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Sportscar racing tipped for "golden era" as new rules get green light

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RACE TECH
Motorsport Engineering

Volume 26 Issue 9
Published July 2019
The next issue will be published in early August 2019
ISSN 1356-2975

SUBSCRIPTIONS

Subscriptions from Kimberley Media Group Ltd
841 High Road, Finchley, London N12 8PT
Tel +44 (0)20 8446 2100
Fax +44 (0)20 8446 2191

Overseas copies are sent via air mail
Special offer 12 issues for the price of 10
12 issue subscription UK: £45.00
Europe: €97.50, US/Canada: US$127.40
Rest of World: £75.00
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Price including post & packing:
UK: £5.50, Europe: £6.50, Rest of World: £7.55
You can pay by cheque or credit card but please note the minimum on Switch & Delta is £14

Race Tech (ISSN: 1356-2975) is published monthly by Kimberley Media Group Ltd.

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A fork in the road for endurance racing's future?

HYPERCARS or hybrids, that is the question. On the one hand, the Automobile Club de l'Ouest and the FIA have opted to go the hypercar route from September 2020, with the engine regulations left open about the use of hybrids; on the other hand, in the US, IMSA is keeping its green credentials alive by announcing that the Daytona Prototype international (DPi) class will be run to hybrid rules from 2022 using a standardised 48V mild hybrid system. There is therefore a real divergence between the two endurance championships and the question is which has the winning ticket?

The ACO/FIA proposals for the new-look World Endurance Championship are adventurous and exciting. With manufacturers having a choice of entering a prototype in the style of a hypercar or developing a road-going version, with the stipulation for the latter being that at least 20 must be made over a two-year period, the prospects are mouth-watering. However, there is a big question mark and that is how many car manufacturers are going to enter it.

Toyota and Aston Martin have already committed to it but so have fringe assemblers ByKolles and Glickenhaus. To stop excess spending by any team, budgets will be controlled, while a GTE-based Balance of Performance system is set to be applied in-season to keep the hybrid and non-hybrid machines closely matched. While this should lead to close racing, the danger for established luxury/lifestyle car manufacturers that can sell their limited-edition specials for a couple of million dollars or euros, is that if they lose to an unknown maker like ByKolles or Glickenhaus, then their image could be dented. It will therefore be very interesting to see if other carmakers do commit to the championship.

The IMSA proposals are also intriguing and would seem to offer greater scope for car manufacturers.

At the end of May, IMSA president Scott Atherton and EPA Transportation and Climate Division director Karl Simon unveiled plans for expanded IMSA Green initiatives, both on and off the racetrack. These will come online over the next few seasons.

An important part of this is the debut of its next-generation Daytona Prototype international in 2022 that will be powered by hybrid powertrains. It could lead to IMSA becoming the first racing series to attain Green Racing Cup status, the highest level of environmentally responsible racing, through implementing innovative engine and fuel technologies. This status is defined within the SAE J2880, the Green Racing protocols, which was first published in 2008 and revised in 2014.

"We're making IMSA a leader in reducing the environmental impact of our sport," Atherton said at a press conference held at this year's Detroit Grand Prix at the end of May. "If you've been following the reports, it's not news, but for the record, we can confirm that the engines that will power the next-generation prototypes will be hybrid power. IMSA is working with our current and interested OEM partners, along with input and insight from the EPA and the DOE, to finalise those regulations.

He also said that IMSA Green can be a proving ground for manufacturers to showcase advances in these areas through IMSA's seven sanctioned championships. Its own initiatives include tyre usage reductions and the development of alternate-blend fuels.

All-wheel drives are not being considered on cost grounds, while the standardised hybrid unit is said to cost the teams $100,000 per season rental. The initiative pleases both Ford and General Motors, which are increasing their production car electrification programme. It might also tempt other manufacturers into the WeatherTech SportsCar Championship.

So Hypercars or hybrids? It will be fascinating to see how the two championships develop over the next few years.

William Kimberley
EDITOR

ABOVE Aston Martin hopes the Valkyrie will bloody the nose of the world's largest carmaker on the roads around Le Mans

Toyota and Aston Martin commit to new FIA/ACO hypercar regs

AT the Automobile Club de l'Ouest's pre-Le Mans 24 Hours press conference on 14 June, details were given of the new Hypercar class that will be introduced in September 2020.

Manufacturers will have a choice of entering a prototype in the style of a hypercar or developing a road-going hypercar with the stipulation for the latter being that at least 20 must be made over a two-year period. While the body and underbody designs will be free, the aerodynamics will be more tightly regulated for safety reasons.

Whether a car is a prototype or based on a limited series production vehicle, manufacturers will have the choice of their cars being either conventionally powered or driven using a hybrid unit restricted to 200 kW (270 hp). With the aim of cars completing a lap of Le Mans in 3 minutes 30 seconds, the average powertrain output will be limited to 550 kW (750 hp) for the cars which must also not weigh less than 1100 kg.

For non-hybrids, the prototypes will be able to be powered by a bespoke race design or a modified hypercar engine, while production versions can either be powered by the unit from the road-going car itself or another engine from the same manufacturer. The power curve will be regulated and there will be a single tyre supplier.

The hybrid system will drive the front wheels on the prototype whereas the position is identical to the street-legal model for road-going hypercars. However, they will not be able to boost below 120 km/h on slick tyres or below a point, yet to be defined, between 140-160 km/h on wet weather tyres.

The ACO has said that budgets will be controlled and teams will be encouraged to run two cars in a full FIA WEC season over five years.

"Today, the FIA is pleased to announce the new regulations that will see hypercar-type cars become the premier category of the 24 Hours of Le Mans and the FIA World Endurance Championship," said FIA president Jean Todt at the announcement of the new regulations. "Taking effect from the 2020/21 season, they have been developed through a process of positive collaboration between the FIA, ACO, manufacturers and teams, and will provide a stable platform for the long-term, as well as a cost-effective proving ground for next-generation automotive technologies. Together, we look forward to the many benefits we can expect this new direction to bring."

Toyota Gazoo Racing has already committed to the new Hypercar championship with the GR Super Sport that it first revealed at the Tokyo Auto Salon in January 2018. The car shares most of its principal parts with Toyota's TS050 Hybrid including the twin-turbo, direct injection V6 engine and a Toyota

Hybrid System racing powertrain.

"Rather than developing production cars into sports cars, we aim to work out how to incorporate the know-how gained from racing and rallying into production cars," said Shigeki Tomoyama, president of Toyota Gazoo Racing, when the car was unveiled in Tokyo. "This is how sporting competition contributes to Toyota Gazoo Racing's efforts to make ever-better cars.

"For Toyota Gazoo Racing, this new era of competition is a fantastic opportunity to demonstrate our credentials not only as a race team against some of the best in the business, but also as a sportscar manufacturer."

Aston Martin also confirmed that it would field a minimum of two works Aston Martin Valkyrie hypercars that have been specially-developed for the 2020/21 FIA WEC season.

The Aston Martin Valkyrie is the combined vision of Adrian Newey, Aston Martin Red Bull Racing's chief technical officer, Marek Reichman, Aston Martin EVP and chief creative officer, and David King, Aston Martin vice president and chief special operations officer. It was created as a result of a technical collaboration between Aston Martin, Red Bull Advanced Technologies and project partner AF Racing.

In line with WEC's newly confirmed hypercar regulations, designed to allow race-prepared derivatives of the world's fastest road cars to fight at the forefront of world sportscar racing, the Aston Martin Valkyrie race car will draw on all the radical pillars of the road car and its track-only AMR Pro variant.

The new car will feature a race-prepared version of its bespoke high-revving normally-aspirated 6.5-litre V12 engine. Placed within a lightweight carbon fibre structure, and featuring F1 inspired aerodynamic technology, it forms a fully competitive platform capable of challenging for outright race wins.

WORLD'S MOST EXTREME HYPERCAR

"The FIA World Endurance Championship and the 24 Hours of Le Mans represent the ultimate challenge for the Aston Martin Valkyrie – the world's most extreme hypercar," said King. "Designed and built with the purpose of pushing boundaries on the road, it's natural to conclude that the next stage in its development would be to measure its capabilities on the track. I can think of no better way to do that than to compete in a world championship and the most prestigious and famous race of all."

Aston Martin Lagonda president and group CEO, Andy Palmer added: "We have always said that we would one day bring Aston Martin back to Le Mans with the intention of going for the outright win when the time was right – now is that time. David Brown came here in 1959, with a car and a team of drivers capable of winning. We intend to do the same in 2021. The Aston Martin Valkyrie is primed for such a challenge and sits perfectly within the ACO's new hypercar rule framework. Bringing to bear all of our previous experience and knowledge of competing at the top levels of motorsport, we embark on this most ambitious project with the necessary ingredients for success. What could be more evocative than the wail of an Aston Martin V12 leading the charge into the night on the Mulsanne straight?"

ByKOLLES Racing has also confirmed its intention to build its own road-legal supercar which will have its racing definition as a hypercar. This plan, which involves all engineering and production resources at ByKOLLES, has meant that the team opted not to lodge a full-season entry for 2019/20 WEC in order to focus on the hypercar which is planned to be unveiled in 2020.

Toyota Gazoo Racing, Aston Martin and ByKOLLES Racing join Scuderia Cameron Glickenhaus, the first confirmed entry for the 2020/2021 season last November.

"The hypercar regulations are very open to a diverse approach to the technology used, balancing both hybrid and non-hybrid powertrains with manufacturers able to introduce new ideas," said Richard de Mille, president of the FIA Endurance Commission. "It will be a new era with regards to the way technology will be used in endurance racing.

"I am confident that the new hypercar category will take the top class at the 24 Hours of Le Mans and in the FIA World Endurance Championship to new heights from 2020 onwards." RT

ABOVE Toyota hopes the technology it has developed in LMP1 will help its GR Super Sport to victory in 2021

IMSA/LAT USA

ABOVE IMSA could become the first race series to attain Green Racing Cup status with a switch to hybrids in its top class

IMSA commits to a greener future

IMSA president Scott Atherton and EPA Transportation and Climate Division director Karl Simon have unveiled plans for expanded IMSA Green initiatives both on and off the track which will come online over the next several seasons.

An important part of this plan is the debut of next-generation Daytona Prototype international (DPi) rules in 2022 that will be powered by hybrid powertrains. It could lead to IMSA becoming the first racing series to attain Green Racing Cup status, the highest level of environmentally responsible racing, through implementing innovative engine and fuel technologies. This status is defined within the SAE J2880, the Green Racing protocols, which was first published in 2008 and revised in 2014 along with IMSA's expansion of its own set of initiatives known as IMSA Green. This combination will considerably reduce the championship's carbon emissions and overall environmental footprint in an attainable fashion.

The objective of these multi-year initiatives will be to keep IMSA's racing relevant for manufacturers and marketing partners with an increased focus on proactive environmental responsibility.

"We're making IMSA a leader in reducing the environmental impact of our sport," Atherton said at a press conference held at this year's Detroit Grand Prix. "If you've been following the reports, it's not news, but for the record, we can confirm that the engines that will power that next-generation prototype will be hybrid power. IMSA is working with our current and interested OEM partners along with input and insight from the EPA and the DOE to finalise those regulations.

"We believe that the introduction of the 2022 DPi will help us become the first racing series to achieve the Green Racing Cup status, the highest level of environmentally responsible racing, through implementing innovative engine and fuel technologies, as defined by those Green Racing protocols."

He also said that IMSA Green can be a proving ground for manufacturers to showcase advances in these areas through IMSA's seven sanctioned championships. Its own initiatives include tyre usage reductions and the development of alternate-blend fuels.

All-wheel drives are not being considered on cost grounds, while the standardised hybrid unit is said to cost the teams $100,000 per season rental. The initiative is said to please both Ford and General Motors which are increasing their production car electrification programme, while the new direction may also tempt other manufacturers into the US WeatherTech SportsCar Championship. RT

BELOW Spending limits in F1 present a headache for some but opportunity for others

F1 teams to be subjected to $175m cost cap from 2021

FROM 2021 to 2025 teams competing in Formula 1 will be subjected to a cost cap of $175m, forcing Red Bull, Mercedes and Ferrari to trim their spending. The long-discussed measure has been enshrined in the newly created Formula 1 Financial Regulations, which will stand alongside the FIA Sporting and Technical Regulations.

The spending limit has been devised by former Brawn and Mercedes financial executive Nigel Kerr, who was hired by F1 managing director Ross Brawn to design a viable schedule for reducing costs in the sport.

The $175m limit is set to be in place for five seasons, from 2021-25, and is higher than some previous estimates of what the budget cap would eventually be, however it also doesn't include a progressive reduction as many expected. Additionally, the $175m doesn't include some key elements of team spending, making comparison with the top teams' $500m+ total outlay difficult.

The 2021 cap does not include driver salaries, marketing expenses, and any costs associated with engines. Without these elements included, it is thought that the top teams are spending $220-$250m, meaning a significant reduction of 20-30 per cent, however this figure is still higher than many of F1s midfield teams had been hoping for.

Despite this, McLaren chief executive Zak Brown hinted that the limit might enable the Woking-based outfit to do more in other series such as the WEC.

"The budget cap comes in for 2021. The soonest we would be ready here [Le Mans] is '21, so as you look to restructure your whole organisation, that's opportune timing," he said. "I think it is a positive that these dynamics are going on in F1 at the same time that we're considering WEC."

A final decision on the technical regulations for the 2021 season, meanwhile, has been delayed until October. The teams were presented with a draft of the new ruleset in early June, with the package expected to be given approval at the FIA's World Motor Sport Council meeting soon after. However, at a meeting between teams, the FIA and F1 owner Liberty Media it was agreed that more work was needed to be done on the rules.

Subsequently, a move to hold back the publication of the final regulation was approved unanimously.

"While the FIA Formula 1 World Championship's key stakeholders feel the core objectives outlined for the future set of regulations have been defined, in the interests of the sport it was agreed that the best outcome will be achieved by using the extra time for further refinement and additional consultation," read a statement from F1. RT

Formula E ban on use of twin motors

THE FIA has banned the use of twin motors in Formula E from the 2019/2020 season.

Manufacturers have had freedom over how many motors they use since the electric series' second season when powertrain development was opened up. Several teams used twin motors over past seasons but largely converged on a single-motor approach on the Gen2 cars, with only the Nissan e.dams squad choosing a twin-motor setup.

The FIA statement announcing the decision, which was made at the World Motor Sport Council, read: "A modification to the technical regulations was also approved, reducing the maximum number of MGUs (rotating electromechanical power converters) from two to one."

Nissan was surprised by the decision. "We started [this season] with quite an innovative powertrain and it was a difficult one to put together," explained Nissan e.dams team principal Jean-Paul Driot. "We had difficulties in getting it working and making it reliable but now we've reached the level of reliability and performance, after the season, we will have to go back, in a short period of time, to one engine." RT

ABOVE As the only team to use twin motors, Nissan will have to make significant changes for next year

WMSC approves WRC'S hybrid future

THE World Motor Sport Council approved the introduction of a new generation of WRC cars in 2022, when it convened in mid-June. The new cars, which will have a five-year homologation cycle, will enable manufacturers to use either a production bodyshell, or, for the first time since the Group B regulations of the '80s, a prototype tubular structure to current WRC size guidelines. This change also enables manufacturers the option of 'scaling' a larger body down to meet the category's size limits, in a move that suggests carmakers will be able to send their popular SUV offerings out on the stages.

Another significant change will be to the cars' powertrains, with a supplementary hybrid system to be used for the first time by entrants in the championship. This technological move will allow the WRC to realise its aim of having the cars run on pure electric power while in cities, and having a power boost on special stages. The hybrid system, including its software, will be common between competitors for the first three seasons, before being opened up to allow carmakers more developmental freedom in 2024.

The changes will please manufacturers like Citroën, which, earlier in the year explained that without moves to adopt new technologies, its future in the WRC would be called into question. "We have confirmed we will be there in 2019 and 2020. We will see, according to the new regulations to come in, if we want to stay here longer or not," the French manufacturer's team principal, Pierre Budar, told Race Tech earlier this year. "The target at the end of the day, if you want to get manufacturers involved, is to be able to promote new technology saving CO2. If it's hybrid, it's okay. Let's show what we can do with hybrid in motorsport." RT

ABOVE The adoption of hybrid technology was essential for marques like Citroën to remain in the WRC

Andros Trophy goes all-electric

THE Alps-based Andros Trophy ice racing series will switch to all-electric cars next winter, using the four-wheel drive, four-wheel steer machines featured in RT209.

The 2MO-operated series introduced the electric concept into its headline Elite Pro category at the end of the 2017-2018 season, before running a mix of internal combustion and electric machines in the class last winter.

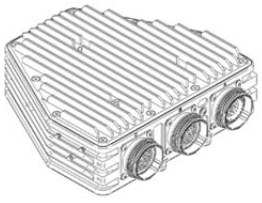
The Exagon Engineering-built, twin-motor, car produces the equivalent of 350 horsepower with 1600 Nm torque and won events last winter.

The headline category will now switch to being fully electric, with entries limited to 12 cars, shared by drivers in the Elite and Elite Pro.

The series is also planning to expand into rallycross events in France during the summer.

2MO tested the Andros Sport 01 machine back-to-back with a World Rallycross specification Peugeot 208 Supercar at the Faleyras circuit recently, completing over 30 laps with drivers Nicolas Prost and Jean-Baptiste Dubourg focusing on suspension refinement and tyre selection. Tyres used in the rallycross events will be grip limited, to make the space-frame machines slide in a similar way to how they do when racing on ice."This new concept is a good challenge for us and gives two advantages to our teams," explained 2MO owner Max Mammers. "The first is through marketing, with the possibility to extend our national presence to places like Loheac, Faleyras or Dreux for example, and also financial, so there is a quicker return on the investment for teams." RT

ABOVE The Andros Sport 01 will be used exclusively in the Andros Trophy, including in its upcoming rallycross expansion



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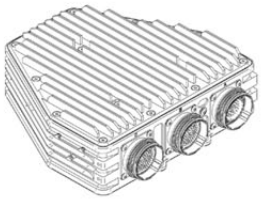

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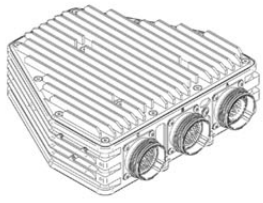

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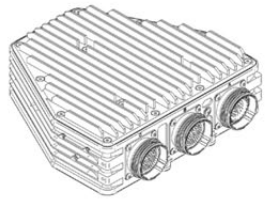

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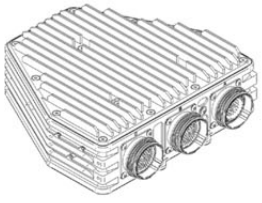

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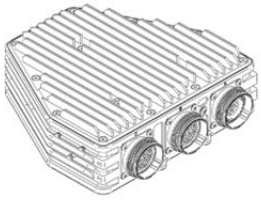

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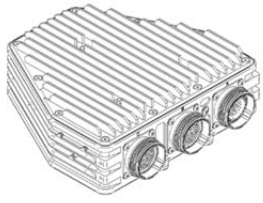

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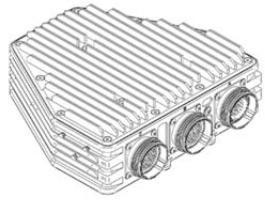

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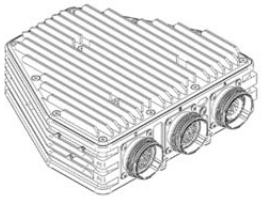

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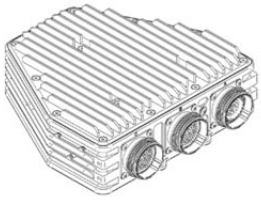

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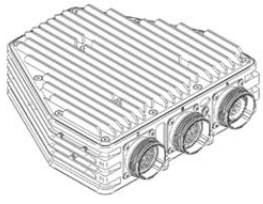

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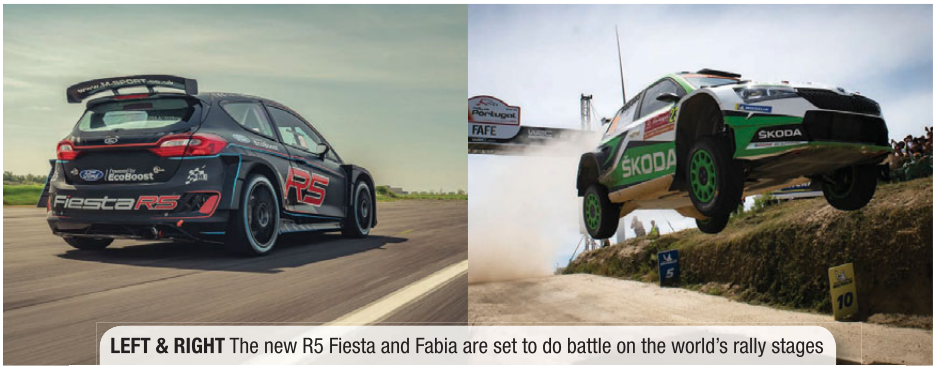
New Fabia and Fiesta R5 machines released



LEFT & RIGHT The new R5 Fiesta and Fabia are set to do battle on the world's rally stages

SKODA Motorsport and M-Sport have revealed their latest generation R5 rally machines.

Skoda has created a new evolution of its successful Skoda Fabia, which made a solid WRC2 Pro debut in the hands of rising Finnish star Kalle Rovampera on Rally Portugal in June, where the car claimed victory, along with second place with Czech driver Jan Kopecky.

While aesthetically similar to its predecessor, the face-lifted R5 includes a raft of developments, including smaller headliners and a different radiator grill arrangement. The outermost edges of the front bumper have also been restyled to increase aerodynamic efficiency, to accompany a new carbon-fibre rear wing.

Through a re-styled rear bumper, the exhaust tailpipe, connected to the car's redeveloped 1.6-litre turbocharged engine, is now angled towards the ground, instead of the horizontal exit pipe as on the original version.

The engine has been tuned to improve both outright power and drivability, and includes a new oil pump, water pump and cooling system. The turbo wastegate is now electronically controlled by the car's Magnetti Marelli control system, while the gear ratios have been changed to suit the new engine characteristics.

At each corner, the Brembo braking package has been swapped for Alcon units, while the doors have been fitted with the same kind of foam impact protection technology as used in the top-flight WRC cars.

While Skoda's Fabia is an evolution of its predecessor, M-Sport's new EcoBoost-powered Fiesta, based on the latest version of the marque's hatchback, is a ground-up design.

Based on the Fiesta-ST Line, the new car includes revised suspension geometry and components, with new MacPherson struts all round. The three-way adjustable dampers from Reiger use the latest aluminium damper bodies. A new Sadev five-speed transmission is joined by a new front and rear differential setup, while Brembo supplies the forged four-pot brake callipers front and rear, with 300 x 32 mm vented discs in gravel trim and 355 x 32 mm for Tarmac.

The 290-horsepower engine (with 475 Nm torque) is controlled by a Life Racing F88 ECU with a single PDUX4 unit with smarter control strategies. ATL supplies the 80-litre competition fuel tank.

"The Ford Fiesta R5 is our most successful global rally car. It's a very special car for M-Sport and even though the original cars continue to win rallies and championships all over the world, we have taken our time to ensure this new model is even better with performance gains in every area," said M-Sport owner Malcolm Wilson. "The test programme has been extensive, and we have worked hard to ensure this new car suits every level of driver. We have quite literally travelled the world – testing on a wide range of surfaces, in varying conditions and with a whole host of drivers taking to the wheel. This car is extremely important to us, and its adaptability is vital to its success." RT

IndyCar partners with Red Bull Advanced Technologies on cockpit protection

INDYCAR has formed a partnership with Red Bull Advanced Technologies to design an Aeroscreen to improve driver cockpit protection in the IndyCar series, which is set to be implemented in the 2020 season.

The Aeroscreen is being developed by Red Bull Advanced Technologies to reduce the risk of injury to the driver in the event of debris striking the cockpit area. It comprises a ballistic screen with anti-fogging and cooling properties anchored by a titanium framework, which helps the screen offer load-bearing capabilities comparable to the Halo of around 150 kilonewtons.

"The potential of Aeroscreen to improve the safety for drivers in the event of frontal impacts in the cockpit area of cars has been clear," commented Red Bull Advanced Technologies CEO and Red Bull Racing team principal Christian Horner. "This new partnership with IndyCar gives us at Red Bull Advanced Technologies the go-ahead to fully explore that potential, and to deliver a protection system that will help prevent serious injuries and potentially save lives." RT

See Windows 2.0 Page 42

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Ginetta LMP1 return as LMP3 announced

TWO Ginetta G60-LT-P1 LMP1 cars are confirmed on the provisional 2019/2020 FIA World Endurance Championship entry list and are set to challenge for WEC and the 24 Hours of Le Mans overall victories.

Fresh from successful tests at Motorland Aragon and Spa, Ginetta's G60-LT-P1 LMP1 car, which is now powered by AER's high-performance turbocharged V6 engine, is ready to return to the WEC LMP1 fray. The car has always featured very efficient aerodynamics but the outfit said that its overall performance was compromised by its powertrain. Now, having switched to the AER engine, the package is complete.

BELOW Ginetta will return to LMP1 next season

"We are genuinely excited by the performance and potential of our LMP1 car now we have a competitive powertrain," said Ginetta chairman Lawrence Tomlinson. "We now have the package to challenge for best privateer and even an outright win."

Ginetta has also unveiled its all-new G61-LT-P3 LMP3 model. The car features an uprated power package, LMP1-inspired aerodynamics and enhanced safety credentials, as well as a series of detail changes to improve its overall performance.

The G61-LT-P3 is eligible for a number of high-profile international race series next year including the European Le Mans Series, the Michelin Le Mans Cup and the Ultimate Cup Series as a number of global categories adopt the new breed of LMP3 cars.

"We are proud to have pioneered the LMP3 class and we have comprehensively updated every area for our Gen 2 car to make what we believe is a race-winning package," said Tomlinson. "It should be a great car to drive, perfect for pros and gentlemen drivers alike, with really balanced and predictable handling characteristics." RT

Mission H24 given Total support

TOTAL will be providing the hydrogen fuelling system for MissionH24, the project initiated by the ACO and GreenGT to lay the foundations for a hydrogen-electric class at the 24 Hours of Le Mans to be introduced in 2024.

The specially designed compact portable filling station fits in a 6 x 2.5-metre shipping container and can be transported to circuits around the world, ready to fuel the LMPH2G's future endeavours on the race track. The mini filling station houses a hydrogen tank, a multi-stage compressor, a cooling system and a distributor/connector to dispense the fuel. The system currently feeds hydrogen at 350 bars, but the intention is to reach 700 bars, in line with the development of the car. The filling station was specifically designed to meet the constraints of endurance racing in terms of rapidity, with safety the number one priority.

ABOVE The MissionH24 hydrogen sportscar project will be fuelled by Total

Total is a member of the H2 - Hydrogen Council and, along with 12 other global leaders in energy, transport and manufacturing, strives to promote hydrogen's key role in energy transition. Total is also involved in H2 Mobility in Germany, a joint venture launched in 2015 with Air Liquide, Daimler, Linde, OMV and Shell, with the aim of building a nationwide network of 400 hydrogen filling stations.

"Our research and development team has been working closely with manufacturers for over 30 years, ensuring our products evolve in line with automotive technology and racing regulation," said Philippe Montantême, senior vice president – strategy marketing research at Total Marketing Services SA. "Mission H24 gives us the opportunity to put together a customised package for the ACO/GreenGT joint venture – a hydrogen fuelling system that is both energy efficient and raceworthy." RT

ABOVE Ligier revealed its new LMP3 contender in the run up to the 24 Hours of Le Mans

New Ligier JS P320 revealed

THE Ligier JS P320, the new LMP3 powered by the Nissan V8 VK56 engine from Ligier Automotive, was revealed to the public in the build up to the 24 Hours of Le Mans. It follows the successful Ligier JS P3, which clinched no fewer than five titles in 2018: the IMSA Prototype Challenge, European Le Mans Series, LM P3 Cup, V de V Endurance Series and Asian Le Mans Series, scoring 26 victories in 34 races.

In 2020, however, the JS P3 will largely give way to the Ligier JS P320, which will race in the European Le Mans Series, the Michelin Le Mans Cup and in the Ultimate Cup Series. The JS P3, however, will still compete in the 2019-2020 Asian Le Mans Series, the 2020 IMSA Prototype Challenge and the 2020-2021 Australian LM P3 Cup.

The Ligier Automotive design department worked flat out to create the Ligier JS P320 after the first discussions with the Automobile Club de l'Ouest on the new LM P3 regulations. The design of the new car was guided by feedback from Ligier clients and drivers, and resulted in a modern hypercar look, while retaining the signature hollow in the nose. With its 95 per cent new bodywork, Öhlins dampers, a new, more powerful Nissan V8 VK56 engine, an adapted cooling system and aerodynamics optimised for all the circuits, the Ligier JS P320's aim is to thoroughly outshine its predecessor.

"In 2014, when we designed the Ligier JS P3, the LM P3s were not supposed to race on the 24 Hours of Le Mans circuit," said Nicolas Clemençon, Ligier Automotive Design department manager. "For the Ligier JS P320, we took this layout into account and optimised the car's aerodynamics to make the car efficient on all the circuits. Some constructors brought out their LM P3 in 2017, three years after the Ligier JS P3. We've corrected the few youth weaknesses of the Ligier JS P3 and used all the knowhow accumulated with our sports prototypes in LM P2, the Ligier JS P2 and Ligier JS P217, to create an even more accomplished and competitive racer."

"Our aim was to optimise the development of the Ligier JS P320 within the constraints of an evolution kit and a fixed budget," explained Olivier Jansonnie, who supervised the technical direction of the project. "We focused on the fundamental parameters of performance: aerodynamic finesse, weight, cooling and damping while respecting the restrictions and freedoms imposed by the new regulations, in particular, the twin-element wing, the safety kit and the 290 km/h speed limit. We did a huge amount of work on the bodywork with the help of our partners EXA in CFD and HP Composites for the manufacturing process." RT

Goodyear to return to Le Mans and FIA World Endurance Championship

GOODYEAR has announced that it will re-enter European and International sportscar racing by developing a new range of tyres for the FIA World Endurance Championship (WEC), including the Le Mans 24-hour race. It has been developing a new range of tyres for Le Mans Prototypes for over a year at its innovation centres in Hanau, Germany and Colmar-Berg in Luxembourg.

The tyres will be developed and manufactured alongside Goodyear's latest range of Eagle F1 SuperSport tyres for performance and track-day cars, ensuring that the technology and knowledge transfer between the road and race ranges is optimised to benefit the performance of both. The tyres will debut at the start of the 2019/2020 WEC season at Silverstone in August. RT

ABOVE Goodyear will make its return to international sportscar racing at Silverstone in August

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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

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THE WINNERS AND LOSERS IN F1'S AERO DILEMMA

Irritated by suggestions that some of the top teams have fumbled Formula 1's front wing revamp, our **Secret Aerodynamicist** – a paddock insider – shoots down a few myths

THE new aero rules for this season forced teams to make some hard choices early on in the design process, with the two title protagonists notably opting to go in different directions.

The result of those choices has led to contrasting fortunes – and an awful lot of nonsense being written in the media.

It's easy for those on the peripheries of the business to criticise or poke fun of these choices, but they have to be made. The car cannot be optimised for both the conflicting concepts, and the concept choice has to be made early in the development cycle when one cannot see the final result of continued evolution on each.

WE IGNORED HISTORY – AND PAID!

Together, the rule-makers (the FIA) and Formula One Management (FOM) are collaborating on rules for the longer term. I fully expect these to be a significant step in the direction of making overtaking easier, hopefully without the need for a false overtaking aid like the Drag Reduction System.

Aerodynamic experts – most of us, that is – have long believed that good aerodynamic downforce, combined with the ability to race, *is* possible. The reality of F1 over the last 20 years appears to contradict this view. I believe, however!

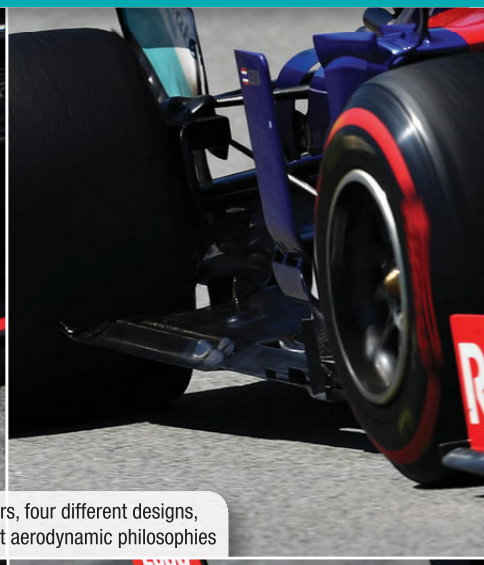
Given the challenges faced, particularly since the introduction of the 2017 rules, the 2019 regulations fast-tracked some of the ideas being researched for the longer-term. The intention was to create an interim solution. Not the great panacea we are all hoping will transform racing for 2021, but at least measures that would prevent the inability of the cars to overtake from getting worse in the meantime.

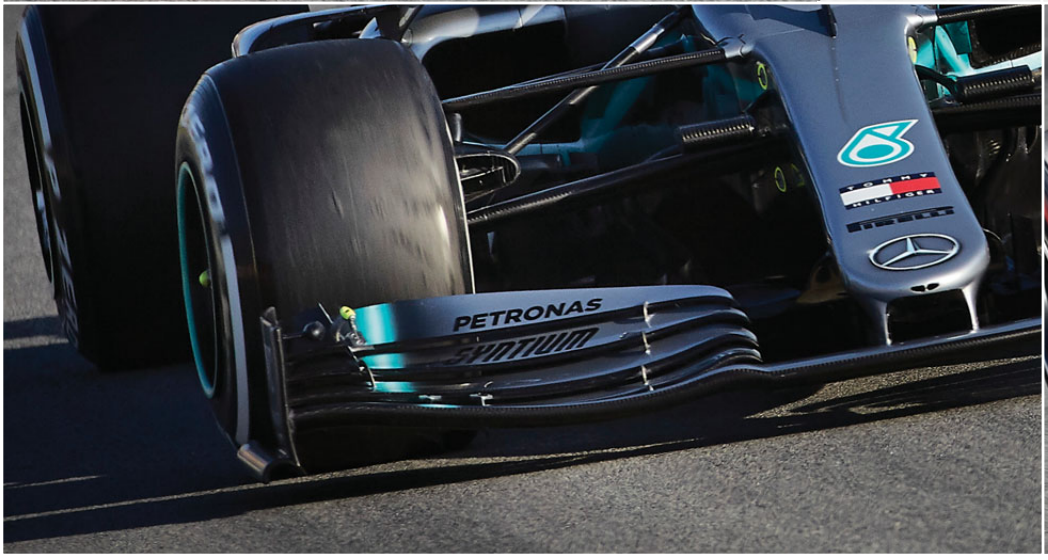
Although the 2017/18 changes made the cars faster, insiders knew that they would make overtaking more challenging.

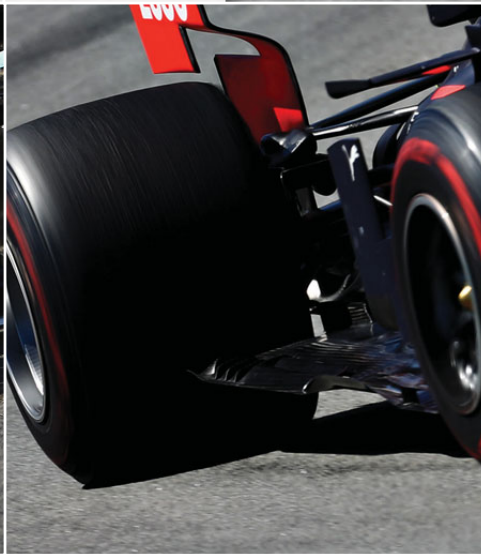
So how did we know? In the lead up to what became the 2009 regulations (delayed due to insufficient time from the original plan of 2008), specific research was done into the aerodynamics of following cars. This research was paid for by the now-defunct Formula One Teams Association (FOTA): in other words, it was paid for by the teams. Several items made overtaking harder. These included low, wide rear wings and powerful bargeboards. The 2017 rules put these items back onto the cars. ▶

ABOVE The contrasting aero approaches collided – almost literally – in Montreal. The event suggested that the much-criticised low outboard front wing expansion route, favoured by Ferrari, will still pay dividends at some of the remaining tracks

ABOVE & BELOW Those involved in the research conducted back in 2009 knew that the 2017 aero revamp would make it harder for cars to follow each other. Multi-car testing is now banned







ABOVE & BELOW Four cars, four different designs, but two obviously different aerodynamic philosophies

That original research saw two small-scale models tested in the FondTech wind tunnel. Each model was modified identically, and the forces measured with and without a second model in front of the primary model (that is the one behind).

Changes that were made for 2017 reopened areas of freedom that we knew, from the research done 10 years earlier, were clearly going to make it more difficult for cars to follow closely in the leading car's wake. We ignored the lessons of history and paid the price with the additional challenges that drivers faced when getting close to the car in front.

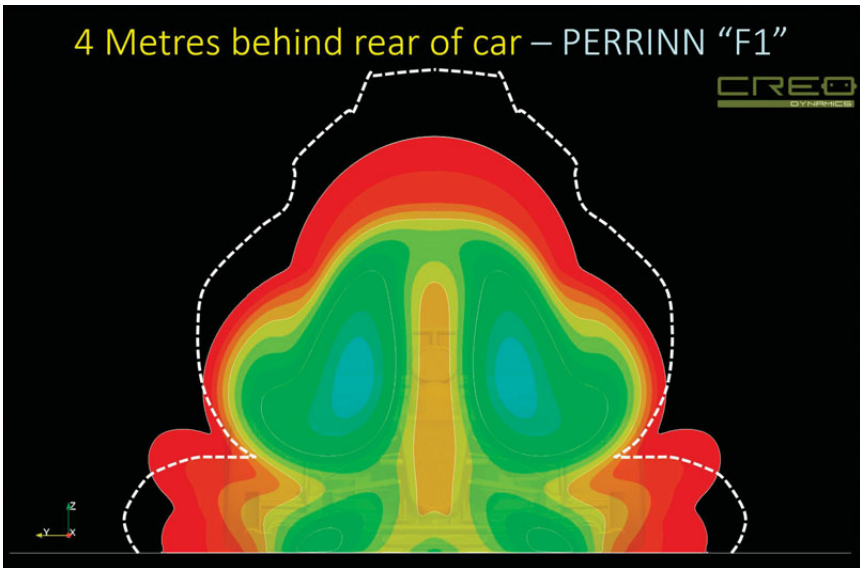
For 2019 the fact that teams play a pivotal role in the creation of the regulations has led to a set of rules that were always going to struggle to achieve their objective of improving overtaking. One positive outcome is a more powerful Drag Reduction System (DRS). This is certainly helping. But there is also, perhaps inevitably, a major negative too…

> *"The low outboard front wing expansion route – chosen by Ferrari, Toro Rosso and Alfa Romeo – is high efficiency but cannot be tweaked to achieve high downforce"*

The front wing regulations box has been enlarged so much that teams have freedom to use only part of the box to generate their downforce. Consequently, they have returned to the game of punching the front wheel wake far outside the periphery of the car in order to generate more downforce. As with every new regulation change, the theoretical performance of the cars has evolved quickly (in CFD and in the wind tunnel). So the intent of the rules has effectively been circumvented.

When the 2019 regulations were being discussed, the teams, as usual, tried their best to argue for changes they believed might be beneficial to themselves. Experience has taught me that the short-term and selfish needs of each team dictate the way they explain motivation for or against the regulations. Engineering truth and the health of the sport overall are hardly ever compatible when the teams have to vote. The exception, I must confess, is matters relating to safety.

So, when the outwashing endplates and turning vanes were eliminated by a push from the rule-makers, the teams requested more volume to recover the lost downforce. Every aerodynamicist in F1 will have known that the lost elements did not create (significant) front downforce; they managed the tyre wake, creating a large vortex that brought high-energy flow back into the area of the bargeboards which, in ▶

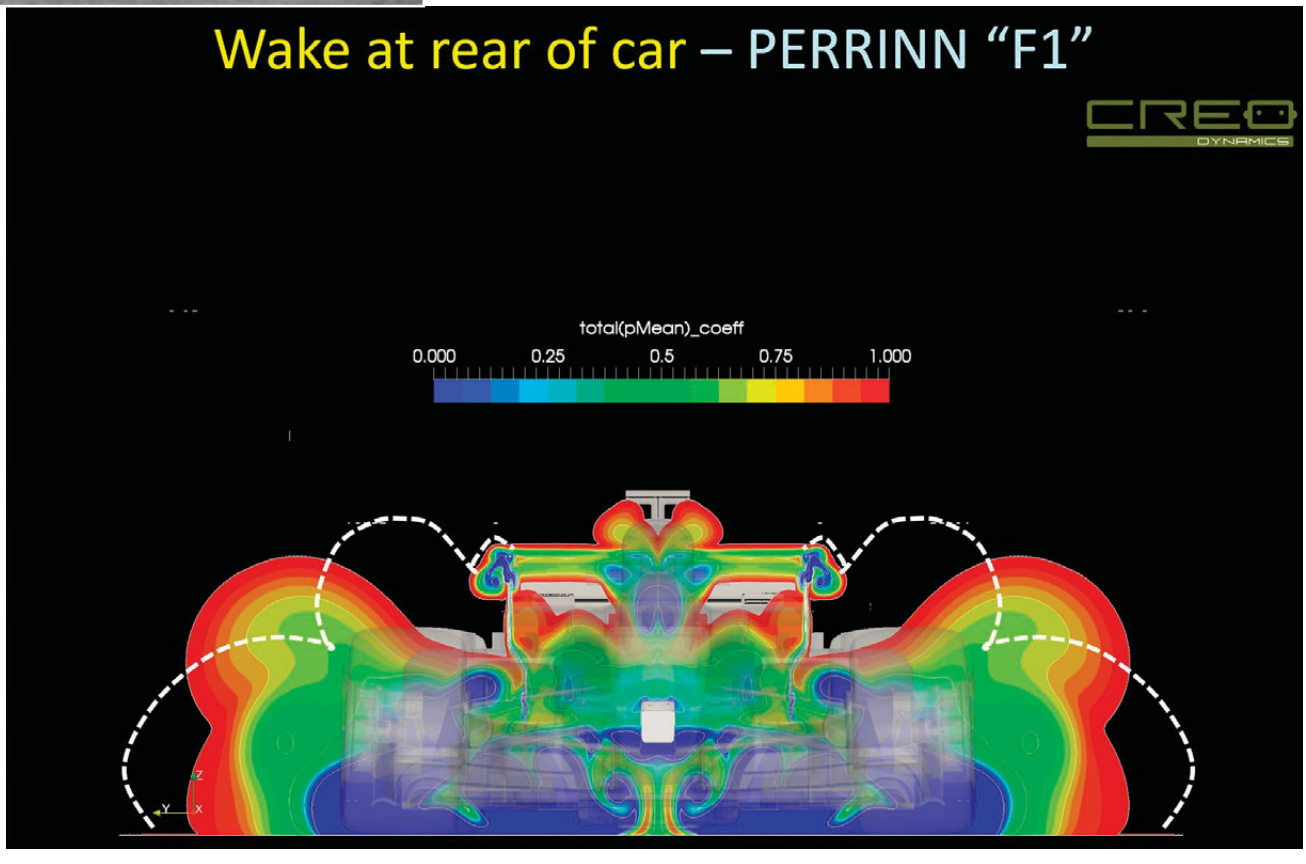


ABOVE Four metres behind the car and a big part of the wake is going higher than the car, but regrettably a lot of the wake stays wide. The car shape can be seen ghosted into the picture. The wake of a real 2017 car would look like the dashed white lines. The wake of a 2018 car would be wider but also stretched taller. Showing the wake of a 2019 car is not something I'm prepared to do!

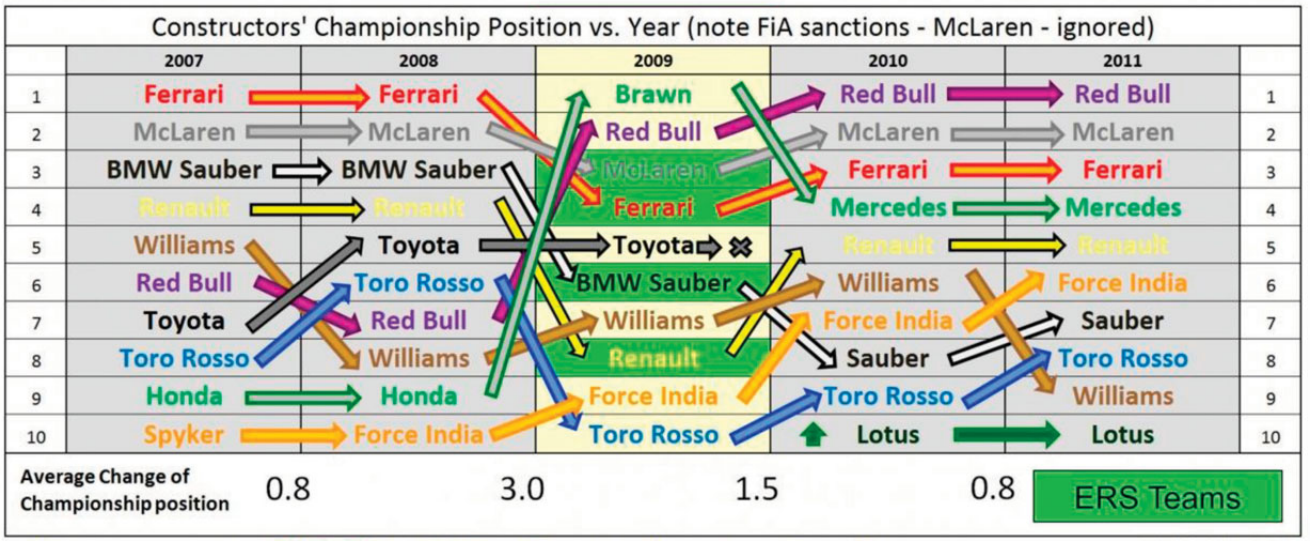
BELOW This diagram shows the wake just at the back of the "Perrinn" 2017 "F1" model. The white dashed lines are roughly where the equivalent wake of a more developed 2017 car is likely to have been.

Nick Perrinn has released this geometry into the public domain – a service that makes it possible for non-experts to dig into the aerodynamics of recent F1 cars. I would like to show you the wake around a real F1 car and, if I did, it would have a wider low-down wake outside the wheels but also a more powerful upwash coming from the rear wing. The upwash will tend to suck the majority of the wake of any car up into the air and much of it will flow above the following car. Unfortunately though, the front wheel/tyre wake is punched outboard so aggressively with all of these cars that it stays low and has a detrimental impact on following cars.

Thanks to Nicolas Perrin for creating the car geometry and to Creo Dynamics for the simulation.



BELOW All teams with KERS suffered in the 2009 championship, a series which illustrated how difficult it is to react once you have made your initial choice of concept



turn, allowed more downforce to be generated further back on the car.

The new regulatory box for the front wing is significantly wider and taller than the old one. This has allowed teams to return to the game of creating outwash. My belief is that the outwash on the 2019 cars is not smaller, averaged over the grid, than it was in 2018. For certain teams, the 2019 cars have a larger outwash than those of 2018, which then allows the cars to produce more downforce.

The cars are heavier this year due to the regulations, but they are faster.

HARD CHOICES

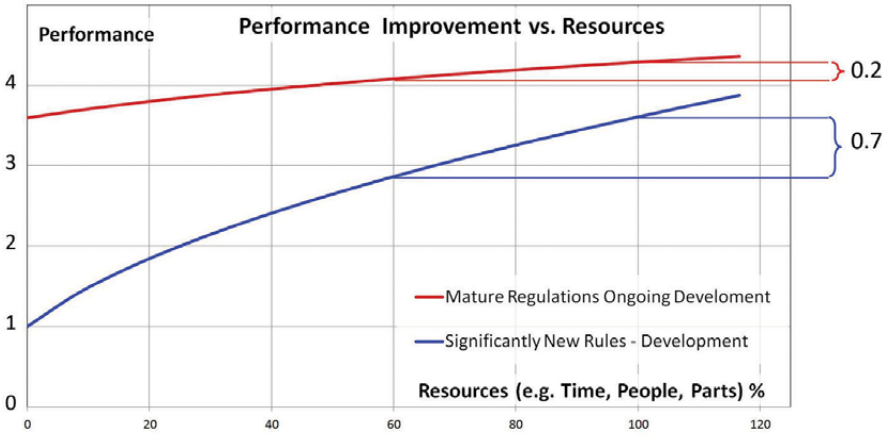
Now to the large range of designs used by the different teams on front wing design. One cannot cover every aspect and, as an expert, I know that it is dangerous to predict which design will ultimately prove to be the best for individual car performance.

Let us keep things simple. Expansion and front downforce generation using the inboard parts of the front wing will have the following consequences: less air will travel past the front wing to the area behind the front wheels, where teams locate their variously-named bargeboards. A powerful Y250 vortex remains and still provides energy to the bargeboard area. With this inboard "blockage", more air will flow outboard towards the front wheel where even the small angle now permitted on the front wing endplate (FWEP) will directly create significant outwash. Further tricks to create more outwash have been evident as the race season has progressed.

Then consider this. The front wings are now back to being as wide as the overall vehicle. Therefore, front wing losses and potential outboard damage to front wings is inevitable. If most of your front downforce is generated outboard, it is likely you will lose more of that downforce if you damage your FWEP.

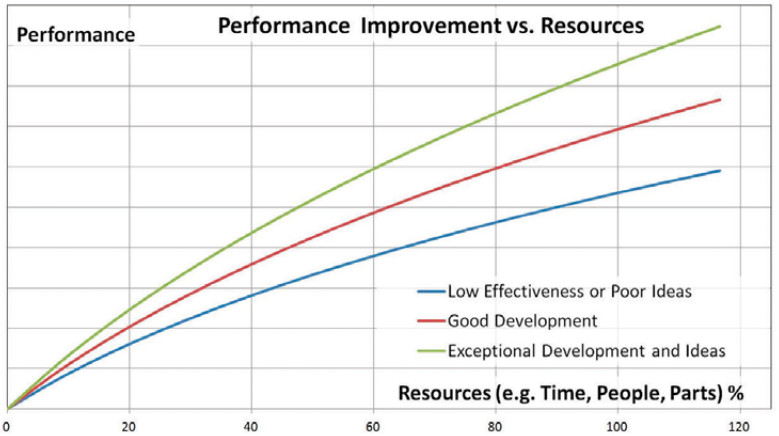
No matter how the spanwise lift distribution is organised, there will still be a massively powerful series of vortices which add up to the so-called Y250 vortex. These ▶

Smoothed Plot - Performance Change vs Research



ABOVE & BELOW As a resource-planner, your main role is to deploy resources where they are most useful. You expect a reasonable development curve that will look like one of these curves once it is smoothed out

Smoothed Plot - Performance Change vs Research



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will take flow nominally aiming to pass around beside the driver and rotate some of that flow down into the area that can be used by the bargeboards.

For the teams generating the majority of their front wing downforce outboard, a little less direct outwash can be created at the endplate, but more air is directly available to the bargeboard area. This means that the front wheel wake can be controlled from behind the wheel more and from in front of it a little less. Both conceptual designs can be evolved to generate more downforce with the front of the car as total downforce levels increase due to the evolution of the designs. There is still a lot of front wing "box" available.

> *"My question to all of you budding aerodynamic experts is: do the teams all investigate the opposite solution to the one they currently run?"*

LESSONS FROM KERS UPHEAVAL

So, my question to all of you budding aerodynamic experts is: do the teams all investigate the opposite solution to the one they currently run? If they do, what are the consequences?

Again, we don't have to delve too far back into recent history to fathom some of the answers

In 2009, F1 permitted energy recovery systems (KERS) to be used for the first time. These allowed any team running them to gain a theoretical 0.25 seconds per lap advantage and to have a strategic (potential overtaking) advantage by using up the energy and deploying it all in one overtaking manoeuvre rather than spreading its use out over a single lap. At the team I was working for at the time, I argued vociferously not to have the KERS on our car. The strength of my conviction, and quite possibly the way that I argued, ultimately lost me my job.

Every team that decided to fit an ERS went backwards in 2009. So why?

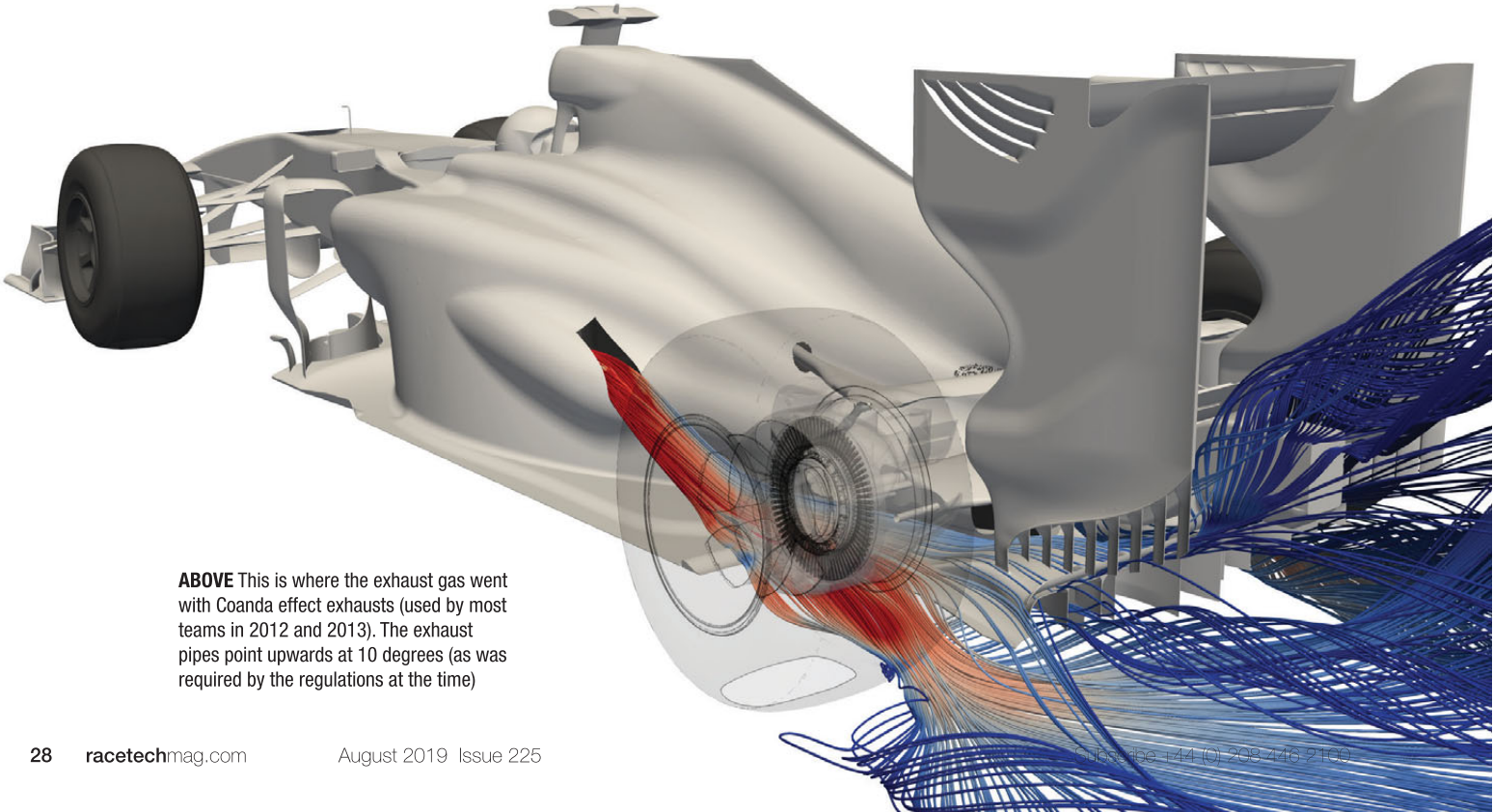
ERS added a huge research load on many departments, including the aerodynamics department of the teams choosing to run the system. This, combined with the dramatic rule changes on the aerodynamics themselves in 2009, was why I wanted to give up that "advantage". There was more to gain from having a conventional car and working on the aerodynamics.

With the changes to the aerodynamic regulations for 2009 this is what I explained would be the result with KERS. Aero research cut to about 60% would mean a loss of 0.7 seconds compared to deploying the whole department's energy into rules optimisation rather than use 40% of the department on KERS-related work. The truth was that gains made by all teams in the run up to 2009 were larger than expected. Thus the gain for adding research capability (i.e. using the whole department) was also bigger than I had predicted.

I then made a really large mistake. My people, knowing very well that non-KERS was the way to go, begged and pushed me to let them do some research into a non-KERS package. Eventually I relented. We made gains but the fundamental unchangeable design philosophy of the car could not be altered and the gains were not big enough. This then, was a waste of time and took away from that final performance of the car. Looking back, I kick myself for this mistake.

THE COANDA COMMITMENT

In 2012 a few early adopters discovered that you could use the Coanda effect to circumvent a new regulation which ▶



ABOVE This is where the exhaust gas went with Coanda effect exhausts (used by most teams in 2012 and 2013). The exhaust pipes point upwards at 10 degrees (as was required by the regulations at the time)

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BELOW Teams have returned to the game of punching the front wheel wake far outside the periphery of the car, to the detriment of those following behind

Pirelli

pushed the exhaust gas uphill and away from the floor of the cars. We discovered early that aerodynamic evolution created a diverging path for car shape depending upon the use or not of a Coanda exhaust system.

I polled my department heads and influencers about the best direction. Everyone bar one said Coanda exhaust would be fastest. Most, however, wanted to research both, just in case. It was clear that the gains from using the exhaust for performance were so large that even driveability disadvantages would be overcome. The step in performance available, especially coming out of low- and medium-speed corners, was huge.

> *"One has to be both arrogant and brave to change – it can work but usually does not"*

So, remembering the lessons from the past, I pushed both my people and my bosses in the direction of making one choice. It was another fight, a really *big* fight, but I'm not afraid of a fight.

2019 DILEMMA

For 2019, I would suggest that, for most teams, staying with their present car concept is likely to give them the best result across the remainder of the campaign.

If you were the boss of an F1 team and you had to decide whether to change direction and investigate a new concept or not, you have to consider the consequences of that choice. To give the alternative concept a fighting chance, you have to apply a significant proportion of your always limited resources to studying that concept. Remember that changing to the new concept may require a new nose design. That means a new crash test, which brings its own risk.

Redeploying resources necessarily removes resources from your previous concept and hence reduces your rate of development on your original concept. Consequently, if the new route proves wrong, you have crippled the development rate on the best concept. If the new concept is the best one, you are at least six months behind everybody else who is developing it. Result: you are going to have a bad season. The chassis is too hard to change and may already cause a compromise, further crippling a potential change of direction. One has to be both arrogant and brave to change – it can work but usually does not.

THAT SINKING FEELING

After the pre-season tests in Barcelona, learned opinion suggested that, for whatever reasons, Ferrari had got it right. Post-Melbourne, it was clear that Mercedes had actually got the best package/setup for that event. Over the subsequent races we developed a more balanced picture of where the cars and drivers really stand.

Evidence now suggests that the low outboard front wing expansion route – chosen by Ferrari, Toro Rosso and Alfa Romeo – is high efficiency (at least potentially) but cannot be tweaked to achieve high downforce. The high outboard expansion front wings are costlier in drag but can produce more downforce.

I am convinced that any squad choosing to change concepts will have a bad year – so far no team has done so – because chassis design and cooling layouts are influenced by the concept. So a change of concept would bring its own compromises around a geometry frozen with the other concept.

Happily for Ferrari (and the others), in Canada the high efficiency available with their concept enabled the Scuderia to grab pole position there. That bodes well for Monza and Spa for those teams, but the championship is much more likely to be won by those that have selected the other concept: Mercedes, in other words.

But, if you want to know which concept is best, perhaps our friends at Red Bull (not the team, but the sponsor) are in the best position to ferret around and find the answer. They sponsor a car with each concept… RT

THE BRAVEST SPORTSMAN EVER

Tony Dodgins reflects on a hero who, as the title of his autobiography suggested, went 'to hell and back'

Ferrari

CERTAIN people and events shape your life. 'Car' was the first word I said. I loved all sport but watching Jackie Stewart and Jochen Rindt at Silverstone on TV as an eight-year-old in 1969, put F1 top of the list. Seven years later, Niki Lauda, his Nürburgring accident, recovery, and subsequent battle to retain his world title, turned an interest into an obsession.

That 1976 season defined Lauda in the public consciousness. It also took Grand Prix racing from the back pages to the front and, some say, fully awoke a mid-forties Bernie Ecclestone to the full commercial potential of a sport he turned into the global colossus it is today.

Versus the tall, blond, handsome, drinking, smoking, womanising public school James Hunt, the skinny buck-toothed Austrian wasn't exactly Hollywood material. That contrast was exaggerated even further in the 'Rush' movie film script that re-told the '76 story almost 40 years on.

But Lauda had steel. Renowned sportscaster Harry Carpenter, who interviewed Niki for Sportsnight just a couple of months after his fiery Nürburgring shunt, said: "I have never in my life spoken to anyone with the iron-clad determination of Niki Lauda." And Harry was used to dealing with boxers.

LEFT Lauda: an inspirational figure whose popularity transcended motor racing

BELOW In full flight for the Prancing Horse, with which he won two world titles

Motor racing was Lauda's escape from a protected, sometimes stifling upper-class Viennese upbringing, that had seen him pretty much drop out of schooling. Tinkering with VWs on his parents' estate led on to hillclimbing Mini Coopers and then Porsche 911s, much to the family's disapproval.

One positive was that the family name made the borrowing of money easier than for most. It was how Lauda was able to do F3 and then buy his way into the March F2 team until his grandfather, the family patriarch 'Old Lauda', had a quiet word with a bank and suggested that any 'sponsorship' of his grandson, should stop. Niki didn't speak to him again.

Lauda may not have embraced formal education but always had a quick brain and an ability to strip out incidentals and get right to the meat of any matter. He was ever a pragmatist. Which is what makes it so remarkable that he mortgaged himself to the hilt to buy himself into the March F2 and then F1 teams, at a time when there was no evidence to suggest he was the next Jim Clark or Jackie Stewart.

Austria's Jochen Rindt had won the world championship posthumously in 1970. The day of Rindt's death that September had a significant influence on Lauda, but not for the reasons you might expect.

On the same day, Lauda was racing F3 at Zolder. He had his fourth accident in a series he thought was complete madness, populated by lunatics. That, along with Rindt, made his mind up. There would be no more F3. He'd buy himself a ride in F2 with March.

The rising star was Ronnie Peterson. The man who would become 'SuperSwede' before he too was killed, at Monza in '78. Outwardly it appeared Peterson was in a different league, but it was the direct comparison in F2 that convinced Lauda he had what it took.

Testing the same car, same day, the gap was around six tenths before Niki started to chip away. The races, he claimed, were skewed further because Ronnie had a better engine, a famous one reputedly used back in the day by Clark himself.

The story goes that the wider racing world took notice of Niki when he outbraked Ronnie and passed him at Rouen, but Lauda himself dismissed that. Peterson, he knew, had the wrong wings on the car that day.

> *"Getting your own way is an indispensable part of success"*

Lauda could always sort a car quickly, something Peterson was hopeless at. Ronnie preferred to use his natural ability to drive around problems.

It was enough to persuade Lauda to get himself into a million Schillings worth of debt, a sum he calculated would take between 40 and 70 years to pay back by 'normal' means. Motor racing had to work out for him.

In those days you didn't have a gravelly-voiced Ray Winstone on the TV every five minutes imploring you to 'gamble responsibly' – surely the ultimate oxymoron – but Niki would obviously have ignored him!

When March decided they wanted Chris Amon, Niki persuaded BRM's Louis Stanley to take him on alongside Clay Regazzoni and Jean-Pierre Beltoise for '73, with sponsorship money that was 'coming.'

By then he was showing ability outside single-seaters too. Ford and BMW were engaged in touring car wars and Lauda was earning money driving anything and everything, then paying it to Stanley as the 'first instalment' of his non-existent sponsorship. On the Nürburgring Nordschleife, in a BMW, he lapped three ▶

> *"I remember getting to the hospital, feeling tired and wanting to sleep, but knowing that it wasn't sleep, it was something else…"*

seconds quicker than track specialist and resident dare-devil, Hans Stuck.

Everyone needs a bit of luck and although Lauda would probably have claimed he made his own, it came at Monaco. All of a sudden he was second quickest to reigning champion Emerson Fittipaldi in practice, ultimately qualified sixth (Regazzoni and Beltoise, who'd won the race the previous year, were eighth and 11th) and raced with the big boys until the gearbox packed up. Stanley immediately put him on a salary and made him sign a long-term contract.

Enzo Ferrari had noticed too and had already been in contact with Regazzoni about '74, having fallen out with Jacky Ickx. Regga told Il Commendatore that Lauda could sort cars and endorsed Niki's candidacy too. They both signed for '74 shortly after, with Ferrari taking care of Niki's debts and his contract with Stanley. Ironically, he replaced Arturo Merzario, a fact that would save his life less than three years later.

Part of what Niki called 'the Lauda system' was to be totally focused and self-centred. "Getting your own way," he said, "is an indispensable part of success."

That success came quickly. There were nine poles and wins in Spain and Holland with the Ferrari 312B3 in '74, followed by five wins, including Monaco, en route to his first world title in '75 with the transverse 'box 312T. Niki had given Enzo Ferrari his first Monte Carlo victory since '55 and his first world championship since John Surtees in '64. They were in love. But not for long…

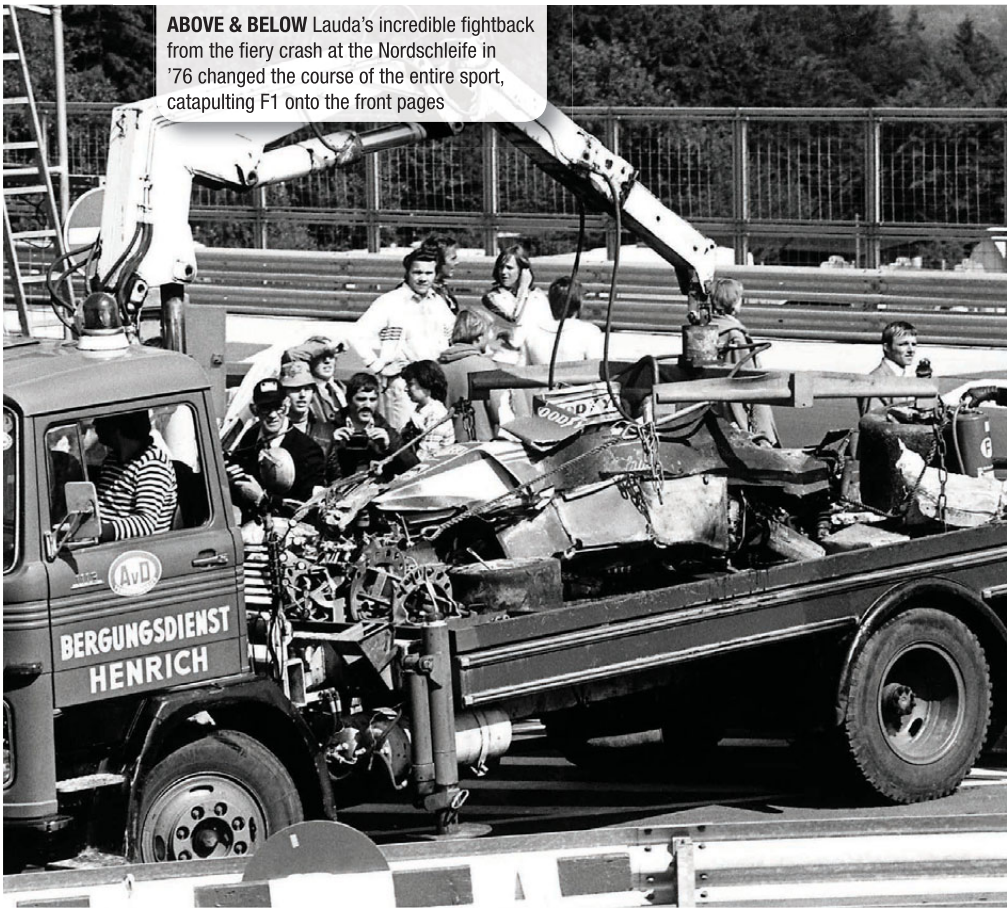
"THE GRILL ROOM"

Lauda would have cake-walked '76 too, but for the Nürburgring accident, when he lost control of his 312T2 mid-way around Nürburgring's 14-mile lap at Bergwerk, for reasons it was never clearly established. The car snapped right into the barrier, ruptured the fuel tank and spun back across the road, ablaze.

The Ferrari struck Guy Edwards' Hesketh. When his car came to rest, Edwards ran to Lauda's aid and was assisted by Brett Lunger and Harald Ertl. But the heat was intense and Lauda was straining against his belts, which they couldn't release. Merzario then arrived and, a former Ferrari driver, he knew how the harness release worked and they were able to drag Lauda from the cockpit. Niki later presented 'Little Art' with his gold Rolex as a token of gratitude.

For days Niki's life hung in the balance. As well as burns to his face and scalp, his lungs had been seared by toxic fumes from burning fibreglass and his blood oxygen level at one point was reported to be below that considered necessary to sustain life and organ function.

"I remember getting to the hospital, feeling tired and wanting to sleep, but knowing that it wasn't sleep, it was something else…" Lauda recalled. He combatted it by listening to voices and trying to understand the context. He was asked if he wanted to see a priest and thought that would give him something else to concentrate on. But was dismayed to find the priest say nothing, administer ▶



ABOVE & BELOW Lauda's incredible fightback from the fiery crash at the Nordschleife in '76 changed the course of the entire sport, catapulting F1 onto the front pages

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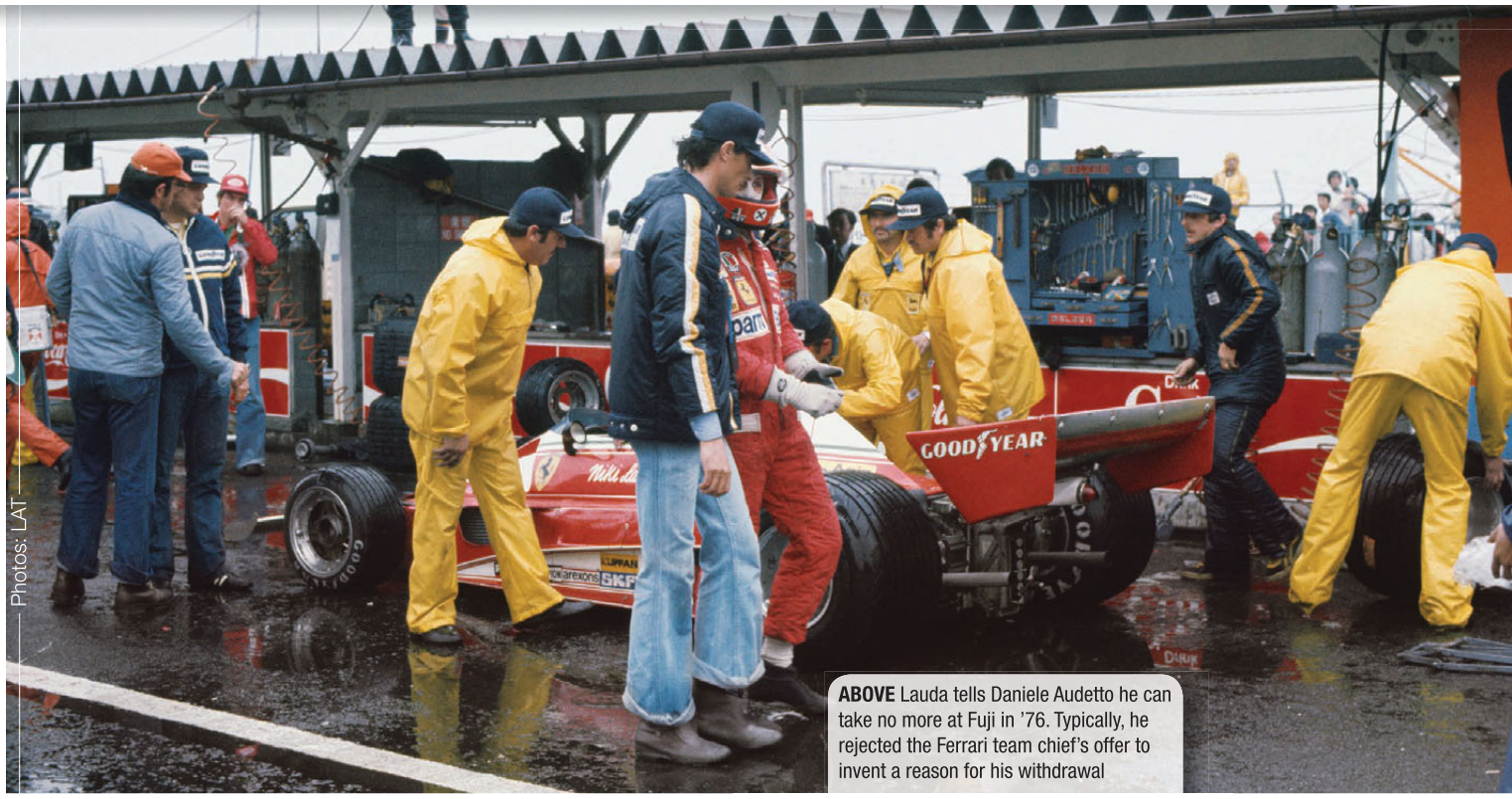

Photos: LAT

ABOVE Lauda tells Daniele Audetto he can take no more at Fuji in '76. Typically, he rejected the Ferrari team chief's offer to invent a reason for his withdrawal

the last rites and immediately leave!

"I'd prefer he'd have encouraged me to fight and given me the last rites so I didn't know or feel it…" Lauda said.

Later, he would look back at Nürburgring in his usual straightforward manner with his characteristic black humour. He and Merzario, together with Bernie Ecclestone and Niki's son, Mattias, went back to Bergwerk, where photos and the odd schnapps were taken.

"For years journalists tried to get me to go back to the scene," said Lauda, "maybe in the hope that I'd let my emotions run riot and burst into tears. Unfortunately for them, I was always more likely to say, 'Ah, yes, the Grill Room…'"

That he was back in the cockpit 40 days later, his wounds and burns still raw and weeping, defied belief.

"When I climbed into the cockpit at Monza, fear hit me so hard that all my self-motivation theories flew out of the window," Lauda admitted in his autobiography *To Hell And Back*. "Diarrhoea. Heart pounding. Throwing up. I got out of the car at the first opportunity. I went back to the peace and quiet of the hotel and went over the situation in my mind, trying to identify what I had done wrong. I had attempted to drive as fast as I had done before the shunt irrespective of my weakened condition and the rain."

Lauda had scared himself. So he applied some of that iron-clad determination that Carpenter was talking about. Controlling fear was a matter of willpower. The accident, he admitted, had shaken him up, but it hadn't unbalanced him. On Saturday, in the dry, he built himself up slowly to the point where he qualified quickest Ferrari.

The team had by this time taken on Carlos Reutemann alongside Regazzoni after the Italian papers had repeatedly written that 'it was over for Lauda'. He finished the race fourth. Carpenter called it the bravest sports story he had ever reported.

That championship went down to the wire at Fuji in Japan, with Lauda leading by three points going in and points awarded 9-6-4-3-2-1. After a delayed race in chaotic wet conditions, Hunt finished third. Fifth for Niki would have been enough but he parked up after a couple of slow laps and withdrew. Emerson Fittipaldi, Carlos Pace and Larry Perkins also stopped.

"Life," said Lauda, "is more important than the world championship." Daniele Audetto, Ferrari's team manager, offered to tell the media it was an engine problem. Niki wouldn't have it: "Tell it like it is, I stopped."

It wasn't as simple as spray and dangerous conditions. Lauda had lost part of his eyelids in the Nürburgring fire and had yet to have corrective operations. He couldn't blink away tears properly and, in the streaming rain and heavy spray, could see even less than everyone else. Yes, he admitted, it cleared up a bit and if he'd kept going he'd probably have finished fifth, but…

He left for the airport immediately and had it confirmed to him there that Hunt had scored the necessary points. He made the call to Enzo Ferrari. The Old Man only wanted the facts. There was no acknowledgment of Lauda's heroic return. No human touch.

FERRARI BETRAYAL

Ferrari was now in a dilemma. Thinking that Lauda's best days were behind him, he'd signed Reutemann as number one for '77. After Fuji he didn't quite know what to make of Niki but didn't want him in someone else's car, so offered him ▶

ABOVE Amid the monsoon conditions of the '76 title finale, Lauda could no longer master his fear

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Lauda responded by waving his '77 contract in front of the Old Man. After a big conflab it was agreed that Niki could drive but that Reutemann was number one. Hogwash, Lauda thought, he'd soon prove who was number one. It didn't look too good when Reutemann won race two in Brazil. Lauda thus demanded an intensive test session prior to the next race in South Africa and promptly won the first race since his return despite running over debris following a tragic accident that claimed the life of Tom Pryce.

He quickly subjugated Reutemann and wins in Holland and, fittingly, Germany (although it was Hockenheim not Nürburgring) set him up to re-capture his world title. But the trust had gone and his Ferrari relationship was soured. In Holland, Lauda signed a contract with Bernie Ecclestone and Brabham for '78 but was keeping it under wraps so as not to compromise his '77 challenge.

There followed a barnstorming argument with Ferrari that culminated in Lauda walking off as the old man lambasted him. On reflection, Lauda said, it didn't feel good because Enzo by then was 78 and his information was garnered second or third-hand amid an intensely political environment.

Mauro Forghieri, Lauda said, was a key part of his feeling that the pressure of four years at Ferrari had grown too much for him to countenance a fifth, although he admitted that Forghieri was 'a genius'.

Niki's loyal and diligent Ferrari mechanic was a dyed in the wool long-term Ferrari man, Ermanno Cuoghi. Lauda had asked him to move to Brabham with him and Cuoghi was considering it, but his wife wasn't sure about moving to England. Ferrari got wind of it and confronted Lauda about poaching staff and Cuoghi about whether he was staying. Cuoghi said he needed time. Ferrari told him he didn't have it, he was fired. When Lauda turned up at Watkins Glen, a distraught Cuoghi told him what had happened and literally cried on his shoulder.

It was the final straw for Niki. When fourth place clinched the championship in the USA, Lauda was gone, the Ferrari chapter closed. The young Gilles Villeneuve replaced him in Canada and Japan.

Happily, Lauda said, there was a rapprochement five years later. He was in the early days of his F1 second coming with McLaren when Ferrari unexpectedly ▶

ABOVE The unlikely friendship with James Hunt was a result of the respect forged from a fierce rivalry

BELOW Remarkably, he bounced back to win the '77 title with Ferrari. Here he leads Hunt's McLaren at Monaco

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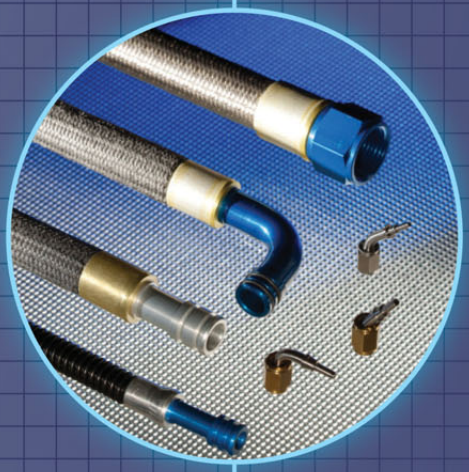

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turned up at an Imola test. Driving out of the track in his grey Lancia, the Old Man saw Lauda, stopped, got out and clasped Niki to him like a long-lost son. It meant quite a lot to a man not famous for showing emotion.

Lauda's Brabham career did not match the success he had at Ferrari. The BT46 of '78 was no match for Mario Andretti's ground effect Lotus 79 but there was the famous 'fan car' win at Anderstorp and another victory at Monza.

The BT48 of the following year was a bit of a lemon, hamstrung by a long, heavy, unreliable Alfa V12. It prompted a late decision to return to Cosworth power. Gordon Murray designed the lovely, neat BT49 and Lauda drove it for the first time in practice for the Canadian GP at the end of September.

A man who had always driven 12-cylinder F1 cars at BRM, Ferrari and Brabham, he recalls feeling unsure about his motivation at the end of that year and driving out with the muted tones of a Cosworth V8 at his back. After a few laps of Friday practice he decided he wanted pastures new. He climbed out and told Ecclestone he'd had enough, there and then. Okay, Bernie said, he understood, and they ripped up the $2m 1980 contract that it had taken Lauda four months to extract from Bernie.

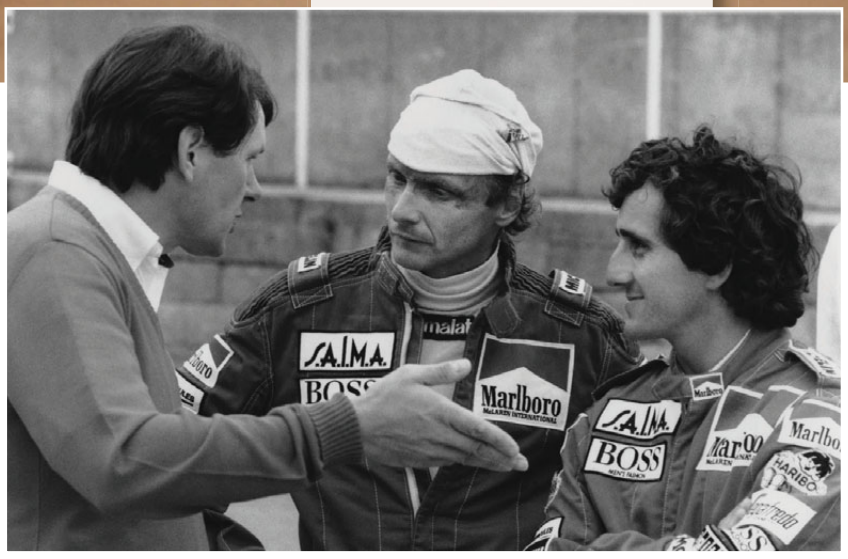
A cynical Alan Jones saw it differently. He figured that Lauda could see the writing on the wall with talented new team-mate Nelson Piquet. With the V12 it didn't matter because the car broke down every five minutes. But with the Cosworth, it wouldn't. Niki was protecting his market value.

According to Lauda though, he'd been through the mill and had got a bit disillusioned with not being able to compete. The aircraft world was calling him and he wanted a new challenge.

But it was now 10 years since the wilful youngster with no formal qualifications or job prospects had crazily mortgaged himself to the hilt and pulled off a miracle. A return to the 'real' world dismayed him. Everything was so slow and took so long! Mediocrity, at best, was everywhere.

At first he didn't miss F1, didn't even watch it, but less than two years later he was back at Monza having a quiet word with Ron Dennis, who had kept in

ABOVE & BELOW Shocked by Prost's speed at McLaren, Lauda's pragmatic approach salvaged a third world title by just half a point in 1984



> *"He taught me how to put things into perspective after a loss, taught me how to be detached"*
>
> ALAIN PROST

monthly contact. A test was set up in a McLaren at Donington and in '82 Lauda was back.

He won his third race, at Long Beach, and also claimed the British GP at Brands Hatch. Keke Rosberg won that year's championship with just a single win.

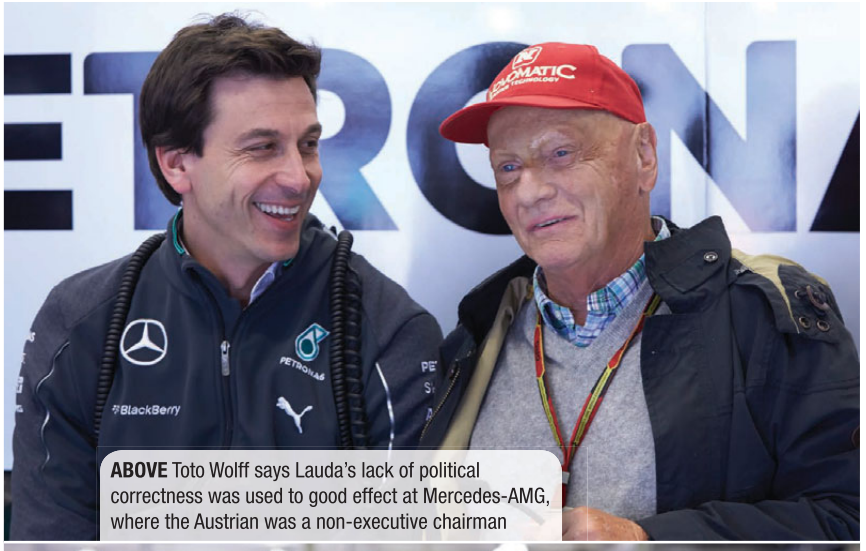
The '83 season was pretty much a write-off as the march of the turbos took hold of F1 while Dennis was still in the process of putting together a TAG-Porsche V6 turbo deal with Mansour Ojjeh for '84.

The McLaren-TAG MP4 was the class of the field but Niki had a new problem. His team-mate was now a certain Alain Prost.

"THAT LITTLE FROG IS BLOODY QUICK!"

"That little frog is bloody quick…" Lauda was moved to admit early-season. His pragmatism going into overdrive, he realised there was no point trying to outqualify Prost and set about spending his entire time prioritising race set-up.

It worked well enough to keep him in the fight. When Prost's Renault had retired in the '83 season finale at Kyalami, he lost the championship to Piquet by two points and said he'd never get closer. He was wrong. With five wins to Alain's seven, Niki beat him by half a point in '84 (Monaco was stopped and only half



ABOVE Toto Wolff says Lauda's lack of political correctness was used to good effect at Mercedes-AMG, where the Austrian was a non-executive chairman

ABOVE Even heroes have heroes: Lewis Hamilton with Niki

points were awarded, so Prost scored 4.5 for his win).

On the podium in Estoril when Niki had scored his decisive second place behind Alain, he whispered in his ear: "next year is yours" – and it was.

Prost was not bitter.

"It's simple," he said recently, paying tribute to Lauda. "When I started to take an interest in F1, I had two role models: Jackie Stewart and Niki. And I had the chance to spend two years by his side. These were the two most beautiful and best seasons of my career.

"He taught me how to put things into perspective. When I did not feel well, after a loss, he taught me how to be detached.

"He made me drink my first whisky in 1984 to take things off my mind. He taught me how to compartmentalise. That was his philosophy."

That was part of Lauda's personality. In his dealings with the media, he would never use 10 words when two would do. All part of the pragmatic approach. No bullshit. Tell it like it is. Say what you think. If people don't like it, tough. Get it done. Finished. Move on. Efficiency. As he mellowed and added a sprinkling of humour, he became ever better-appreciated.

Whether with a team or broadcasting on TV, Lauda called a spade a shovel. Politics and unwieldy management structures were anathema to him and he quickly lost patience. He wasn't cut-out for running the abortive Jaguar F1 attempt or the early noughties.

Lauda quickly came to accept being misquoted or misrepresented in the press as one of the inevitable consequences of fame. It was futile wasting energy on it, he concluded, because you can't stop it. But it did bug him every so often, one such subject being safety.

As a senior figure, Niki took over some of the safety mantle when Jackie Stewart retired in '73. The length of the Nürburgring and lack of marshal cover was a concern and Lauda was spokesman for a GPDA advocating a move away from the Nordschleife.

On the very eve of his '76 accident he was sat watching a TV programme on which the host was accusing him personally of being too yellow and chicken to continue driving at the Ring. Niki was angry at the feeling of helplessness at being unable to defend himself.

Did this buffoon not appreciate that he'd lapped a BMW quicker than Stuck and, 12 months ago, had taken the Ferrari 312T around in 6m 58s for pole position – the first man around the 'ring in under seven minutes. I'll show you chicken!

Lauda was quite proud of that Ferrari lap but, as ever didn't let it get in the way of pragmatism.

Some 35 years later, Toto Wolff tried to do the same thing in a Porsche GT car and had a substantial shunt.

Speaking at Monaco, as he tried to get to grips with the loss of an F1 icon and close friend, Wolff said: "You can't compare the Nordschleife in an F1 car in the seventies to an amateurish attempt 35 years later. But the night before I tried it, I had dinner with Niki."

Ahhh. Toto was goaded into it?

"No, no. Quite the opposite. It wasn't him to blame, it was my mid-life crisis! I told him I was keen to try to break the GT record on the Nordschleife and also to break seven minutes. He said, 'This is the dumbest thing I have ever heard! The risk of injuring yourself badly is there and who cares anyway?'"

As non-executive chairman at Mercedes, Lauda had come to be much appreciated.

"Once our trust settled down, his loyalty to the team was immense," says Wolff, "and it was a huge advantage having someone who didn't need to be politically correct. Niki Lauda could say anything he wanted.

"Sometimes he would give the communications teams grey hairs but his comment would always be, 'Who cares?' It was so refreshing and necessary for F1 to have somebody who really didn't care. That was Niki."

There will never be another like him.

ABOVE Red Bull Advanced Technologies will design an Aeroscreen for enhanced driver cockpit protection ready for the 2020 IndyCar season

WINDOWS 2.0

A Formula 1 import had a big impact at the Indy 500 – just not the one that was expected. **Matt Youson** talks to the company developing the next generation of cockpit protection for IndyCar

MOTORSPORT tends to be defined by continuity and change. The dramatic tension between historic events and new technology is a powerful driver for racing, exploiting an inherent potential to be simultaneously both complementary and antagonistic. There will be few better examples than the 103rd Indianapolis 500, at which IndyCar chose to show off its 2020 head protection system – aka the Aeroscreen – designed in Milton Keynes, England by Red Bull Advanced Technologies (RBAT).

Uneasy is the relationship between open-wheel racing and head protection. There's a pugnacious streak threaded through motorsport which insists danger is part and parcel of the attraction. Those in positions of authority tend to look askance at this Hemingway-inspired *Death in the Afternoon* recidivism and insist they have a moral, ethical (and legal) obligation to improve safety and implement practical safety technologies where they exist. In this context, head protection devices became only a matter of time for every open-cockpit formulae from the moment Formula 1 announced its plans to implement the Halo device.

The Aeroscreen is a product of the same research project that produced the Halo. Common practice in F1 has been for safety research to be a collegiate affair: led by the FIA but with design and development farmed-out to the larger teams. Thus, while the Halo always seemed to be the preferred option, the Frontal Protection Working Group (FPWG) solicited several second opinions: Ferrari tested an elongated cockpit shield, while Red Bull Racing, via Red

Bull Technologies (RBT), developed the Aeroscreen. It made its track debut on Daniel Ricciardo's car in free practice at the 2016 Russian Grand Prix.

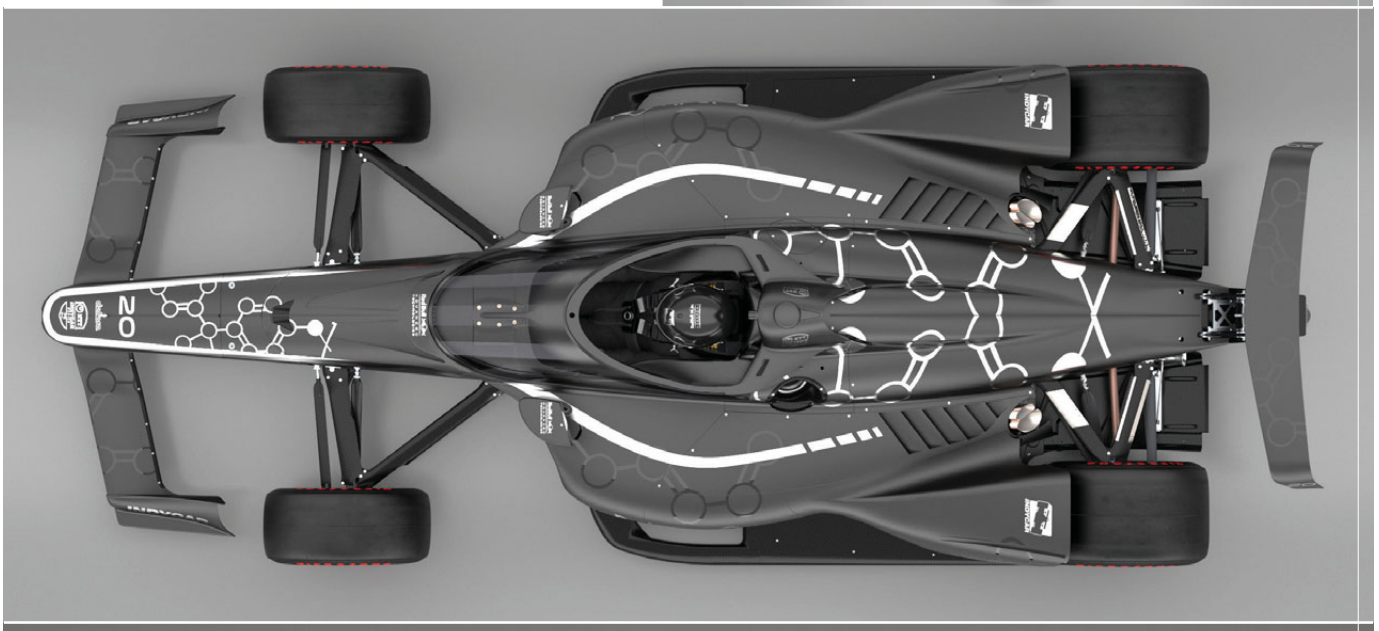
The FPWG primarily concerned itself with negating large scale impacts: bodywork; barriers; untethered wheels. While small objects were considered in the study, the belief at the FIA was that advances in helmet technology would play the leading role in countering cockpit intrusion from these. Red Bull, on the other hand, began its work with Felipe Massa's 2009 Hungaroring accident – in which the Brazilian collided with a loose suspension

> *"IndyCar suggests the Aeroscreen both changes everything, while also changing nothing!"*

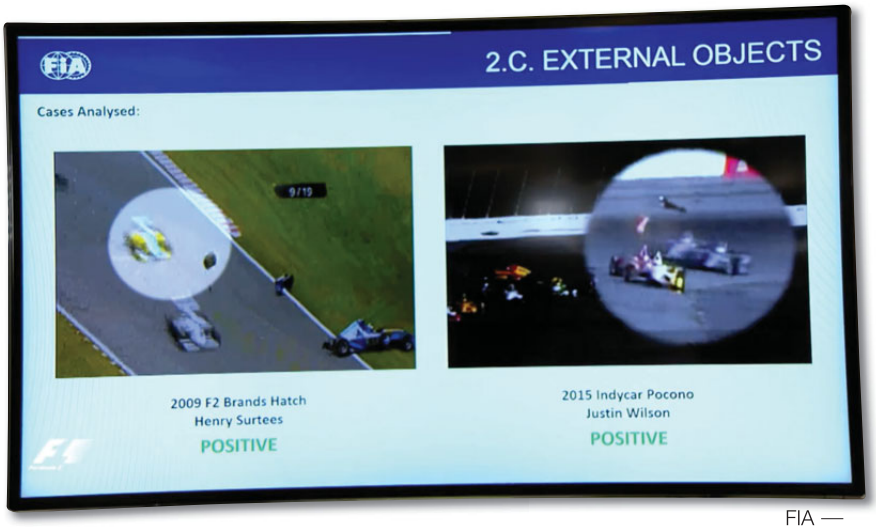
component – at the forefront of its planning. The Aeroscreen protects against these more effectively than the Halo.

Ultimately, the FIA decided to go with the Halo. Its reasoning was that, at the time a decision was required, the Halo represented the most mature solution on offer. That wasn't quite the same thing as saying the best solution on offer. In a briefing ▶

Photos: IndyCar



ABOVE & BELOW The titanium framework will mount to the DW12 in three areas around the cockpit – the chassis centreline, two rear side mounts and roll hoop integration. The load-bearing capability is expected to be 150 kilonewtons (kN), which would equal the FIA load for the F1 Halo



FIA —

ABOVE The FIA's original Halo research included predicting the outcome of IndyCar incidents, as well as single-seater crashes in Europe

FIA —

ABOVE The seeds for Red Bull's work on the Aeroscreen were sown by Felipe Massa's 2009 Hungaroring accident, in which the Brazilian was struck by a loose suspension component

at the 2017 Hungarian Grand Prix, Laurent Mekies, FIA safety director and F1 deputy race director (now Scuderia Ferrari sporting director), spoke approvingly of the Red Bull structure.

"The Aeroscreen was probably the most complete solution," he acknowledged. "It's basically a Halo with a screen in front of it. It was effectively a Halo-type structure behind that edge with two lateral pillars. It was very promising but at the time when we had to make a decision, it was still not passing the wheel test, still failing to completely protect against the wheel being thrown at it at the speed we chose. On top of that, we discovered with the Aeroscreen, and later with the shield, another family of issues that comes with windscreens related to dirt, rain, and how do you deal with fogging? We knew there were a number of disadvantages coming with it.

LESSONS FROM 2016 PROJECT

"It [the decision to ignore the Aeroscreen concept] is not something that is set in stone forever. It is something that we think technically can be fixed – and one day perhaps it will be fixed."

Despite the words of encouragement, Aeroscreen development was discontinued at Red Bull Racing in the summer of 2016 once the decision was taken for F1 to go with the Halo. There it stayed neatly ▶

IndyCar

ABOVE The Dallara-designed debris deflector, raced at the Indy 500 for the first time, will provide an ideal mounting point for the new Aeroscreen

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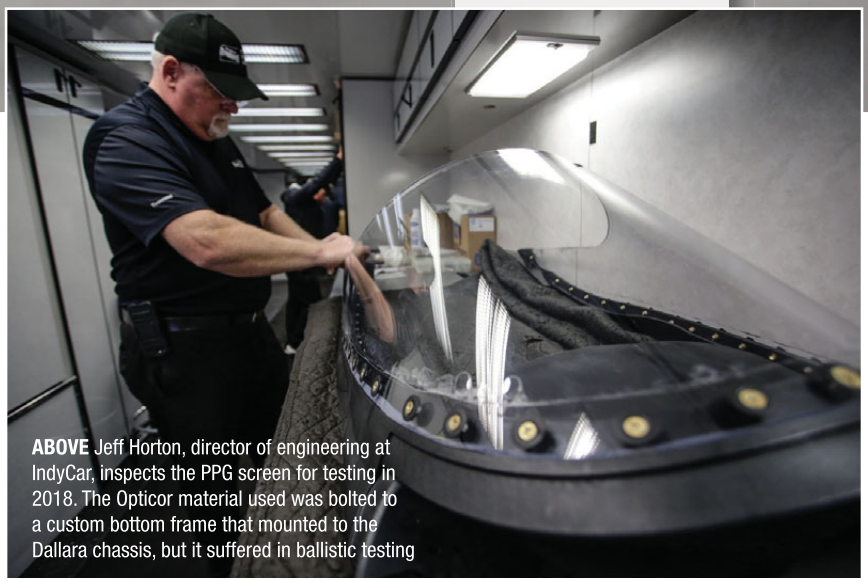
ABOVE Daniel Ricciardo trialled the first Aeroscreen in practice at the Russian GP back in 2016



ABOVE Jeff Horton, director of engineering at IndyCar, inspects the PPG screen for testing in 2018. The Opticor material used was bolted to a custom bottom frame that mounted to the Dallara chassis, but it suffered in ballistic testing

filed away until January 2019, when it re-emerged under the aegis of Red Bull Advanced Technologies (RBAT) at the behest of IndyCar Series president Jay Frye – not coincidentally the former general manager of the Red Bull NASCAR team.

Following hard on the heels of McLaren Applied Technologies and Williams Advanced Engineering, RBAT is an engineering consultancy tasked with taking intellectual property and experience out of the F1 arena and putting it to work in the wider world. Best known for its work on the Aston Martin Valkyrie hypercar, it's also dabbled in America's Cup hydrodynamics, elite cycling analytics and industrial refrigeration.

In common with rival F1 spin-outs, it likes to point out it isn't in the business of repurposing F1 tech, but rather works to take F1 knowhow, working culture and development tools out into other industries. In this regard the Aeroscreen is something of an aberration in that it was created specifically for – rather than being inspired by – Formula 1. Or at least this is the case to a certain extent. Andy Damerum, RBAT business development engineer (and former race engineering co-ordinator at RBR) argues that the Aeroscreen to be used by IndyCar is quite different to the one designed for F1.

"There are no carryover components from F1 to the IndyCar project because the cockpit geometry and the structural properties of the Dallara chassis are different – but the concept and the IP has been taken from the research we did into the F1 Aeroscreen," he says. "RBT learned a huge amount from the 2016 project: we learned how to define the geometry of the windshield; we learned about driver head clearance; the ballistic properties the screen needed to comply with; we learned how to treat the [polycarbonate laminate] screen against contaminants; structural properties of the frame and mounting; driver ingress and egress; emergency removal of the frame in the event of an accident. The work was just sitting there. It was great that IndyCar contacted us."

BORN OUT OF TRAGEDY

As is sadly the nature of safety research, tragedy is a powerful catalyst. IndyCar stepped up its interest in a head protection ▶

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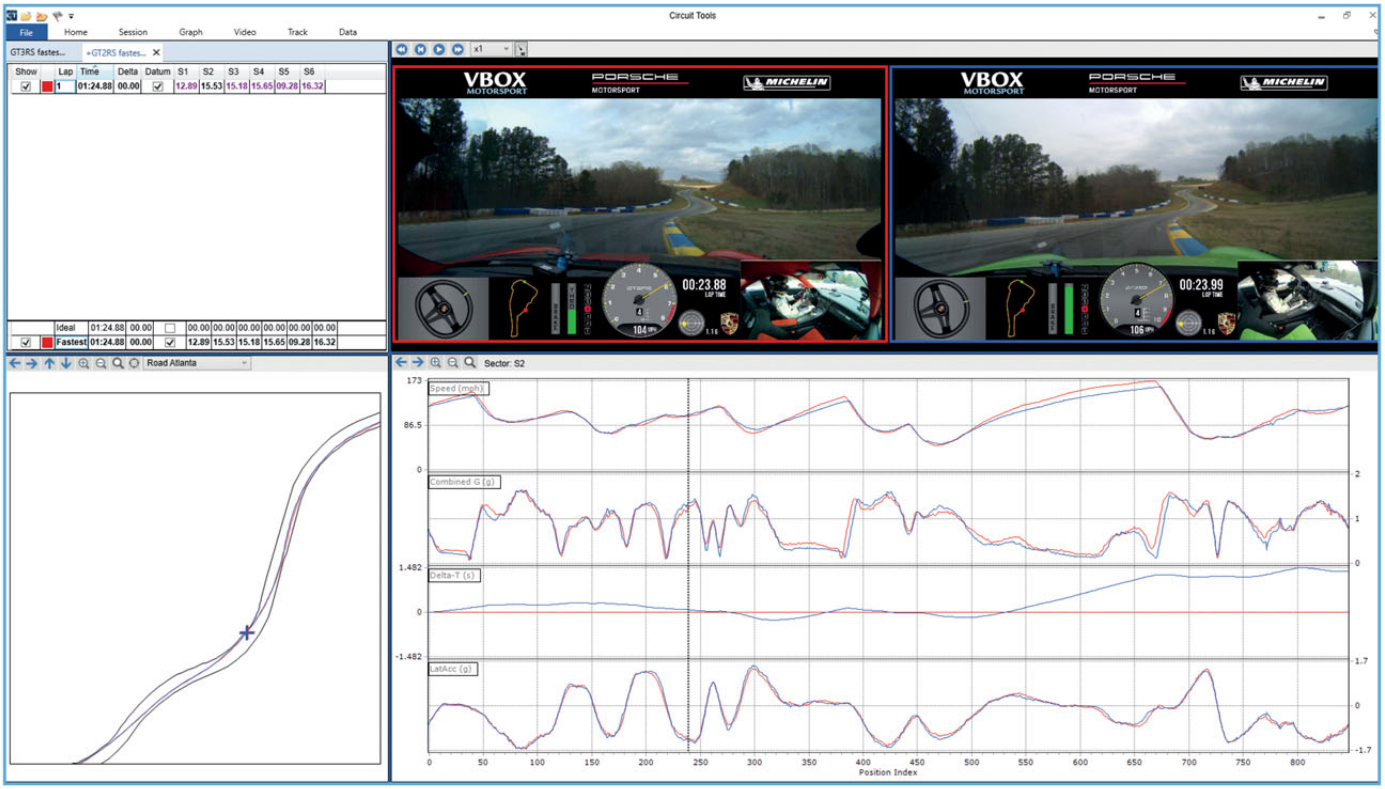
Peter Krause, Professional Racing Coach, Virginia International Raceway.



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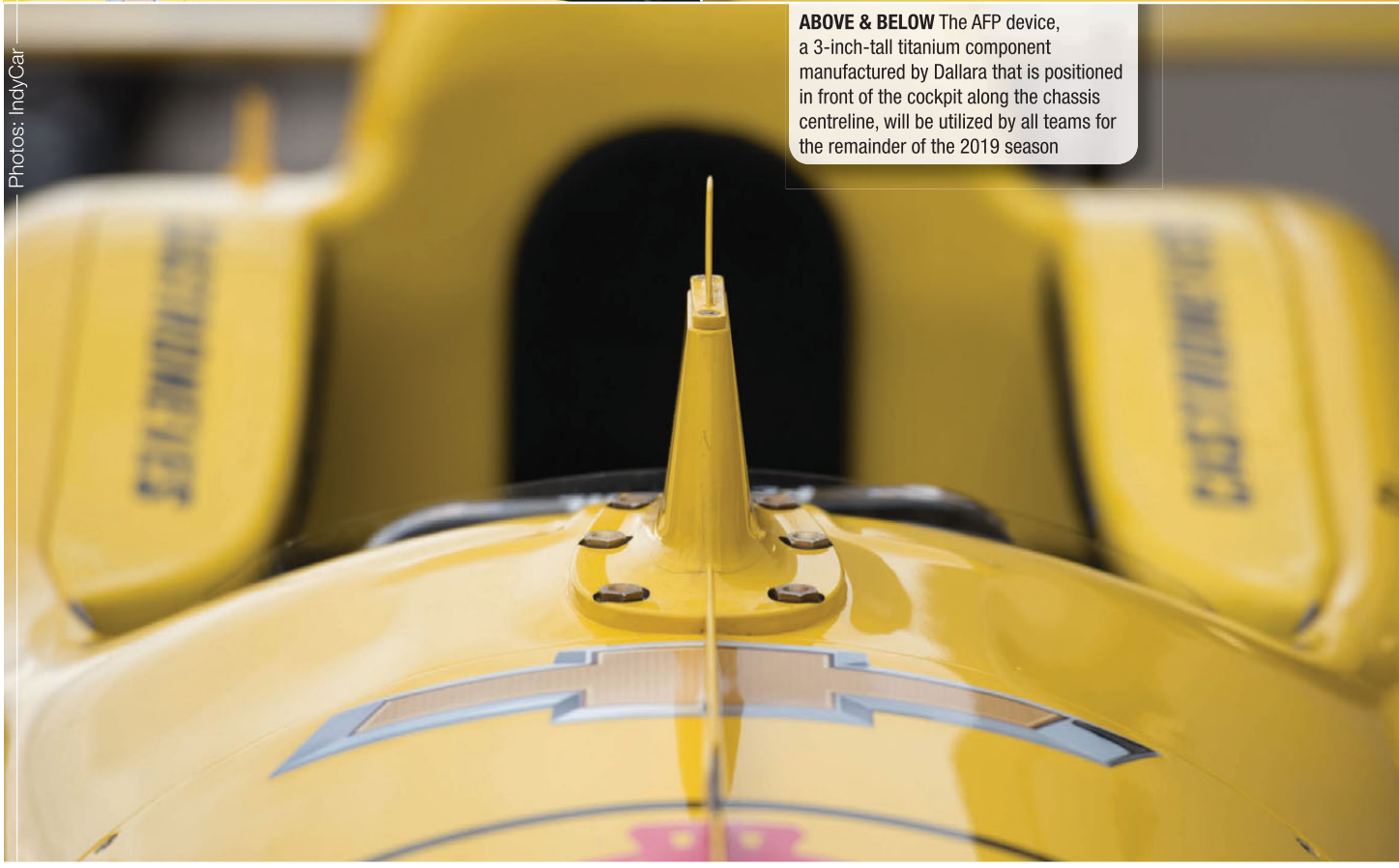
system following the 2015 death of Justin Wilson. Given the ubiquity of banked ovals in Indy racing, and the incursion of the Halo into potential sight lines, it wasn't seen as a strong candidate – but the Aeroscreen had potential.

Chip Ganassi Racing's Scott Dixon tested a prototype device designed by PPG Aerospace (suppliers of flight deck windows and canopy coatings for civil and military aviation) early in 2018 at the rookie oval test in Phoenix, followed by a test with a tweaked design by Josef Newgarden at Indianapolis several months later. While the driver feedback was largely favourable, after ballistic testing, IndyCar decided to pursue a more robust solution featuring the titanium-framed Red Bull Aeroscreen.

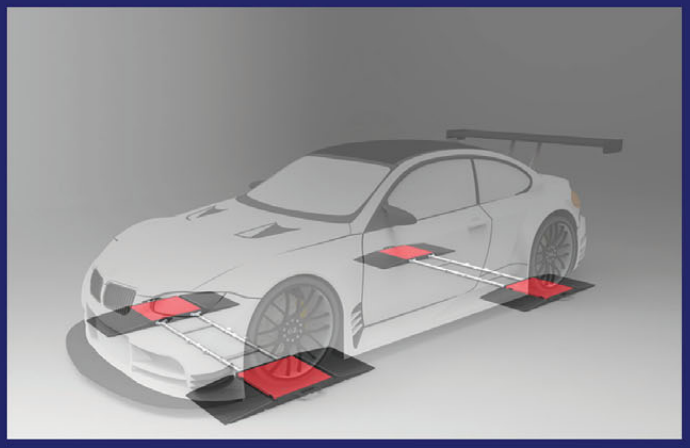
The project came together very quickly. IndyCar began talking to RBAT at the beginning of January this year, with a specification defined in February and a proposal submitted by Red Bull in March. On April 1 an agreement was signed, with a view to presenting a concept at the Indy 500 and having detailed design and structural testing completed in time to have a prototype ready to run at the end of summer, with a view to autumn manufacturing and parts being shipped to teams at the start of November.

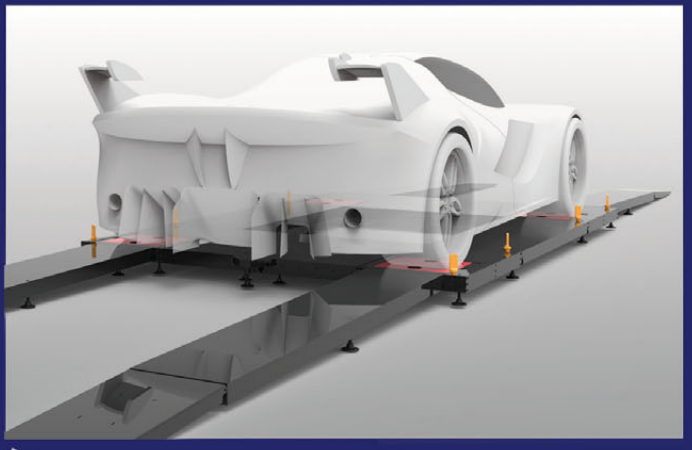
Considering the gestation period of the Halo, IndyCar's take-up of the Aeroscreen seems almost indecently rapid. It had the advantage, however, of an existing body of work on which to draw [the FIA study had included IndyCar incidents in its analysis]. Furthermore, the existing chassis has already been upgraded with a view to accommodating a head protection system: the new Advanced Frontal Protection ▶



Photos: IndyCar

ABOVE & BELOW The AFP device, a 3-inch-tall titanium component manufactured by Dallara that is positioned in front of the cockpit along the chassis centreline, will be utilized by all teams for the remainder of the 2019 season





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(AFP) spike featured on the Dallara chassis has proved useful to RBAT.

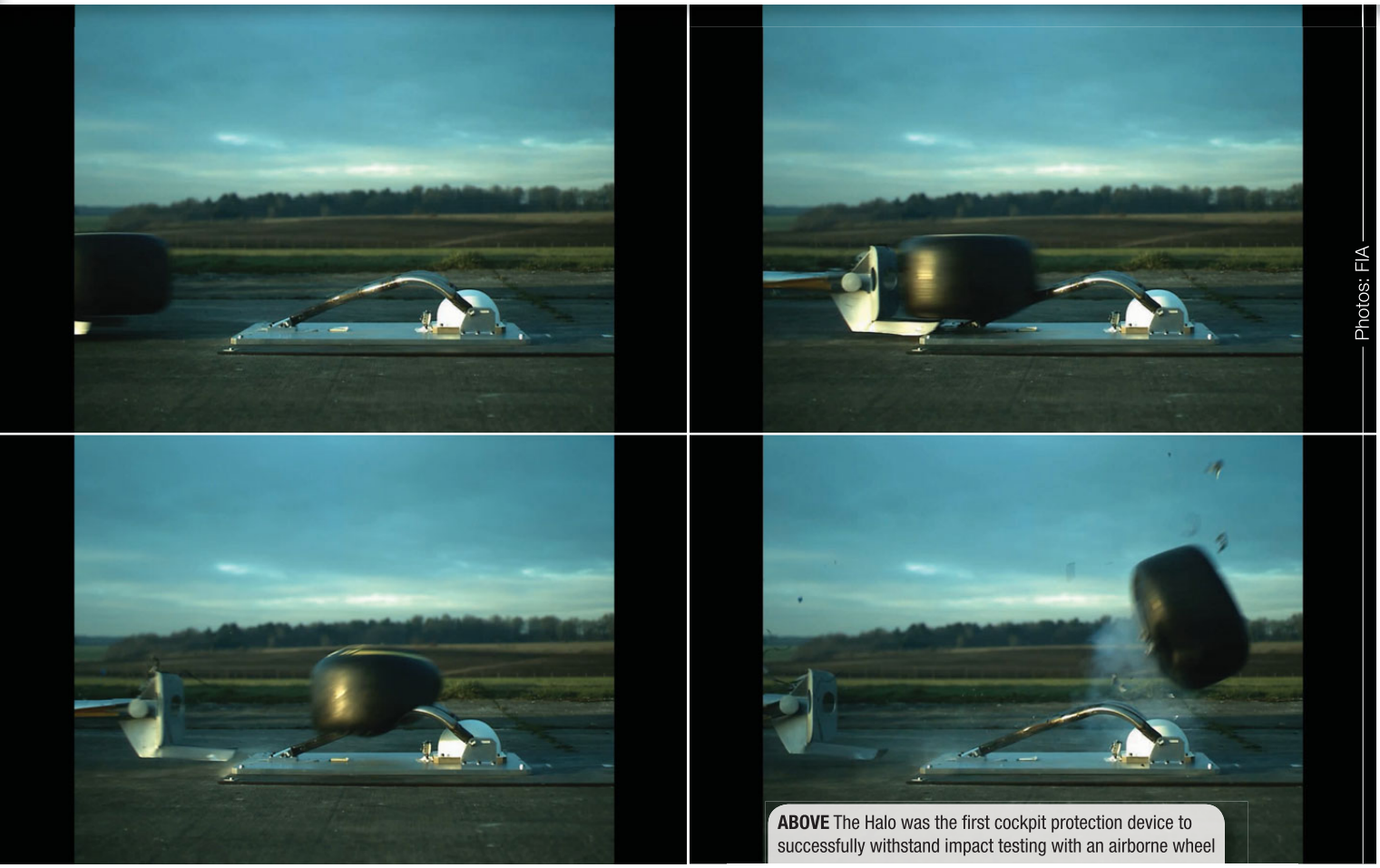
"IndyCar had already made structural changes to their chassis to fit their debris deflector," explains Damerum. "On the F1 Aeroscreen, the mounts went down the side of the cockpit, in line with the wing mirrors, but we needed a slightly different concept for the IndyCar application. The debris deflector made an ideal point on which to mount our frame."

The homologation crush tests for the Halo were the stuff of nightmares for F1's chassis engineers. However, Damerum insists the IndyCar project, while offering a similar level of protection, does not require the extra bulk that went into F1 chassis.

"That was one of the initial concerns from Dallara – that the chassis would not be strong enough to take a Halo-type device," he says. "So, right from the very beginning, we opened a dialogue about structural properties. We knew we would need a hoop of some sort, mounted to the chassis [something absent in the PPG design]. It was fortunate the 2019 IndyCar has the AFP, and that was strong enough to take the forward point. Behind the driver, the roll hoop is certainly strong enough to take the rear fixings. It's worked out very well: there will be carbon composite fairings that need to be fixed to the cockpit, but the car won't need

ABOVE & BELOW An experimental windscreen constructed by PPG was tested both at Indianapolis by Josef Newgarden (above) and at Phoenix by Scott Dixon (below). Cooling and buffeting issues were reported

Photos: IndyCar



Photos: FIA

ABOVE The Halo was the first cockpit protection device to successfully withstand impact testing with an airborne wheel

> *"The negatives that came out of tests on the previous screen were driver cooling and helmet buffeting"*

significant structural changes to the chassis to take the loads."

Aside from adapting the Aeroscreen to fit the geometry of an IndyCar chassis, many of the tweaks to the original 2016 design have come about as a result of driver feedback, both from the testing done in F1 but also the PPG windshield tests conducted by IndyCar last year. Based on the F1 feedback, RBAT is using anti-reflective coatings to deal with internal reflections and is planning a visor-style tear-off to deal with external contaminants. The IndyCar feedback has promoted greater structural change, with RBAT and Dallara working to combat issues relating to airflow, or lack thereof.

"The two negatives that came out of the PPG testing were issues around driver cooling and also one of the drivers mentioning helmet buffeting, with airflow leaking around the side of the windscreen and pulling his helmet forwards," says Damerum. "Ourselves and Dallara have worked to address those concerns. It's Dallara's chassis, so they've been leading the effort in CFD and will introduce a vent – like a NACA duct – forward of the screen, in the area where the dampers are mounted. The other issue is that the Aeroscreen makes the cockpit environment very quiet. It's going to seem odd initially for the drivers – but we can't do anything about that!"

BACKLASH

IndyCar's information campaign surrounding the Aeroscreen has been a curious mix of extremes, with the series keen to suggest the Aeroscreen both changes everything while also changing nothing. While all involved are keen to stress the choice of a screen over the alternatives was driven by safety rather than aesthetics, as a happy accident the Aeroscreen also looks more integrated than the Halo and, without stretching the imagination too hard, vaguely reminiscent of the windscreens that adorned Indycars in the 1980s. It is unlikely to suffer the severity of backlash that dogged the introduction of the Halo.

Beyond the 2020 implementation, interest around the Aeroscreen centres on its potential to be adapted for further use. RBAT's contracted involvement ends when the Aeroscreen is delivered, though it is being designed with the new 2022 IndyCar chassis in mind. There is also potential to see it reengineered for use in other formulae. As has been the case with the Halo, a cheaper steel variant of which is used in Formula 3, there is potential for trickle-down.

"It's really a question of weight," says Damerum. "This is bigger than the Halo because it goes further back and mounts onto the roll hoop. Added to the weight of the screen, which will be nearly 10 mm thick, and the carbon fairings, it becomes quite a heavy device – which is why we're making the structure from titanium. It's entirely possible a cheaper version could be made from steel, for series that were not concerned about weight – and there's no reason why, if 2020 is a successful season in IndyCar, it won't trickle down into Indy Lights or other junior formulae.

"Then, who knows? Maybe the FIA will look at it again for F1." RT

LE MANS HERE WE COME?

With hydrogen on the radar for Le Mans 2024, **Chris Pickering** talks to the only team to have successfully raced a full-size hydrogen fuel cell vehicle

LIKE it or not, the days of the conventional gasoline engine may soon be numbered. Imagine the year is 2030 or 2040 and you have to complete the entire Le Mans 24 Hours race with zero tailpipe emissions. What do you do?

It's highly unlikely that one battery pack could ever power a racing car for the 5,000 km or so that the French classic involves. 'Hot swapping' ready-charged battery packs may be an option, but it wouldn't be straightforward to engineer and it could involve as many as 30 different batteries for each car – all loaded with precious metals and carrying their own sizeable carbon footprint.

A lot of those problems go away if you substitute the battery for a hydrogen fuel cell. Suddenly you have what is effectively an electric car that could still call into the pits and refuel. It almost sounds too good to be true, but there are already cars that are capable of doing exactly that. So far, however, only one team has successfully raced a full-size hydrogen fuel cell vehicle. That honour rests with the Forze team from Delft University of Technology in the Netherlands.

Regular readers may recall that we spoke to the Delft team back in 2016, just as the LMP3-based Forze VII was about to begin testing. While other fuel cell cars had completed demo runs and

> *"We can sustain full output for about eight seconds, after which we're down to the fuel cell's baseline output of 90 kW"*

ABOVE Proving themselves a match for gasoline-engined cars looked a daunting task initially, but the team has kept on raising the performance bar

ABOVE The hydrogen tanks have been revised for the Forze VIII

sprinted against the clock – notably in the Formula Student and Formula Zero competitions – the Dutch team was the first to bring this technology to conventional circuit racing. The following year the Forze VII went on to compete in a round of the Dutch Supercar Challenge.

In terms of the powertrain, the biggest step from the experimental Forze VI to the Forze VII had been the fuel cell, which was scaled up to provide more power. When the time came to review the car and begin planning for the current Forze VIII, it was felt that the limiting factor was no longer the fuel cell stack but the systems around it.

The underlying carbon fibre monocoque remained unchanged, but a considerable amount of work went into redesigning the composite bodywork in time for the Forze VIII's debut in the summer of 2018. Other tasks included a thorough redesign of the suspension kinematics.

"The first design of the suspension was based on a lot of assumptions regarding things like weight distribution, speed and power, so it was quite a conservative setup," says Forze's chief engineer Daan Treurniet. "Once we got the car working we were able to collect real-world data for those parameters, which has allowed us to optimise that further."

The car still uses the same basic configuration as the Adess LMP3 chassis upon which it's based, with double wishbones with pushrod actuation all-round. As with a lot of sports prototypes it uses torsion bars at the front and coil springs at the rear, allied to a set of Koni adjustable dampers. Almost every aspect of the kinematics has changed for the Forze VIII, however. At the rear, the subframe that holds the suspension was ▶

ABOVE With real-world data to work with, rather than the initial assumptions, the suspension has been redesigned

redesigned to move the pick-up points. Likewise, the outboard mounting points on the uprights were relocated.

There's less freedom to alter the geometry at the front as the inboard pick-up points are integrated into the monocoque, but they too have been shifted slightly. Likewise, the pushrod setup has been revised relative to the original LMP3 design.

"With the original setup you need quite a lot of time in the car to gain confidence. Now it handles very much like a conventional racing car," says Treurniet. "We had a new driver in the car for the first time a few weeks ago and he commented that it was very stable and intuitive to drive."

By this point, the team were pretty happy with the performance and handling of the Forze VIII, but its reliability remained a weak point. That's what the students have set out to address for the 2019 season, Treurniet explains: "Our aim for this year is to squeeze all the remaining performance out of the current design without changing the fundamentals too much. We want to identify the limiting factors so we can push those a little bit harder and still maintain the reliability,".

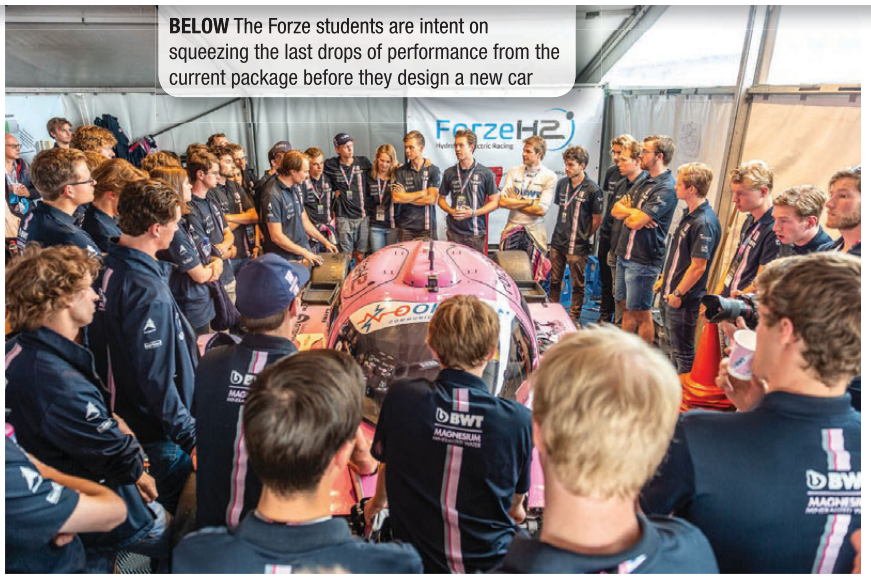
TRACK TESTING

In an effort to expose any potential weak points, the team has undertaken an aggressive programme of track testing, logging around 20 hours so far. One issue they identified was an overheating problem with the electric motor that's used to drive the fuel cell's compressor.

"For the compressor, we use the same AMK motor that a lot of the Formula Student teams use to power their cars. It has to be cooled externally, so the teams make their own shell around the motor," notes Treurniet. "Our previous design used a spiral pattern along the motor, where the fluid ran at a relatively low velocity. We've now switched to a new pattern that allows a higher flow velocity, which has reduced the operating temperature. For example, where the motor previously ran at 60 deg C it's now running at 45 deg C at the same load, so it's a significant improvement."

The team faces a similar challenge with the two 160 kW YASA motors that are used to drive the rear axle. Improvements have ▶

ABOVE Two 160 kW YASA motors are used to drive the rear axle



BELOW The Forze students are intent on squeezing the last drops of performance from the current package before they design a new car

also been made to the cooling of the fuel cell stack itself. Originally, the car used seven different cooling circuits in total. This has now been condensed down to six, but keeping the car cool remains one of the biggest engineering challenges on the project. In particular the accumulator – the bank of supercapacitors that are used to buffer the fluctuating loads going into the fuel cell – is a significant source of heat.

"We're still using the same accumulator design that we had on the Forze VII, but the current has gone up because we're now pushing the car a lot harder. That means it now gives off a lot more heat than the casing was originally designed for, so we're working on its cooling efficiency at the moment," comments Treurniet.

Another critical aspect was the design of the driveshafts, which have to endure a punishing duty cycle, transmitting torque for both acceleration and regenerative braking. These were found to be flexing under the changing loads, which led to some strange handling characteristics, not to mention a reduced fatigue life, so the Forze engineers developed a stiffer design.

As you might expect, control systems and power electronics are a massive part of the work that goes into developing a fuel cell car. The Sevcon motor controllers and Brusa DC/DC converters are carried over from the Forze VII, but the software within has been completely overhauled. That's largely in response to the need for more precise transient behaviour as the team is starting to push the car harder on track.

Fuel cells tend to respond quite slowly to changes in power demand, so the stored energy in the accumulator is used to provide transient response, while regenerative braking also sees current flowing back into the system. The revised software is said to provide much more dynamic control of the fuel cell output, as well as allowing the use of more aggressive regen.

ABOVE & BELOW As pioneers in the field, just finishing the race is deserved cause for celebration

BALANCING SUPPLY AND DEMAND

Balancing this system of supply and demand is harder than it sounds. The fuel cell output has to be reduced once the accumulator is full, to avoid it overloading. Conversely, failing to charge the accumulator sufficiently before a long straight will result in the power output tumbling as the system defaults to the fuel cell's modest 90 kW steady state output (less than half of the 220 kW available on boost).

"If you look at Zandvoort, where we do most of our testing, the fuel cell de-rates six or seven times a lap. That's done right before the corners, in preparation for a flow of current into the system for the regenerative braking," comments Treurniet.

As with all automotive fuel cells, the ▶

Ballard FC Velocity MK1100 stack in the Forze VIII combines hydrogen and oxygen to liberate electrons, creating a flow of electricity. The primary means of controlling this reaction is to speed up or slow down the fuel cell's air compressor. At the same time, it's also important to control the flow of hydrogen: inside each cell, the two gasses are separated by a polymer membrane, which can pop like a balloon if the pressure isn't carefully balanced on both sides. As a result, one of the challenges is to change the compressor flow as fast as you can without compromising the integrity of the cells. Similarly, it's not practical to stop the reaction simply by halting the current as this would cease water production and cause the membrane to dry out.

These challenges extend to the hardware systems supporting the fuel cell stack too. A Fumatech humidifier is used to maintain around 80 per cent humidity at the air intake – a task which is further complicated by the comparatively high temperatures and mass flow rates involved.

The hydrogen tanks have also been revised for the Forze VIII. Previously, the design limitations of the tanks meant that one was mass flow-limited while the other was pressure-limited, but the new design allows both tanks to be pressure-regulated (up to a maximum of 700 bars). This means the plumbing for the two tanks can now be combined, saving weight and space within the car.

The fuel cell itself comes in at 90 kg dry and measures approximately 800 x 480 x 200 mm. It was originally developed for use in buses and represented the state of the art when the team began using it in 2016. The latest prototype designs are significantly smaller still – and potentially as little as half the weight – but the tricky bit comes with the supporting hardware that you need to accommodate.

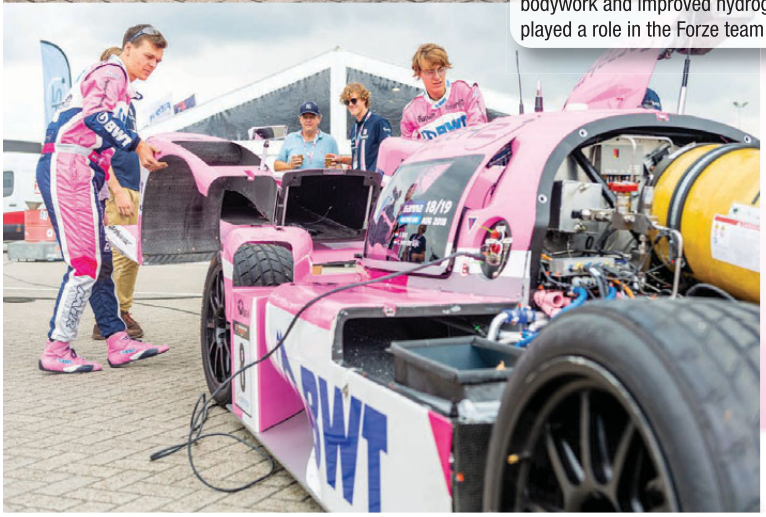
"One of the biggest challenges when we went from the Forze VI to the LMP-style Forze VII was how to package all of the components in a reasonably aerodynamic shape," Treurniet recalls. "Another issue was keeping everything cool. The fuel cell operates at quite a low temperature, which has its advantages, but it also means you don't have much temperature gradient to the ambient air."

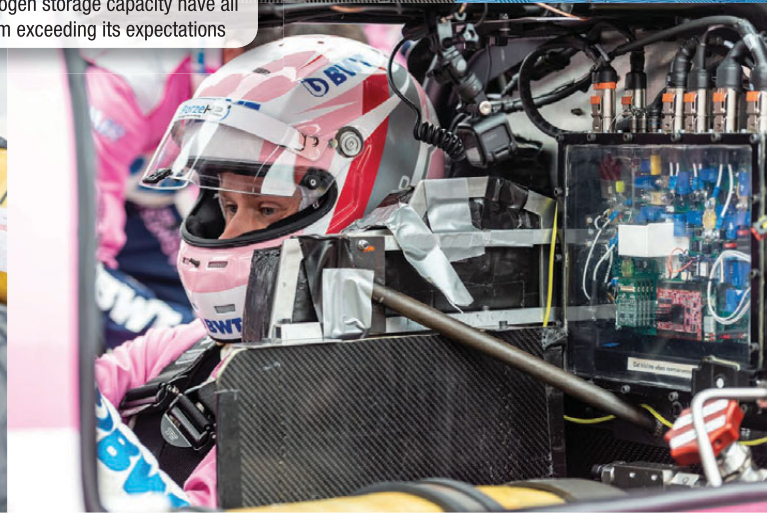
ON TRACK

The Forze VIII has only raced once so far, but it's poised to return to the track shortly after this issue of Race Tech goes to press, with another event planned for August. It competes in the Sport Division of the Dutch Supercar Challenge, which is usually open to production-based cars, such as the Peugeot RCZ and the BMW Z4. Having posted times during testing that would keep up with the fastest cars in this class, the Forze team members are keen to increase their race pace this year.

"The car only weighs 1,250 kg with the driver and there's a lot of torque from the electric motors, so it's quite quick out of the corners. However, the outright power

ABOVE & BELOW Redesigned suspension, completely new bodywork and improved hydrogen storage capacity have all played a role in the Forze team exceeding its expectations





ABOVE The Dutch team was the first to bring hydrogen fuel cell technology to conventional circuit racing

isn't very high at 230 kW (308 bhp), so we're a little bit limited on top speed. We can sustain full output for about eight seconds, after which we're down to the fuel cell's baseline output of 90 kW," explains Treurniet. "At Assen last year we were lapping at around 1 min 58, whereas the fastest car in our class was in the 1 min 54s. In testing, however, where we're not worried about the range, we can do something like 1 min 52. With the improvements for this year we hope to be lapping at about the same pace as the other cars in the category."

Off the line, the Forze VIII is already comfortably quicker than the combustion-engined cars in its class, having posted a 0 to 100 kph (0 to 62 mph) time of 4.1 seconds. Top speed is currently in the region of around 190 kph (118 mph), whereas the other cars are thought to be touching around 230 kph (143 mph). The biggest challenge, however, is energy management, Treurniet explains: "We try to harvest as much energy as possible under braking. At present, the cooling of the accumulator limits how quickly we can harvest energy, so we start braking earlier than you would do in a combustion-engined car. That's something we're trying to work on."

> *"The cooling of the accumulator limits how quickly we can harvest energy, so we start braking earlier than you would do in a combustion-engined car"*

Filling the two 700-bar tanks with hydrogen allows the car to operate for about 45 minutes at full race pace at its home circuit of Zandvoort. That's somewhat dependent on the track layout however, with the fast, sweeping curves of the TT Circuit at Assen causing that figure to drop. At present, it's not practical to refuel the car during a competitive pit stop, but the technology does exist to make it possible.

This year is all about squeezing the last of the remaining performance from the current platform, he explains, and in particular its fuel cell system. There are already plans to build a new car with a higher fuel cell output, which will probably necessitate the use of multiple stacks. Beyond that, the Forze engineers make no secret about the fact that their ultimate goal would be to race at Le Mans. That's a hugely ambitious target, but what would it actually take?

"We'd certainly need more straight-line performance, which would require more fuel cell power and probably a higher output from the motors," says Treurniet. "Other than that, the biggest hurdle is the hydrogen storage. Carrying a gaseous fuel isn't very efficient in terms of volume, so realistically I think you'd probably need liquid storage. That's going to make the refuelling harder, but a lot of that comes down to the legal and logistical challenges rather than the technology. All of these obstacles could be overcome if you had enough money."

Of course, the Delft students aren't alone in contemplating the idea of hydrogen at Le Mans. Last year the ACO announced its Mission H24 initiative, which plans to hold a zero-emissions race at the circuit in 2024. It would be fantastic to see a major OEM like BMW or Toyota – both of which have produced hydrogen road cars – turn up. As things stand currently, however, the students at Delft remain the undisputed experts on racing with hydrogen.

HOW THE ELECTRIC RALLYCROSS DREAM WAS SALVAGED

Just when the burning ambition to introduce electric technology into world rallycross seemed to have died, plans have suddenly been reignited. So what's changed? **Hal Ridge** investigates

To borrow a phrase from Mark Twain, it would appear that reports of the death of Electric World Rallycross have been greatly exaggerated.

Just days before the start of the 2019 World RX season, comprising of solely-private teams following the withdrawal of the manufacturer efforts at the end of the previous term, the whole future of the sport was thrown into disarray. News broke that plans to switch the highest-level of the discipline to electric cars for 2021 had been extinguished, without enough manufacturers willing to sign up for the concept.

An announcement from World RX promotor IMG swiftly followed, revealing plans to continue in the pursuit of

ABOVE A dramatic U-turn will see the existing steel-bodied Supercars converted with a kit, rather than replaced with a new breed of composite chassis

introducing electric cars into World RX weekends with a support class named Projekt E.

Less than three months down the line, the annual June meeting of the FIA World Motor Sport Council produced a number of eyebrow-raising snippets. They included the news that plans for introducing electric vehicles into World RX's top flight for 2021 were very much back on the agenda – and are being progressed with haste.

A year ago, Race Tech detailed the invitations to tender released by the FIA for the initial 'EWRX' concept. In layman's terms, the cars were planned to be single-supplier carbon monocoque chassis adorned by composite silhouette bodies, made by manufacturers. French firm ORECA won the bid to produce the chassis, while Williams Advanced Engineering was given the tender for batteries. Motors, albeit with some restrictions, were the only area where a manufacturer could have an effect before homologating the finished product.

Those plans have now been binned, with the recent WMSC statement revealing that the reignited concept will be to convert existing steel-bodied Supercars with an electric 'kit'. In the short-term at least, the two methods of propulsion will run together on track in 2021. "A gradual introduction will see a mix of EVs and current ICEs for a minimum of one year," said a WMSC statement.

ABOVE STARD will be a contender to win the new FIA EWRX contract, having been a pioneer in the field with its HIPER electric concept

ANDROS INSPIRATION?

That outline concept isn't dissimilar to the Alps-based Andros Trophy winter series, which ran converted existing cars with electric drivetrains racing against conventional ICE (internal combustion engine) machines last winter. It has since announced that the series will be all-electric from this December (see news).

Whether the FIA has taken a leaf from the Andros book or not, it has definitely changed course. Unlike the last plan for EWRX, which was to effectively create a whole new series, the case study of adapting existing cars is a seemingly far more achievable objective.

New invitations to tender for three different aspects of the new plans are being released, but for the top flight, the most interesting is for the electric kit that will replace conventional running gear. "An identical specification powertrain and battery kit is to be introduced for a four-year cycle, comprising two motors developing between 400 and 500 kW," stated the WMSC.

Those plans don't fall far from a concept pioneered by Austrian firm STARD with its world-first electric rallycross Supercar prototype, called HIPER, detailed in RT193. It's the same Manfred Stohl-owned outfit that has announced a partnership with IMG to supply the powertrain kits for the planned Projekt E series, and prior to the WMSC's news, released information about the specification of the proposed cars.

STARD's new concept involves four-wheel drive cars using a pair of driven axles, integrated limited slip differentials and electronically-controlled front-to-rear torque distribution. They are intended to produce similar performance to that of a current World RX Supercar, with 450 kW (equivalent to 612 horsepower) and 1,110 Nm torque, that will be "fully flexible and designed to fit any type of road car bodyshells from B-segment upwards, especially including current and future EV crossovers."

That kit will include the electric motors and controllers, transmission, RESS (Rechargeable Energy Storage System ▶

BELOW Electric leads ICE in the Andros Trophy ice racing series, which has demonstrated that it is possible to accommodate both technologies in the same field

Andros Trophy

or battery), wiring and electronics, and charging system. It will initially run in a Ford Fiesta bodyshell for testing and demonstration, aesthetically appearing the same as the car used in World RX this season, called the Fiesta ELECTRX.

With its concept falling in line with the FIA's plans, Stohl makes no secret that while continuing to work on Projekt E, his firm will bid for the electric kit tender for World RX.

"It's good that this statement [from the WMSC] is coming because it shows that World RX goes electric. It *has* to go electric!" says Stohl. "I see that as a positive step for the future for this championship. For sure it will be difficult in the beginning for all the fans accepting it, but I think it will be finally very positive for everyone.

"We will definitely go for the tender. We have much experience with that type of car. I'm looking at it positively and hopefully everything goes right. There will be not any holidays for us during this summer. I'm really waiting and looking forward to testing for the new car [Fiesta ELECTRX] for the first time."

While further details are yet to be released by the World RX promotor about its planned Projekt E initiative, Managing Director Torben Olsen says it will run cars at events in 2020. "We're very pleased that the FIA approved the future plans for the electrification of world rallycross. It's something we've been evaluating and working on since 2017 and we think it's a good step for the sport," he says.

"We also agree with the phased approach, where from '21 it's mixed, which allows a soft entry into the environment. We're full steam ahead on Projekt E and as we planned in 2020 it will become an electric support series, running alongside the World Championship at the weekends. We're working very closely with STARD, as we have been for a long time now. So it's really perfect timing and it's all aligned very well with the FIA's vision and our vision for the world championship to have a support series, already starting next year, so we can start to bring electric to the weekend of rallycross."

Asked if Projekt E will continue into 2021 if STARD wins the tender to supply the World RX kits, Olsen explains: "At the moment we feel it will, but we're in constant dialogue and seeing how the weekends pan out. We think it's certainly important to have a support series in this technology that can feed into the World Championship, so we're keeping an open mind for that. We do believe in STARD's technology."

The promotor says discussions with manufacturers about the future road map of the discipline are ongoing, but that it is focusing on making a series accessible for private efforts: "The interest increased as soon as we announced Projekt E and we've been in regular dialogue with manufacturers. I met a couple when we were in America for Americas Rallycross recently. There is definitely interest.

"Projekt E and the new World Championship model for 2021 is focused on the private teams. We feel that's important, that the solution is targeted at private teams, then also that there is an opportunity for manufacturers to get directly involved in the sport. We welcome manufacturers back, but we also focus on the product and the private teams."

> *"All the manufacturers are talking about hybrid or electric; we need to go more green"*

The new plans have a powerful advocate in the form of 14-time European Rallycross Champion Kenneth Hansen. The Swede gave up his own team, after over 30 years at the helm, when Peugeot took its rallycross programme in-house last year. Then the manufacturer promptly left the sport again, before the end of its first term, unwilling to wait as the planned switch to electric was ▶

delayed. Now Hansen has rejuvenated his team for 2019 as a private effort, and leads both the Drivers' and Teams' standings at the halfway stage of the year.

He maintains that switching to electric technology remains critical to the success of the sport in the future: "If we should bring the sport forward we need to follow something in this direction with electric, because all manufacturers are talking about hybrid or electric; we need to go more green. If we want to have some manufacturers involved in supporting teams or to be interested about the sport, we need to go this route.

"I think it's very good that it will be with standard [current] cars and to change them to be electric, or even if you take an electric car and just change it for the other [FIA kit] system. I haven't seen anything about the more detailed version but overall, I think it's very interesting and very right. I believe that we could have interest from manufacturers coming back in the future with this."

The decision to retain the current style of existing steel bodyshells in the new strategy, as opposed to the previously proposed single-make carbon chassis, is potentially a key move for the supplier market. It means that teams will still be able to work with their own suppliers and partners over items like suspension, with brands involved in the series including Reiger, Öhlins, Bilstein and TIEN.

Brakes too would seemingly remain open, allowing teams to continue developing products as they do currently, with suppliers like Alcon, Brembo and AP Racing.

"It wouldn't have been possible for us to do before [with the previous EWRX plans], with the costs, the level and it was so complicated," says Hansen. "We don't know the complete information about what is coming now, but I think it would be possible for us to do this. Of course we also need to have partners that believe in it and if it's not a manufacturer-backed programme, then we need to have sponsors that believe in it and support us to do it. But it feels right."

WILL THE PRICE BE RIGHT?

Although figures are unlikely to be put on the kits until the tender process is released, Hansen, who is well involved with the sport as a whole, believes the new proposal will be more cost-effective. A works-built World RX Supercar (circa 2018) is believed to be valued around €600–700,000, but the carbon chassis EWRX machine would almost certainly have cost significantly more. "What I understand is it [the new plans] should be quite efficient economically to do. If that's the reality, then it's good," he says. "We are for sure interested. Hopefully the fans are a little more open to it now and they can be a little more positive because it's a route that is coming and times are changing. What I hope is that the electric car is faster than the cars we have today, so it's a development in the right direction."

Single-supplier kits, in various forms, as showcased in the present generation of British Touring Cars, have proved a success.

FIAWorldRallycross.com

ABOVE The focus will now be on the privateers, rather than manufacturers

The BTCC is a good example here of a series attracting works-supported efforts, like BMW with WSR and Honda with Team Dynamics, much like rallycross did in the past. Indeed, much of Hansen's top-flight career was supported at arms-length by Citroën.

The new proposal could potentially offer the opportunity for teams to attract either official backing or a stealthier form of support from manufacturers. This could entice back marques like Peugeot, which previously admitted to having little concern over what was under the skin, so long as it was about to market its consumer product.

Hansen says that fitting an electric kit to an existing body is not so far removed from using a different engine, like the ORECA and Pipo units used in the series today. "Obviously the [previous] idea that they proposed was not the right thing," he suggests. "If it was, we would have three or four manufacturers [now]. What the reason was, if it was the cost or if it was too locked to do anything, we will never know. I think the manufacturers all looked differently at it.

"This must be more right than before, because you use the actual product from the manufacturer as a base. At the moment, there is not a lot in the engine we use today that are proper PSA products; there are some parts there, but more or less it's a specially-made engine. The kit is just like fitting an engine."

In addition to the tender for the World RX 'kit', tenders are also being released for a single-make FIA Junior eRX series for four-wheel drive cars producing around 250 kW, and for the operation and charging infrastructure for both series. Each of the tenders is for a four-year term, with potential applicants being able to bid for one or more of the contracts.

ABOVE Sign of the times: even the World Rally Championship can resist the changing tide no longer, announcing plans to introduce hybrids

> *"It will be difficult for the fans to accept at the start, but ultimately it will be very positive"*

WRC GOES HYBRID

Another indication of the push to introduce electric tech into top-flight motorsport outside of endurance racing and Formula E can be found one bullet above the rallycross news in the WMSC announcement. That reveals that the next generation of World Rally Championship cars will be introduced in 2022, with a five-year homologation cycle. Assumed to be in addition to the current 1.6-litre engines, cars will be fitted with a "supplementary hybrid system, to be comprised of common components and software for the first three years, with the potential for more technical freedom in 2024," said the WMSC statement. "The aim is to enable the cars to run on pure electric power in cities and provide an electric power boost on special stages."

Interestingly, the WMSC statement also suggests that tubular spaceframe-type chassis will be eligible, something not used in the sport since the demise of the Group B era in 1986. "Manufacturers will be allowed to use a production bodyshell or a prototype tubular structure to current WRC size guidelines, while the FIA is set to define carry-over elements from production vehicles for key visual elements. There will also be an option for 'scaling' of the body within prescribed limits, to allow larger cars to comply with dimension targets," it reads, clearly targeting the use of SUV-type machines for the series.

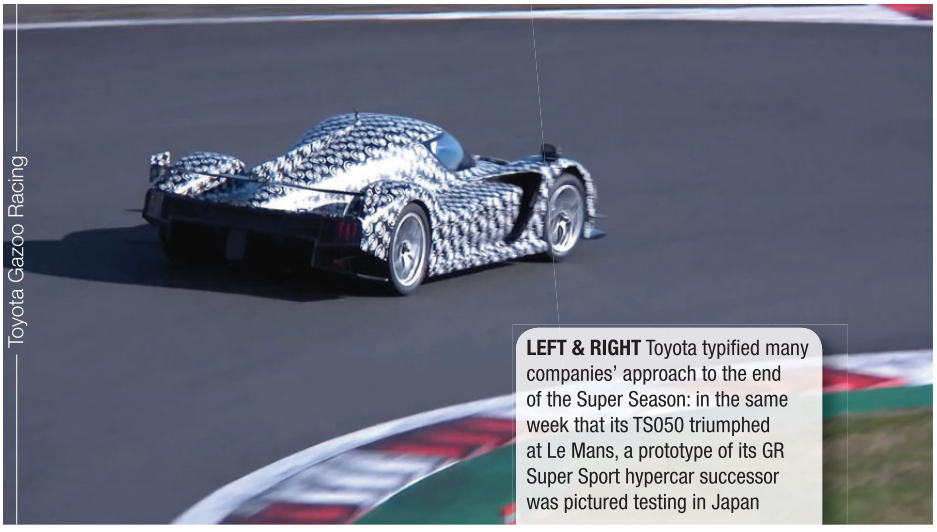
Motorsport is changing. In the same way that the transition to hybrid technology in the World Rally Championship will be a gentle one at first, rallycross' reignited electric plans look to feature a more realistic platform than the previous effort. One thing's for sure, the next few years will continue to be extremely interesting, from both a sporting and technical perspective. RT

HYPED UP ABOUT WEC'S FUTURE

The specification of cars for the Super Season finale at Le Mans was fixed long ago. But, as **Alan Stoddart** finds out, the suppliers have instead been planning ahead for a hypercar future

LE MANS might have been the World Endurance Championship's Super Season finale, but many eyes were already focused elsewhere.

Many of the cars on the grid had been competing in their current form for more than a year, but there were still plenty of interesting technical stories to be found among the race's suppliers. In particular, the confirmation of the upcoming hypercar rules package, allied to the withdrawal and entry of some teams, proved fertile ground for discussion and debate.



Toyota Gazoo Racing

LEFT & RIGHT Toyota typified many companies' approach to the end of the Super Season: in the same week that its TS050 triumphed at Le Mans, a prototype of its GR Super Sport hypercar successor was pictured testing in Japan

LOOKING TO THE CLOUD

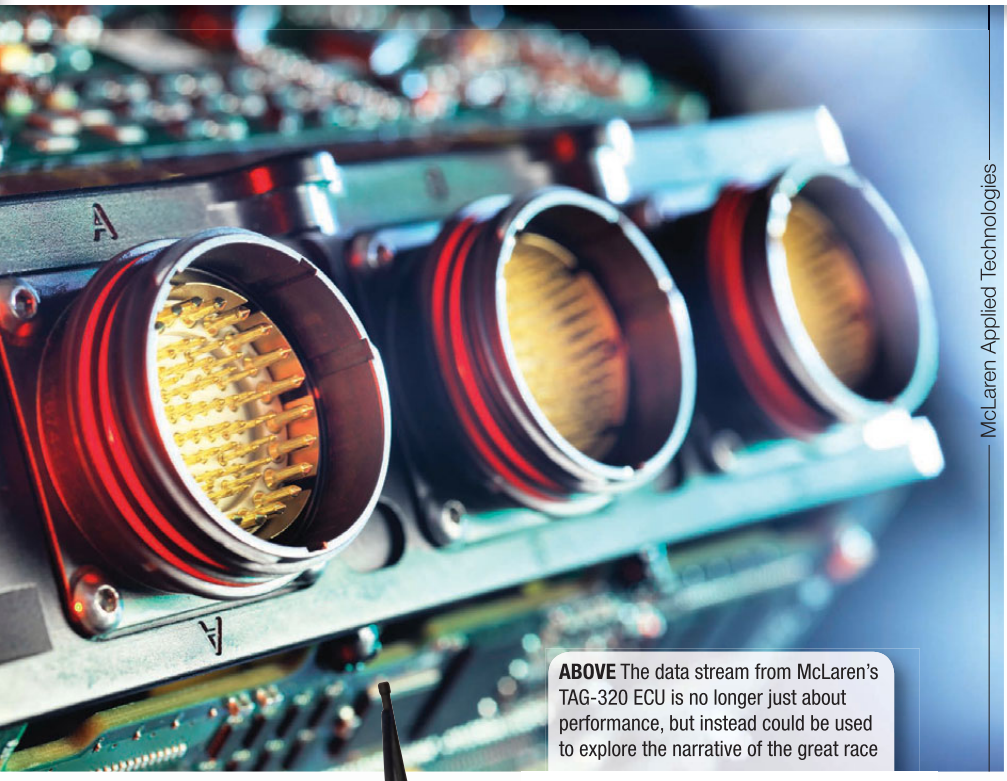
One of the companies with a very wide overview of motorsport is Bosch Motorsport, which is involved in a broad range of series from WEC and F1, to NASCAR and Formula E. Its vice president, Klaus Boettcher, has a balanced opinion on the new regulations: "For us, I think it gives us the chance to go for more technologies like hybrids, but of course, the question will be how many teams and customers will take part. I'm concerned that if the number of entrants decreases, then it will affect us negatively.

"On the other side, I think it is a good opportunity for new technology for high efficiency combustion engines. If we talk about efficiency, then we talk about direct injection technology, and that could affect us in a positive way, because I think we have a good basis and good experience for the future."

Regardless of how the rules shake out and what competing teams ultimately need to go racing, however, Boettcher is confident that the German powerhouse is able to offer solutions that deliver. The possible outcomes and implementations of electric and hybrid technology across different series defined the company's strategic approach, he says: "We started the beginning of last year with a new portfolio regarding electrified components, engines, electric motors, inverters and so on. It is not clear where the way leads, so we decided to have a strategy to put the development into several blocks."

These development lines range from the 48v system Bosch uses in its electric go-kart, through to the upcoming 800v Formula E drivetrain, with different hybrid systems for various motorsport applications, and with different degrees of road relevancy in between. This approach ensures that the company is prepared for any direction that the rules head in.

Bosch isn't just focused on the powertrain side however, with one of the developments brought to Le Mans in 2019 on the telemetry side. In the past, the focus had been to achieve as close to 100 per cent track coverage as possible, and so required a host of



McLaren Applied Technologies

ABOVE The data stream from McLaren's TAG-320 ECU is no longer just about performance, but instead could be used to explore the narrative of the great race

antennas across the course to receive data directly from the car. The direction has now changed however, with some teams utilising Bosch's new modems, which instead of transmitting data to a telemetry station at the track, beam it straight into the Cloud, where it can be instantly accessed by anyone across the world.

"For me it is important that a spectator can have it [the data] on an app... the values are changing, it is now not so much the value of performance, but instead the value of performance and marketing," Boettcher adds.

LOOKING FOR HEROES

Another company present at Le Mans embracing a more open approach to telemetry for the sake of entertainment was McLaren ▶

Adrenal Media/WEC

Adrenal Media/WEC

ABOVE The AER-engined SMP cars got closest to the Toyotas

> *"Data won't just be displayed as 'squiggly lines' but instead as a story"*

Applied Technologies. The British firm is looking to work with promoters of a range of series to take data from cars and share it with fans. Its data engineers are key to the success of this technology, as, in order to ensure the accessibility of the data, it won't just be displayed as 'squiggly lines' but instead as a story.

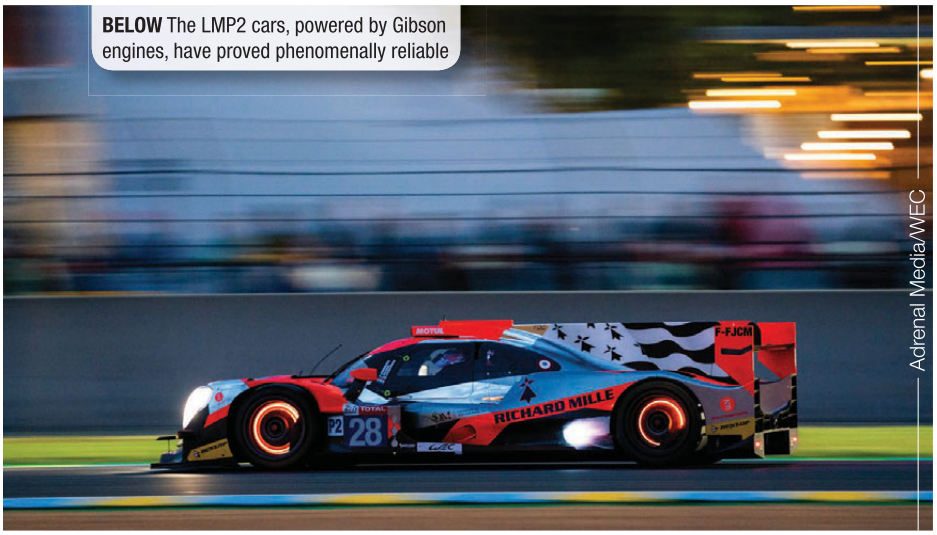
"So what we are doing is working with promoters to say how do we give you a hero status between two drivers? How can we tell who is working hardest?" explains McLaren Applied Technologies' head of business development for motorsport, Jason Watkins. "If you have a scenario where you are looking at a particular lap, and you have two drivers on the same team, in the same car and you have one driver that seems to be driving faster, his hero status might appear quite high.

"But, if you look at other metrics and you can see how much he's been using his tyres, and how he is going to suffer in the long term because he has taken five per cent of the life out of his tyre by overdriving, you can see it was actually better to conserve tyres like the other driver."

The development seeks to unlock dense data for fans, making it accessible and providing additional narratives and insight.

As well as looking to the future, McLaren Applied Technologies also has a presence on most of the grid in one way or another, with some teams opting to use a complete control system and ECU from the manufacturer, and more still using the company's sensors and alternators. One of the advantages offered by MAT's control systems, is that the teams are able to write their own code and strategies in order to develop the car to its fullest potential without the involvement of McLaren itself. "They can maintain that manufacturer confidence or team confidence or whoever it happens to be we are working with," reassures Watkins. "So they can write some really clever strategies for all sorts of things on the car."

On the sensor side meanwhile, as well as a lot of off-the-shelf products, the company also completes a lot of bespoke work. If a team needs a sensor for a particular application, or to go in a harsh environment or be interfaced with some homegrown technology, for example, then that can be facilitated. What's more, even though McLaren Applied Technologies produces some 15,000 sensors a year, which helps to lower the costs, because everything is done in-house and isn't dependent on a supply chain, changes can be made very quickly.



Adrenal Media/WEC

BELOW The LMP2 cars, powered by Gibson engines, have proved phenomenally reliable

HEART OF THE CAR

Away from the electronics, at the heart of any sports car is the engine. In the LMP1 class, the cars closest to the hybridised Toyotas were from SMP Racing and powered by Advanced Engine Research. These were the cars that looked most likely to threaten the dominant TS050s, with the number 17 car's fastest lap of the weekend just two-tenths of a second off that of the race-winning number 8 Toyota.

According to AER's managing director, Dr ▶

Mark Ellis, part of the reason for this strong performance was thorough preparation. "Everything is going well, and the pace of the cars is obviously very good, with the two SMPs within the 3:16 lap times, so the car has improved quite a bit to close the gap," he told Race Tech before the race.

"Partly of course this is down to the increased fuel flow rate this year for Le Mans, compared to last year, so it is now 115 kg an hour compared to 108 kg last year. That has undoubtedly helped, but the team and AER have also worked hard in the past 12 months to improve the package overall."

The changes to the fuel flow did not cause AER any problems, given that, as part of the homologation documentation submitted to the FIA, the engine is calibrated at a number of flow rates. However, Ellis notes that there is still some detail calibration work to get the best out of the engine, which is made easier by the P60C's twin-turbocharged V6 architecture.

"We have an advantage in being able to adapt to changes in fuel-flow rate quite rapidly compared to a normally aspirated engine, so that certainly makes the package more competitive. Although, of course, the peak power is controlled by the FIA and the Equivalence of Technology process."

Given the engine's strength, the package won't require any mechanical changes for the coming WEC season, which gets underway at the end of August, allowing the team to focus on continuing its run of strong performances. When it comes to the 2020/2021 regulations, though, there are multiple directions available.

"We have got a couple of different options. We could use a derivative of our existing V6 twin-turbo, or we also have a V8 twin-turbo which is a development of an LMP engine that has been run previously. We have already built these engines for different customers in different applications, so we'll see," Ellis concludes.

Also considering the future Le Mans regulations was John Manchester, the operations director of Gibson Technology, which supplies engines to the entire LMP2 grid.

"Things have to change don't they, and hopefully this is the right change, but they [the ACO & FIA] will have to take a look at other categories as well because the LMP2 cars are very quick, so they might have to address that," he suggests.

Although he warns that the rule-makers will have to tread carefully: "The P2 is a great car and it's been absolutely brilliant for sportscar racing. The FIA and the ACO got exactly what they asked for: a 600-plus horsepower engine and a very good car, so it is probably the best it has ever been. ▶

Adrenal Media/WEC

BELOW Mobil's long-term partnership with Porsche in endurance racing paved the way for its ground-breaking work in Formula E

Goodyear

ABOVE Goodyear's return to high-profile racing coincides with the launch of its flagship performance brand, the Eagle F1 SuperSport range

BELOW Aside from pure entertainment, there is a demand for the 24 Hours to demonstrate road relevance

Adrenal Media/WEC

"So I think they shouldn't change it too much, and try to keep it as similar as they can, but that is the difficulty of the changes: P2 has been such a complete success, there were 20 cars at Le Mans and there are new teams waiting to come in all the time."

Manchester is also optimistic about another of the issues that has the potential to affect European motorsport in the future. He explains that, obviously, if after the UK leaves the European Union, customs rules change dramatically, then it could be difficult to move things in and out of Europe, and require the use of carnets.

"It could make the logistics of moving things around very difficult, but I honestly don't think that will happen," he says. "I think it would affect trade too much in the UK and Europe."

RENEWABLE FUTURE

Keeping these engines running is the fuel from Total, which, as the official supplier to Le Mans, provides fuel to every team on the grid. This company's work on the 2019 running of Le Mans ramped up three weeks prior to the race, with the delivery of fuel.

"At Le Mans it is a bit specific," says trackside support engineer Thomas Fritsch. "The fuel is not delivered in drums as usual, but instead is delivered in bulk to 60 tanks under the pit lane. We came three weeks ago with seven semi-trucks and unloading it... and while we are unsealing it, we check the quality.

"We have to be certain that the fuel is the same for every competitor. So after filling all the tanks we do another analysis in every box and confirm the product is both the same as in the lab, and that each of the 60 pumps is exactly the same."

This constant examination of the fuel is carried out by two fuel engineers. They perform more than 150 tests in order to make sure that every drop of the 280,000 litres of fuel delivered meets its specification entirely.

One of the reasons that the standards of the fuel are exacting, and one of the challenges for Total, is making a fuel that works for every different car on the grid. That means a range from the hybridised TS050 with a twin-turbocharged V6 to the naturally aspirated V8 of the GTE Corvettes.

"We need to make sure that we are bringing the same kind of performance to each kind of engine," adds Romain Aubry, Total's racing programme technical manager. "That is of great difficulty to achieve in itself, but then while we are bringing performance, we also need to make sure we keep the engine's reliability and cleanliness. So the performance is for sure important, but it also means keeping the engine clean so it can do the 24 hours."

As well as focusing on the present, Total is also keeping an eye on the future, for both the road and race. At present, 20 per cent of the fuel is made of a renewable component. This amount is likely to stay at a similar point, but what Total is working on is moving to different compounds which will not oxygenate while still increasing the energy content of the fuel, enabling increased performance without increased fuel consumption in a racer, or lower fuel consumption for the same performance in road cars.

Also of importance to Total is the source of the renewable elements, which means ensuring that it doesn't compete with the food chain in the creation of fuels. "For this reason, we are using things that are waste," says Aubry. "It can be wood, straw, residue from grain or even cellulose bases, but the thing is that this raw material usually produces oxygenate compounds, because they will be transformed to ethanol.

"However, our idea is to make a hydrocarbon compound coming from the renewable material... we won't have to change anything regarding the engines because it will behave like normal hydrocarbons, but compared to organic compounds, the energy content will be higher."

ROAD RELEVANT

ExxonMobil is another company that has its eyes squarely on the future. In terms of the upcoming regulations, the firm's global motorsports technology manager, David Tsurusaki, is confident that the change won't cause any problems. "Even if the engines change, and there is some change to the lubricants required, it won't make a big difference to us. That is what we do every day. If you look at the teams we support now, they all run completely different engines, and we have different oils for each one of them so that isn't a concern," he says.

In a wider sense, however, Tsurusaki is more contemplative about the French race's future. "In terms of the future of Le Mans, that's part of a bigger picture.

"It's a combination of lots of things. It has to be entertaining otherwise no one can do it, but for us it also has to have some level of road relevancy, because from a research side, from my side of the business, not a marketing or sponsorship side, but from a research and engineering point of view, if it is not relevant to the future of the road products then why would we bother? We can spend our time and money elsewhere if it isn't going to be relevant for the future of road cars."

For some people and organisations, 'the future of road cars' means electric vehicles. For this reason, ExxonMobil is also offering ▶

lubricants to meet the particular needs of EVs, both on and off track.

"We are already selling to the electric vehicle market on the road side, while on the motorsport side we are working with Porsche, creating what I call an 'ultra high efficiency' gear oil for their Formula E programme," he says.

"The goal of the project with the Porsche team was to get the very highest level of efficiency, even considering the 27,000 revs of the FE car. We started on this project before they even announced their FE programme, and at the time there was no gearbox, nothing existed yet, so we did all the design work on computers. We have, for two years, been working on an evolution of what this ultra high efficiency gear oil could be."

GOODYEAR'S RETURN

Looking to the future is of course important, but for one brand at Le Mans, revitalising something from the past is also a priority.

Goodyear-equipped cars have enjoyed significant success at Le Mans over the years, with 14 of the race's winners using the rubber. This made it the perfect venue to announce the brand's return to European and international sportscar racing, with a new range of tyres that will be used in the 2019-2020 WEC season onwards.

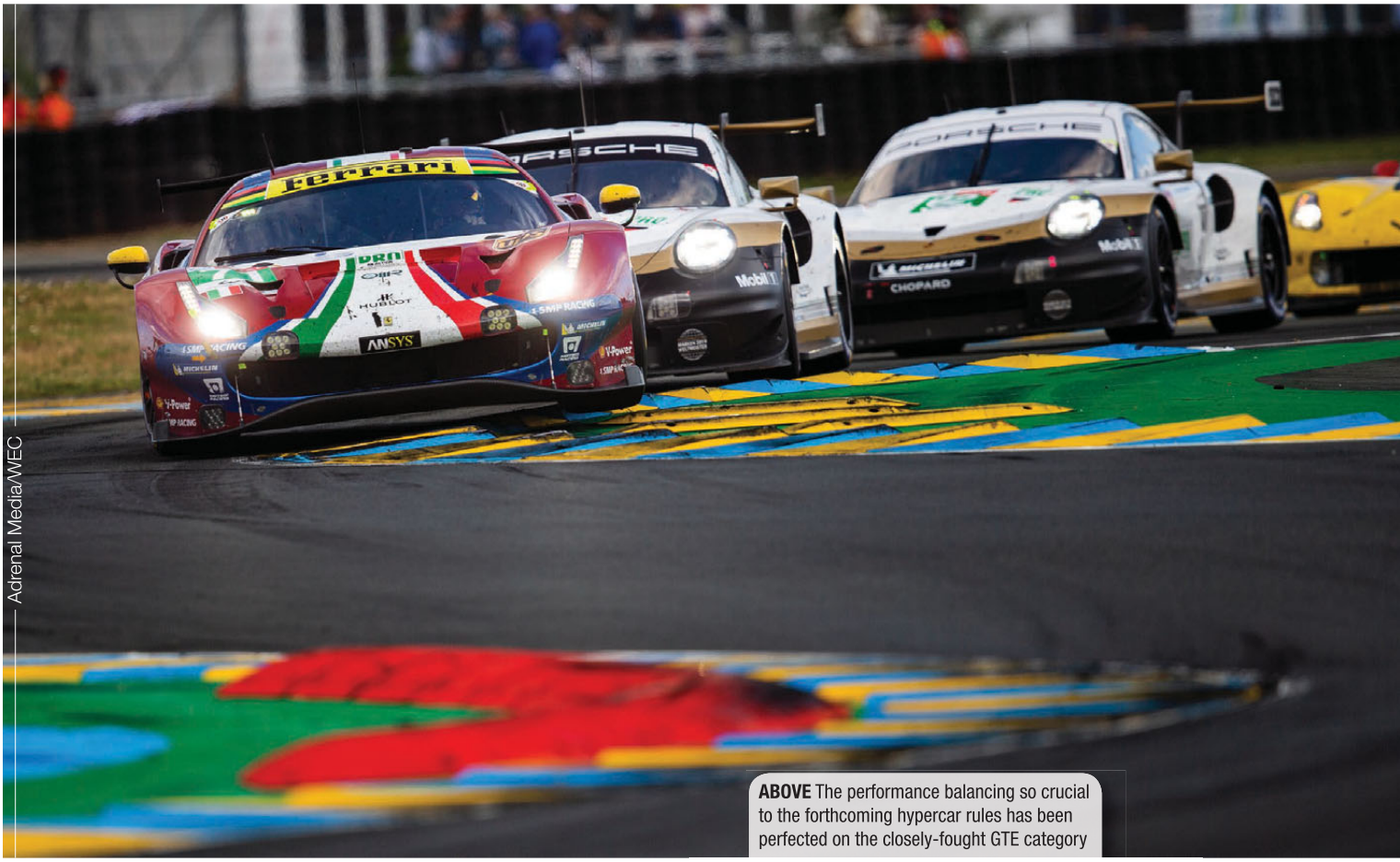
> *"Motorsport is very much in our DNA"*

Ben Crawley, Goodyear's motorsports director, explains the move: "Motorsport is very much in our roots and in our DNA and I think we are coming back to that. We wanted to bring Goodyear back to racing internationally, but especially in Europe because we have launched a new range of ultra, ultra high-performance track-day road tyres, under the name of Eagle F1 Supersport. All of that is returning the Goodyear brand to its roots."

The move also allows for more resources to be utilised for the research and development of racing tyres. Until the end of the 2018-2019 season Goodyear's subsidiary, Dunlop, was used at the French race. Research and development for Dunlop tyres has been conducted mainly at the firm's European R&D centres. With Goodyear, however, developments will be drawn from global resources, including the firm's US research and development infrastructure.

"We will be able to use our global technology in our future race programmes," Crawley continues. "So the tyres that Goodyear will start racing with, in two months' time at Silverstone at the first WEC round, will be new spec tyres, and different to the current tyres Dunlop is racing with in LMP2."

Despite the changes, the challenge still remains the same. "In open tyre competition you have to push forward to meet the dual parameters of outright performance, and longevity of performance. Those challenges remain for every tyre supplier. So we have been very focused on developing and introducing new Goodyear tyres that can win from race one and can provide the balance that we need across the range of drivers and driving styles and so on." RT



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ABOVE The performance balancing so crucial to the forthcoming hypercar rules has been perfected on the closely-fought GTE category

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BAFFLING DECISION!

ATL didn't just lock out the front row at Le Mans, it provided fuel cells for the entire grid! **Alan Stoddart** discovers why

THE 2019 running of the 24 Hours of Le Mans featured 62 competitors, a record entry for the iconic race. These 62 runners were in all different types of cars, from the supremely purposeful LMP1 prototypes with a vast support team, and built with the solitary goal of taking victory, to the privateer entrants in GTE AM who were simply realising the dream of competing at one of the world's greatest motor races.

Despite these differences in aspirations and technology, however, there was one thing that united the entire grid: its choice of an ATL fuel bladder.

ELEMENTS OF PERFORMANCE

"We have about 16 competitors that entrants could go to, but every one of them racing at Le Mans has come to us," says ATL's managing director Giles Dawson proudly, "and I think there are several elements to them making that choice.

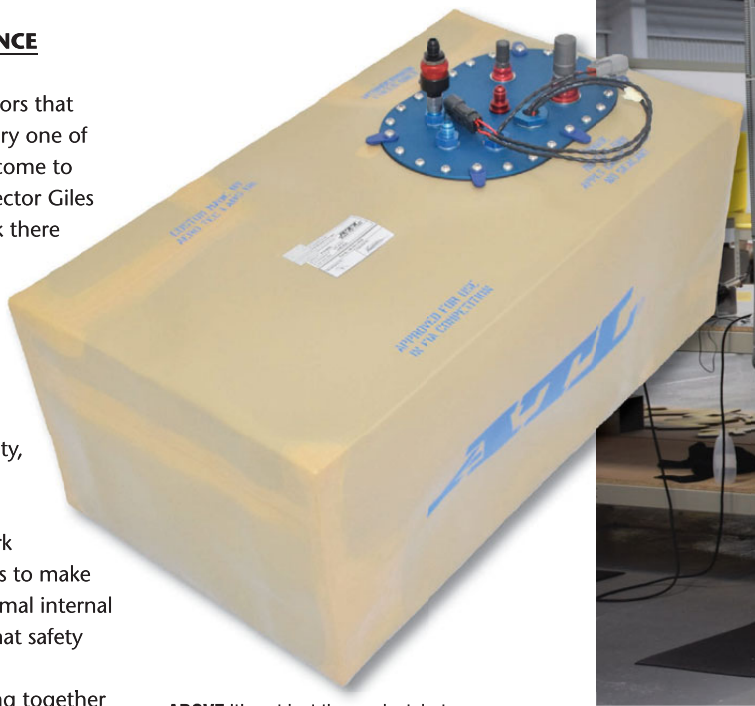
"Obviously there is the technology element, in that we produce something that is extremely suitable in terms of a balance between durability, weight and safety, but there is also the design service and integration elements. We work closely with each of the teams to make sure they are getting the optimal internal setup so it goes far beyond that safety element of the bladder."

This process involves working together to come up with the best solutions for the type of car, whether that is to do with the material the fuel bladder is made out of, or how best to package it and how to balance value, weight, durability, safety and performance. It is a process that is worth doing correctly though, as if the right choices are made, a team is able to get down to picking up the last 100 mL of fuel. Being able to collect fuel so efficiently over the course of a 24-hour race is a real advantage, allowing a team to gain more than a lap or even an entire pitstop over the course of the event.

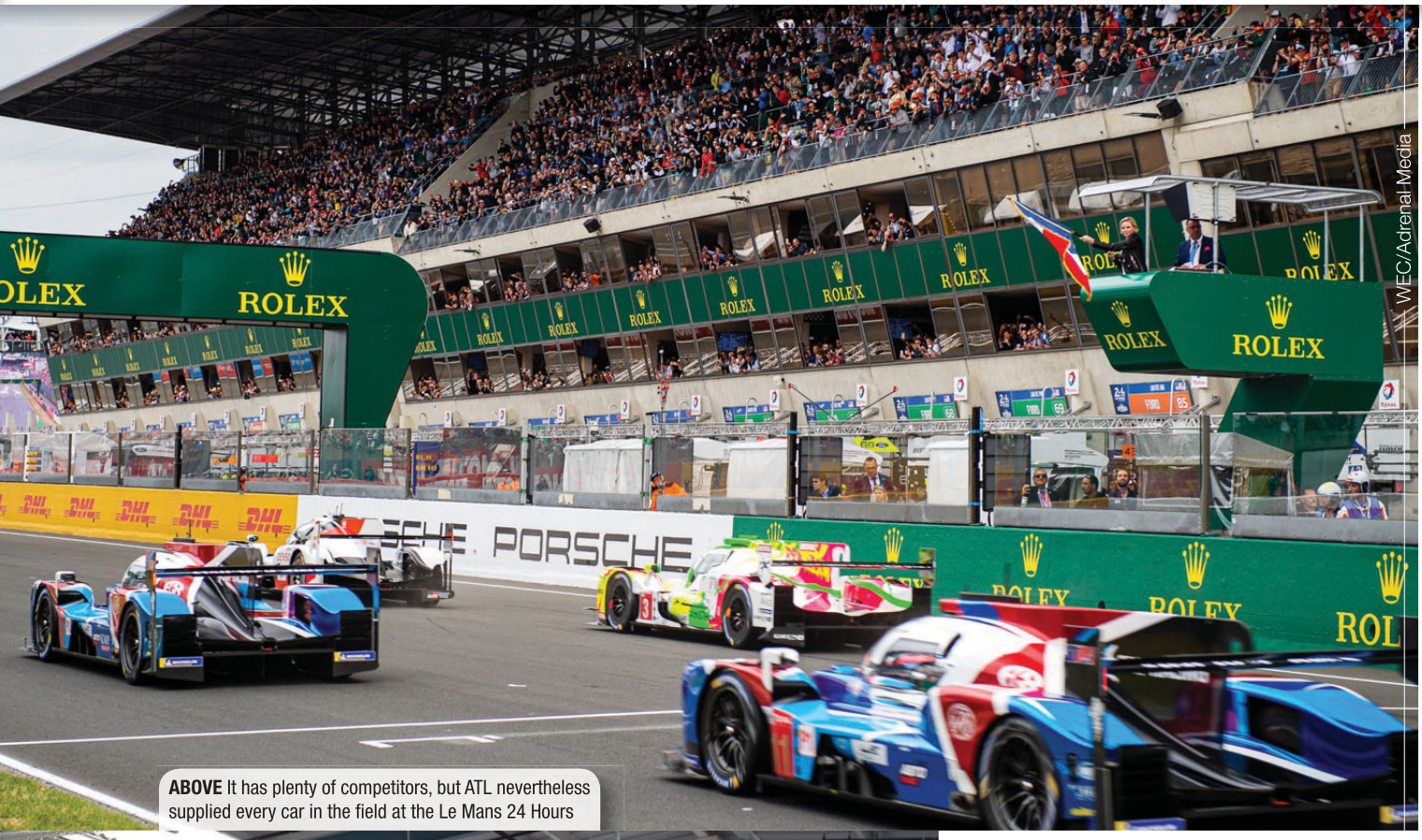
Delivering these impressive results is, however, a relatively involved process. "For some teams, like Toyota, we get sent a very mature model and they ask us to optimise based on our experience. This would already have all the baffles in and will draw heavily from their F1 days, so we get less involved with their iterations, it is more about optimisation of production for them," Dawson explains.

"Someone like Ginetta or Dallara, on the other hand, comes to us with a fuel volume and says: 'Here is the cavity in the chassis, what do you think we should do?' Then it becomes a very iterative process of improving things with them over a six-week period. We are presented with that volume, which is set by regulations and the position of things like the oil tank and the radiators at the sides, as well as the aero surfaces. Once we've got that, the question is how best to pick up the fuel that is sitting inside that hole."

Perhaps surprisingly, working out how best to pick up that fuel isn't done using CFD to analyse fuel movement, instead it relies on the ATL team's expertise and



ABOVE It's not just the product, but the bespoke service behind it that is an important part of the brand's appeal



WEC/Adrenal Media

ABOVE It has plenty of competitors, but ATL nevertheless supplied every car in the field at the Le Mans 24 Hours

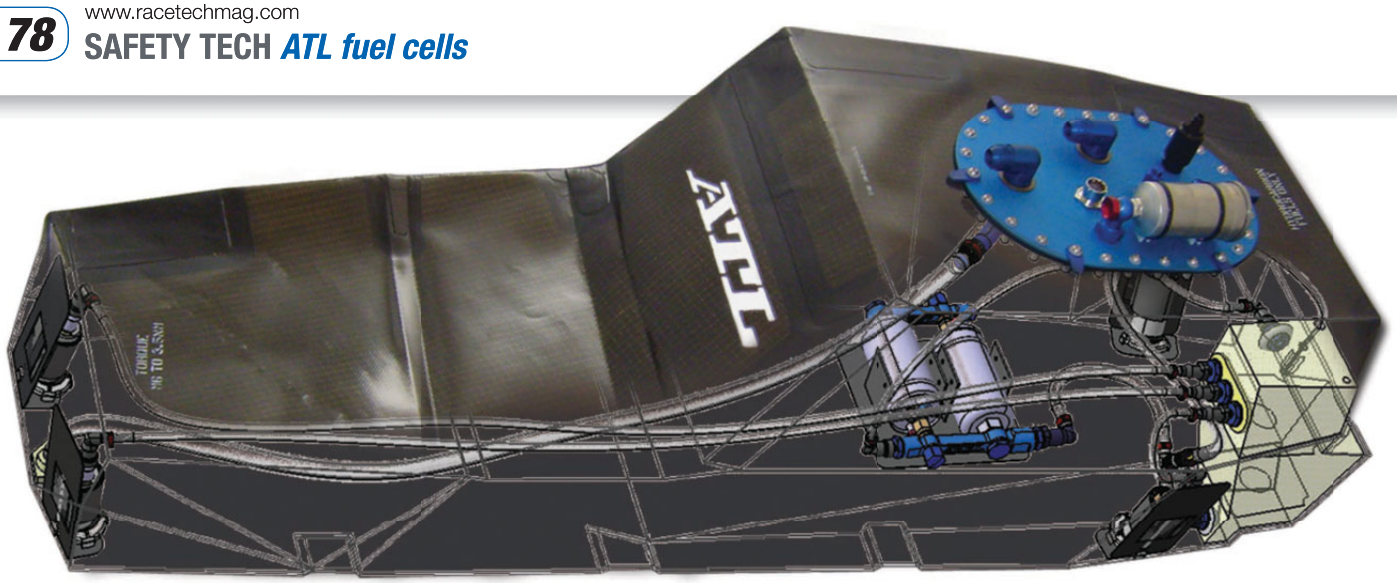
ABOVE Part of ATL'S operation is dedicated to manufacturing for Porsche

> *"Picking up the last 100 millilitres of fuel over 24 hours could allow a team to gain more than a lap over the course of the event"*

experience to ascertain where the petrol is going to move to during any unusual scenario the car might encounter. For example, at the bottom of Eau Rouge, at Spa, the compressions before the hill up to Raidillon cause the fuel to rise up against the ceiling of the fuel tank as the car lurches downwards.

"It is actually the most challenging corner in the world for us, because the compression is mind-blowing," reveals Dawson. "At the bottom of Eau Rouge I don't even need to see a G-force trace because I can tell from the lift pump current. Suddenly the lift pumps are drawing no current for about three seconds while the fuel is coming back down!"

For some series though, the work doesn't stop after the initial tank has been completed. In LMP1, the homologations aren't totally fixed, so, even if the overall shape isn't going to change because of the ▶



ABOVE A glimpse of the detail below the surface of a fuel cell, this one intended for the DTM

fixed boundaries, ATL and its customers are able to continually refine the designs. Changes can be made to things like the placement of baffles, the details of baffles within the fuel collector and even the position of lift pumps within the chambers.

ACROSS THE RANGE

This expertise has also meant that ATL has become the ideal candidate for some companies such as Porsche to trust with making their performance fuel cells. Porsche has continued to select ATL for all petrol-fuelled motorsport projects as the firm has proven itself to have the technology and processes to deliver.

"The RSR has been more iterative in terms of us taking their work on when they first got serious about a GTE programme. We've been involved with every stage of the GTE programme since and worked closely with their technical team in terms of developing the product and making sure that they are getting what they want," says Dawson.

"So we worked with them to get the ultimate product for the RSRs, and then with someone like Porsche that can flow down into the GT3 car. Ultimately some of the parts that we have developed on the RSR go into bigger production projects and make it into the Cup and GT4 cars. There is a lot of carryover between all the different models."

> *"Eau Rouge is the most challenging corner in the world for us, because the compression is mind-blowing"*

Of course, in lower tiers, where absolute leading-edge performance isn't necessarily the priority, some of the more extreme features are removed. Despite this, however, the bloodline to the very pinnacle of sportscar racing, the technology that was chosen by every single entrant in the Le Mans 24 hours, is very much present.

BELOW Eau Rouge is as daunting a test for suppliers as it is for the drivers

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RUBBISH IN... RUBBISH OUT!

Sergio Rinland believes Ferrari's strategy horror show in Monte Carlo provided a painful lesson about simulation that we all need to remember

FOR many years now I have been dedicating my efforts to developing and teaching the ins and outs of simulation in motorsport. It is, you could say, my bread and butter today.

What is simulation? The dictionary definition says: "Simulation is the imitation of the operation of a real-world process or system over time". The term is used in many contexts, such as simulation of technology for performance optimization, safety engineering, testing, training, education, army training and video games.

Often, computer experiments are used to study simulation models. Simulation is also used with scientific modelling of natural systems or human systems to gain insight into their functioning.

Simulation can be used to show the eventual real effects of alternative conditions and courses of action. Simulation is also harnessed when the real system cannot be engaged. This could be for a number of reasons: it may not be accessible; may be dangerous or unacceptable to engage; too expensive; it is being designed but not yet built; or, indeed, it may simply not exist.

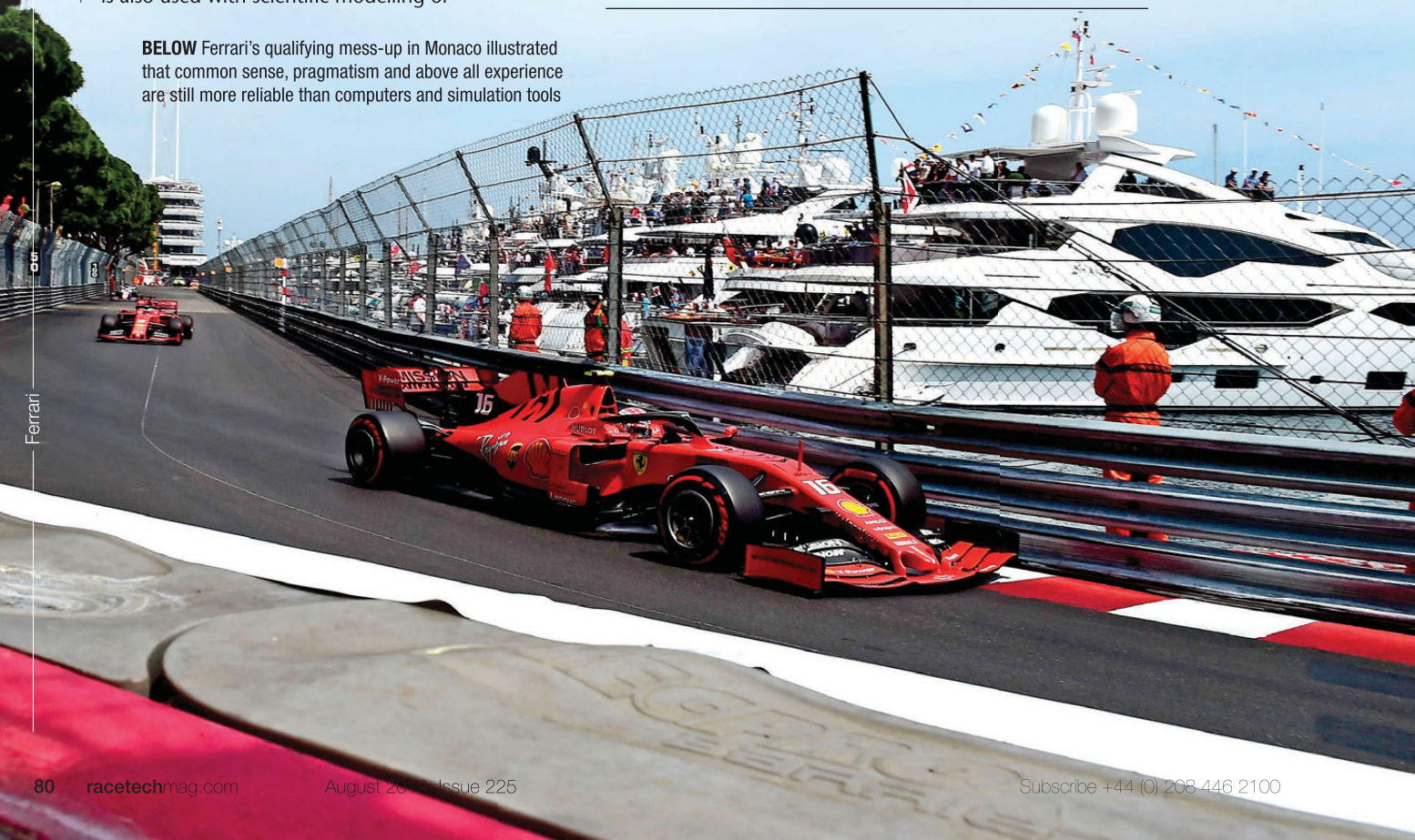
The key issues in simulation include: acquisition of validly-sourced information about the relevant selection of key characteristics and behaviours; the use of simplifying approximations and assumptions within the simulation; and fidelity and validity of the simulation outcomes.

WRONG ASSUMPTIONS

Translating this to plain English, and always remember this in simulation: "Rubbish in – rubbish out"! If your mathematical and physical models are not correct, or if you make the wrong assumptions and the information you put in is not correct, do not expect an accurate result.

Knowing this and being aware of what a double-edged sword simulation can be, I was astonished watching Monaco 2019 qualifying when Ferrari decided to leave hot-shoe Charles Leclerc in the garage after only one run in Q1. It wasn't just me: every 'armchair enthusiast' watching qualifying was screaming at the TV set: ▶

> *"Every armchair enthusiast watching qualifying was screaming at the TV set: 'What are they doing?'"*



BELOW Ferrari's qualifying mess-up in Monaco illustrated that common sense, pragmatism and above all experience are still more reliable than computers and simulation tools

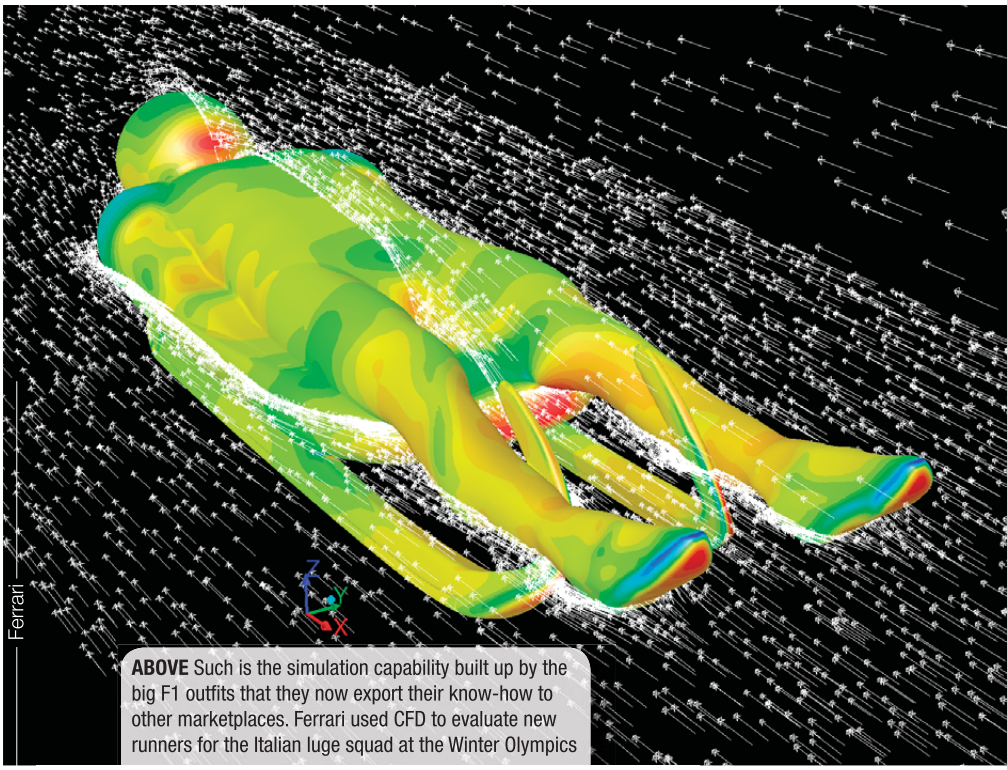
Ferrari

'What are they doing? Let Leclerc out!'

It was a no-brainer. Anyone would know by now that Monaco is unpredictable. So many factors come into play there which affect grip, and hence performance at the Monegasque circuit. The only way not to be caught out is to be out on track.

At a circuit such as this, that evolves by the minute, it is difficult to predict with precision what the ultimate lap time will be at the end of a session. You go out on track on Saturday after a day when other racecars have been leaving stuff on the surface, and you have had the wealthy owners of every Pagani, Lamborghini or Ferrari in the vicinity droning round and round the track until well after Friday midnight. Add to that the cleaning trucks, trying to leave the surface as green as possible. And that's if it doesn't rain!

Hence, it was almost comical to see the Ferrari engineers glued to their computer screens and poor Charles walking around the garage in disbelief. It transpired after qualifying that the Ferrari engineers trusted their simulation system telling them that with the first run lap time Leclerc would safely make the cut. They evidently trusted this more than their common sense and nearly 70 years of experience of going to Monaco since 1950!



ABOVE Such is the simulation capability built up by the big F1 outfits that they now export their know-how to other marketplaces. Ferrari used CFD to evaluate new runners for the Italian luge squad at the Winter Olympics

INVALUABLE TOOL

In this day and age, when testing is either prohibitively expensive or forbidden by the rules, simulation has indeed become an invaluable tool, that being:

a) Virtual Simulation such as Lap Simulation, where we create a virtual model of a vehicle to circulate in a virtual track, driven by a virtual driver. Include CFD and FEA analysis under this umbrella.

b) Physical Simulation. This refers to simulation in which real-life physical objects are replaced with physical objects, sometimes at a smaller scale, or with cheaper materials, or by an equivalent system to test relevant functions. A wind tunnel is a good example of this. Transient dynos are another.

c) Interactive Simulation is a kind of simulation where either the virtual model or some of its components are replaced by the real thing, called "Hardware-in-the-Loop", or the virtual driver is replaced by a real driver in the simulator, called "Driver-in-the-Loop".

Every F1 team has these sophisticated simulation tools at their disposal, plus an army of engineers to handle them.

Computers have come a long way and we are on the verge of seeing Artificial Intelligence (AI) allowing these machines to perform certain tasks better than humans. But they are not there yet, at least not to the point that one can predict the progress of the Monaco racetrack through the weekend with a good degree of accuracy.

Ferrari found out the hard way that common sense, pragmatism and above all experience are still more reliable than computers and simulation tools. Don't underestimate humans, particularly Charles Leclerc.

ABOVE Driver-in-the-Loop: Marc Gene clocks up another virtual lap in the Ferrari simulator

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