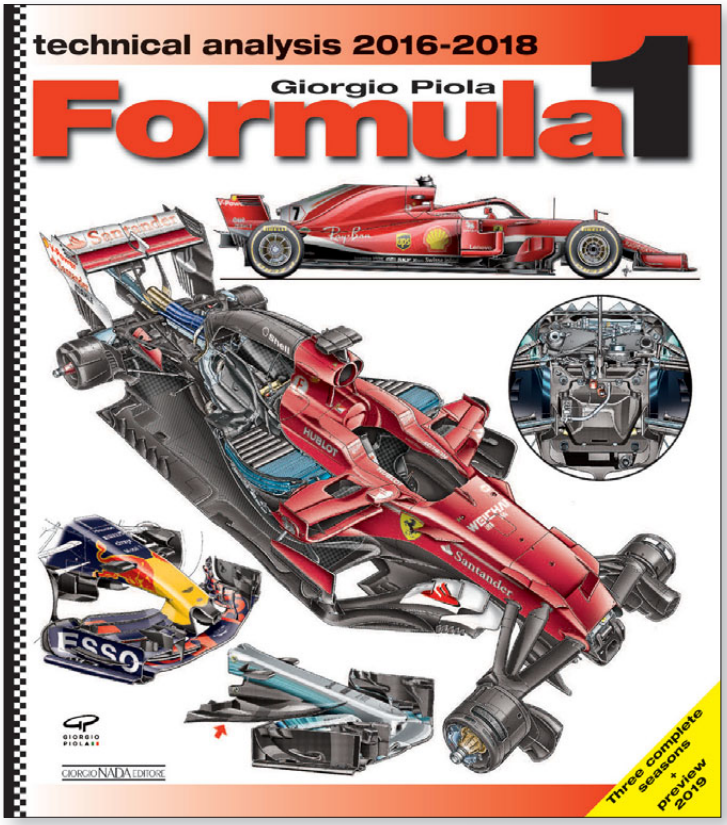

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THE last edition of an automotive literary classic: the technical analysis of Formula 1 penned by Giorgio Piola. After 25 years of publication, the historic draughtsman brings the curtain down on this experience with a volume that examines the last three seasons, from 2016 to 2018, as always reviewing the principal technical innovations in the spheres of chassis and engine design. This three-year analysis is appropriately completed with a retrospective of some of Piola's most important drawings from a 50-year career that began back in 1969.

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ABOVE JE Piston's new Aligned Grain Flow technology ensures that pistons can offer strength where needed, but still be lightweight

rings and different liners," notes Fred Barozier, Pipo Moteurs' general manager. "Combustion is also much improved with the fuel depending on the mixture, so we can also increase the compression ratio."

This means that for next season, the engine will utilise a custom head, while there will be a redesign of the port and the combustion chamber to work effectively with the new fuel.

The volume of fuel these greener engines will consume will be higher, but the weight will be similar, this is down simply to the lower density of the new, sustainable fuels. More impressively the new engines will actually consume less energy, because the efficiency of combustion in the engines is improved.

Another company improving the internal combustion engine is **JE Pistons**, which is using the new Aligned Grain Flow technology in its Ultra range of pistons. This new technology aligns the crystalline structures of the metal in structurally important places, which makes the total forging stronger.

This means pistons can either be lighter, but offer the same strength, or stronger, but without suffering a weight penalty.

The Ultra series also includes other key new features. Among them is the ceramic coating on the crown, that provides a thermal barrier between the combustion chamber and the piston. Not only does this keep the piston cooler, it keeps the combustion chamber hotter, allowing it to have more pressure and greater power output.

The pistons also feature the company's perfect skirt coating, which almost entirely fills the piston's wall clearance and allows an incredibly snug fit. This is particularly important in older engines, which usually have a lot of clearance.

Xceldyne is also offering a new upgrade to engines used in some US motorsport competitions in the form of a new range of titanium valves. This range will offer a valuable performance increase to those competing in dirt late models, sprint cars and the Outlaw Drag Race series, for example, without going to the extremes required in the likes of Formula 1.

"So we have created a programme for a good value titanium valve, with basically a two week lead time, that is price competitive in the market," says Xceldyne president, Corey Smith.

Although, the new range is not aimed at the lofty levels of the likes of F1 and NASCAR, it still benefits from the technology developed for those leading-edge products. The new valves are made on the same line, and are fully coated CrN, but optimisations to the manufacturing process have meant the entry level can be brought down to include new markets.

Meeting the growing need for components for electric and hybrid powertrains, **Krontec** has developed cooling lines for Formula E and other electric series made out of PEEK, a special plastic which offers a combination of strength, high temperature resistance, and resistance to chemicals, wear, fatigue and creep.

The technology was perfected for LMP1 hybrid developments, but it is also perfect for Formula E thanks to its extremely low weight and its ability to withstand the temperatures of the necessarily lightweight cables.

The firm is, however, still very committed to I.C.E. racers and has also brought out a new fuel bottle trolley, which can be laid horizontally to refill, before being stood up for use. The trolley is available now and fits all bottles.

Fuel is also a concern for **Continental** which has revealed a prototype fuel cell, which doesn't require a sensor inside the bladder, but instead has a sensor printed on the outside.

"So what we are doing is the medium inside has a physical capacity, so we are measuring that and not the actual height of the fuel," explains Christian Dohmen, head of production unit fuel tanks.

"We can use this with the known volume of the fuel tank to actually calculate the current fuel level." ▶

ABOVE Xceldyne's titanium valves for dirt late model, sprint and drag series offer many of the company's standout features, at a lower price point

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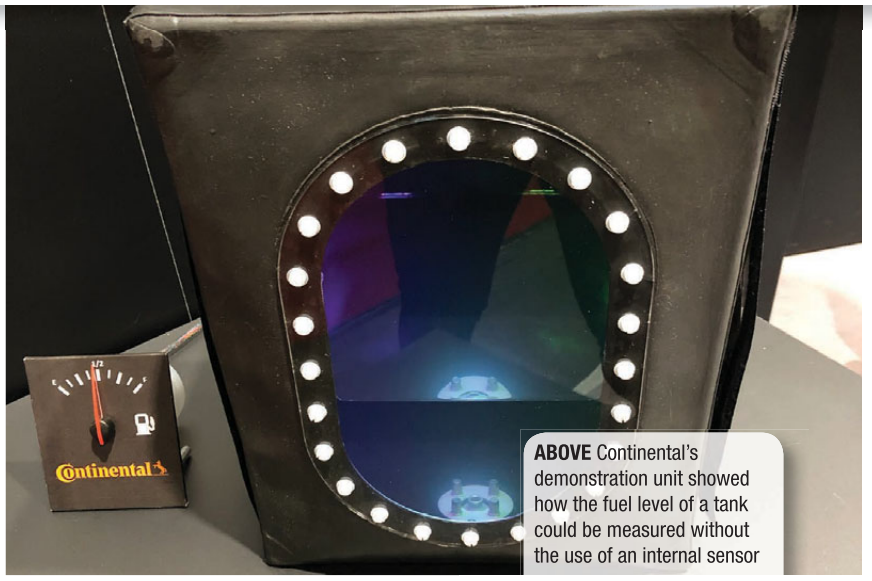


ABOVE Continental's demonstration unit showed how the fuel level of a tank could be measured without the use of an internal sensor

One of the main benefits of this technology, particularly in demanding race applications where the cars will be subject to significant G-forces, is that if the sensors are printed all around the tank, then regardless of fuel slosh within the bladder, the sensors can still accurately determine the fuel level inside.

Another big advantage comes when installing fuel bladders into the cars. Because the sensors are as flexible as the bladder itself, and there is no need for a rigid sensor, the new bladders offer packaging benefits, which is a plus when it comes to managing weight distribution and allowing designers more freedom with other components.

Another German stalwart with an upcoming release is **Bilstein**. The company plans to launch its new range of shock absorbers in December, which more closely ties its tuning range to its motorsport offering. These adjustable dampers will allow drivers to have a motorsport damper, but after some quick adjustment they can also be used on the street.

"The important thing about that programme," explains head of motorsports Martin Flick, "is that the developments from motorsport go into the tuning programme, so we are using exactly the same pistons and specs from motorsport into the street."

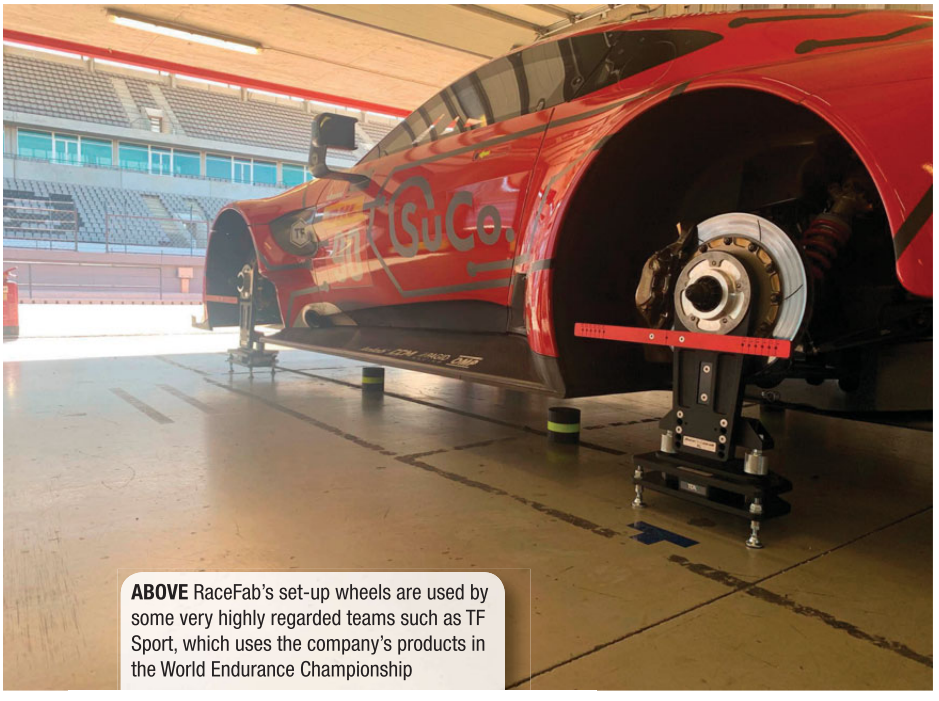
"We also set up the motorsport programme to become more professional in three steps. We started with rallycross with a big, strong damper. We will have one in the middle that is for GT racing and LMPs, and finally, at the end of this year we will have a very small, lightweight damper for Formula racing."

When it comes to suspension, having the correct setup can be as important as having the right components. To this end **RaceFab** has been showing off its setup wheels.

The company, which now supplies about a third of the British GT grid, as well as WEC runner TF Sport, argues that because of the reduction in the performance differentials of the cars through the balance of performance rules, setup is becoming ever more important.

RaceFab's products are designed with the end user in mind, and aim to offer a solid product, with features that mechanics can rely on, at a competitive price. The set-up wheels for example, can be used with digital protractors, which simply attach magnetically to the wheels, while they can also be upgraded to use a laser alignment system, or a height adjustable version.

There are other features that team owners will also appreciate. If someone is racing in GT4 they will need the setup wheel with a five-stud bolt pattern. If the next season the team switches to GT3, the setup wheel can then be adapted for centre locking wheels.



ABOVE RaceFab's set-up wheels are used by some very highly regarded teams such as TF Sport, which uses the company's products in the World Endurance Championship

Also promoting its new products over this show season is **Bosch**. One of the highlights is an update to its well-received Collision Avoidance System. Like its predecessors the CAS M3 Evo combines a camera signal with a radar signal in a software package, which generates an overlay of the information to provide feedback to a driver about following traffic. This overlaid information can prove invaluable in some situations, such as in poor conditions at night, when the radar can warn of hazards that the driver would otherwise be completely unaware of. The latest version includes a new camera, that was developed exclusively for Bosch Motorsport, and comes in at a more competitive price point.

Bosch's other big news was the strides it has made in wirelessly connecting many different parts of a motorsport system, allowing all individual electronic components to be configured from a single tool. So, all aspects related to telemetry, can communicate through the cloud and be viewed and configured by Bosch's Race Connect tool. ▶

ABOVE Bosch has built on the success of its Collision Avoidance Systems with its latest version, the CAS M3 Evo

Elsewhere, **Raceparts** also had some exciting new product news to share. It is now offering a new endurance brake fluid called Prospeed RS683.

The fluid was originally developed for IndyCar, but has since also completed strenuous testing with a GT3 team. While the pedal feel didn't change during the test, the difference was clear to see for the data engineers, who witnessed an improved pedal pressure to calliper pressure ratio. The fluid is also much less corrosive than other products, thanks to its meticulous mixing process. So, as well as offering better braking performance, the new fluid helps increase the seal life of both calliper and master cylinder seals.

Raceparts is also offering a rather less cutting-edge new product, in the form of a cast iron Formula Ford calliper for the historic market. Made by **920E**, which is more frequently associated with very high-tech brakes, the calliper meets historical specifications exactly, and is even made using the same tooling as the 1960s originals. The calliper is being remade thanks to the great levels of demand among Formula Ford enthusiasts who are finding that replacement parts are becoming ever more scarce.

Not all of the season's most exciting new products were on display at this year's shows, however. Among those companies not present was **Sharc**, which has a December launch scheduled for the latest version of its Harpoon meshing software.

The original version of Harpoon came out almost 20 years ago, and was designed from the ground up to be able to mesh very large and very detailed geometries, such as those used for F1 and other racing cars. These complex projects presented a problem because they relied on the input data, which is essentially a CAD model, being absolutely perfect or a mesh couldn't be made. Sharc, however, with the first version of Harpoon, was able to solve these problems, and mesh geometries that would have previously been prohibitively difficult.

ABOVE The data doesn't lie! After back to back tests, the benefits of Prospeed RS683, being sold in Europe by Raceparts, was clear to see

Since then, the firm has continued to refine and improve the package. Last year, Version 6 was released, marking a significant step forward. It was the first version of Harpoon that was a polyhedral mesher, allowing any shape to be exported into a CFD solver. It also did away with the need for an excessive amount of cells to be added to deal with the complexities of some geometries, with the modelling of trailing edges of aerofoils being one of the areas that benefited most from this improvement. This also allowed the meshing of the boundary layer to be significantly improved, which increases the accuracy of the results.

The latest version, V6.2 builds further on these developments. For one it reduces the number of cells that are required to create the mesh. This is particularly pertinent for teams in F1 which face restrictions on the amount of CFD they are allowed to complete. "So typically for an F1 car, you can have 100, 200 300 million cells, some people even go to 500 million or higher," explains Sharc director Richard Bardwell.

"So obviously, something that only needs 400 million cells is going to run faster than something with 500 million cells, it's as simple as that, and with the restrictions in F1 with CPU usage, that is very relevant."

Another of the major improvements also deals with efficiency. Without affecting users' workflows, the latest version of Harpoon poly mesher runs in parallel, whereas the previous version was focused on single-core performance. This again makes the mesher run more quickly, without sacrificing any detail. RT

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DTM DARES TO BE DIFFERENT

The DTM's futuristic vision features spectacular 1,000 hp projectiles, powered by batteries or fuel calls, but it's not the cars that have captured most of the attention. **Sergio Rinland** talks robot pit stops

TWO issues ago, discussing the ACO's plans to introduce Hydrogen Fuel Cell-powered cars to Le Mans by 2024, we said: 'The other option would be to swap batteries, which with current technologies can be done in under a minute, but that brings the challenge of creating the necessary infrastructure. The same is true of Hydrogen to some extent. Both solutions have their pros and cons.'

Unknown to me, DTM, guided by the able hand of former F1 star Gerhard Berger, was about to announce exactly that option, but with some exciting additions.

In this day and age, every car manufacturer in the world is using robots to assemble their cars, save for the very few still using human artisans for those tasks. Hence it is only logical that the DTM, a racing series which historically has been run and developed by OEMs, should try to showcase not only the technology of their cars, but also the technology used to manufacture those cars with a quality and precision only dreamed of a few decades ago.

> *"A way of showing the public how their everyday cars are manufactured"*

So long as the driver of the car is a human, the hero of the situation, replacing mechanics for some dangerous tasks, like changing batteries with 800 Volts, weighing 300 to 600 kg, is the right thing to do. Or at least it is if they want to run with 1,000 HP electric cars for more than 20-30 minutes.

Formula E, to avoid such a risky endeavour, ran for years by swapping the whole car mid-race.

The battery swapping technology has been tried and developed for more than 10 years. The pioneer was a company by the name of 'Better Place' (now defunct), which, together with Renault, tried to develop the technology with the Renault Fluence, in Israel and Denmark. It was too early, for the skateboard-type electric platform had not been developed yet, so the programme failed: not for being unworkable; just for being ahead of its time.

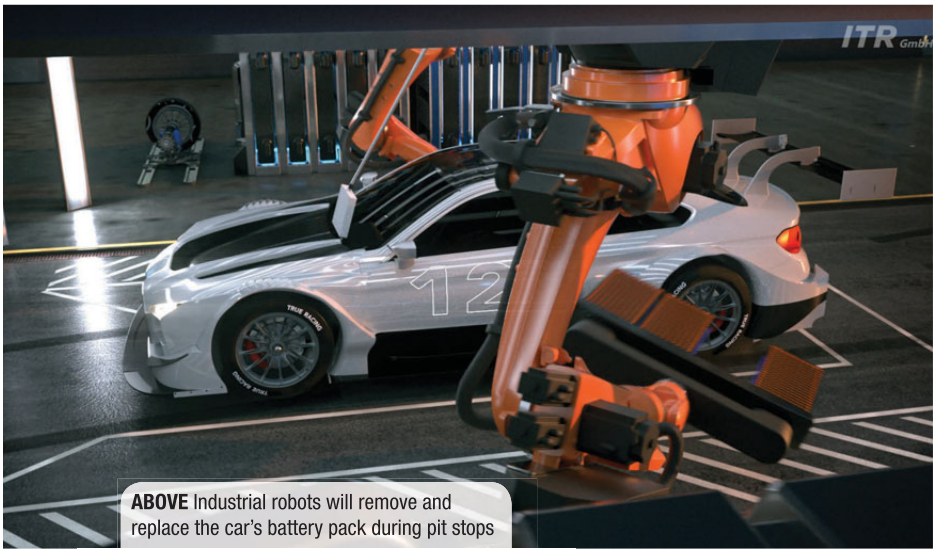
Nowadays, in China and Japan, the technology is used to swap batteries in buses and taxis. It makes sense when all the vehicles are similar and use the same battery. The system falls on its face when it tries to service more than one model and the infrastructure becomes unworkable. So, 'horses for courses': for public transport, when cars or buses need to be operational for 18 to 24 hours a day, it makes perfect sense.

Would it work in motorsport? Only if every car runs the same battery (or Hydrogen Fuel Cell whenever it becomes feasible). The technology could perhaps be showcased in the DTM – where manufacturers have for years cooperated on ventures like running a common safety cell – but I cannot see the likes of Audi, BMW or Aston Martin sharing the same platform any time soon in their production offerings.

But other brands and models? The automotive world is going in that direction of sharing platforms, battery technology and propulsion systems. So having battery swapping stations in order that we don't have to wait for half an hour (or even 15 minutes as the current charging target is developed) to refill the batteries with enough juice to carry on your journey, is a possibility. The technology is out there.

The other aspect announced by DTM is of using robots for tyre changes. These will be very similar to the robots being used to manufacture cars on the production line, so it will be a way of showing the public how their everyday cars are manufactured. This way, tyre changes will cease to be a race decider, leaving it in the hands of the driver to manage tyres and energy on board.

The only drawback I see with this proposal is the cost of pit lane infrastructure. But as long as the bill is picked up by companies promoting their automated technology and OEMs showcasing their 'manufacturing perfection', rather than it being passed on to competitors and spectators, it is not such a crazy idea. RT



ABOVE Industrial robots will remove and replace the car's battery pack during pit stops

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