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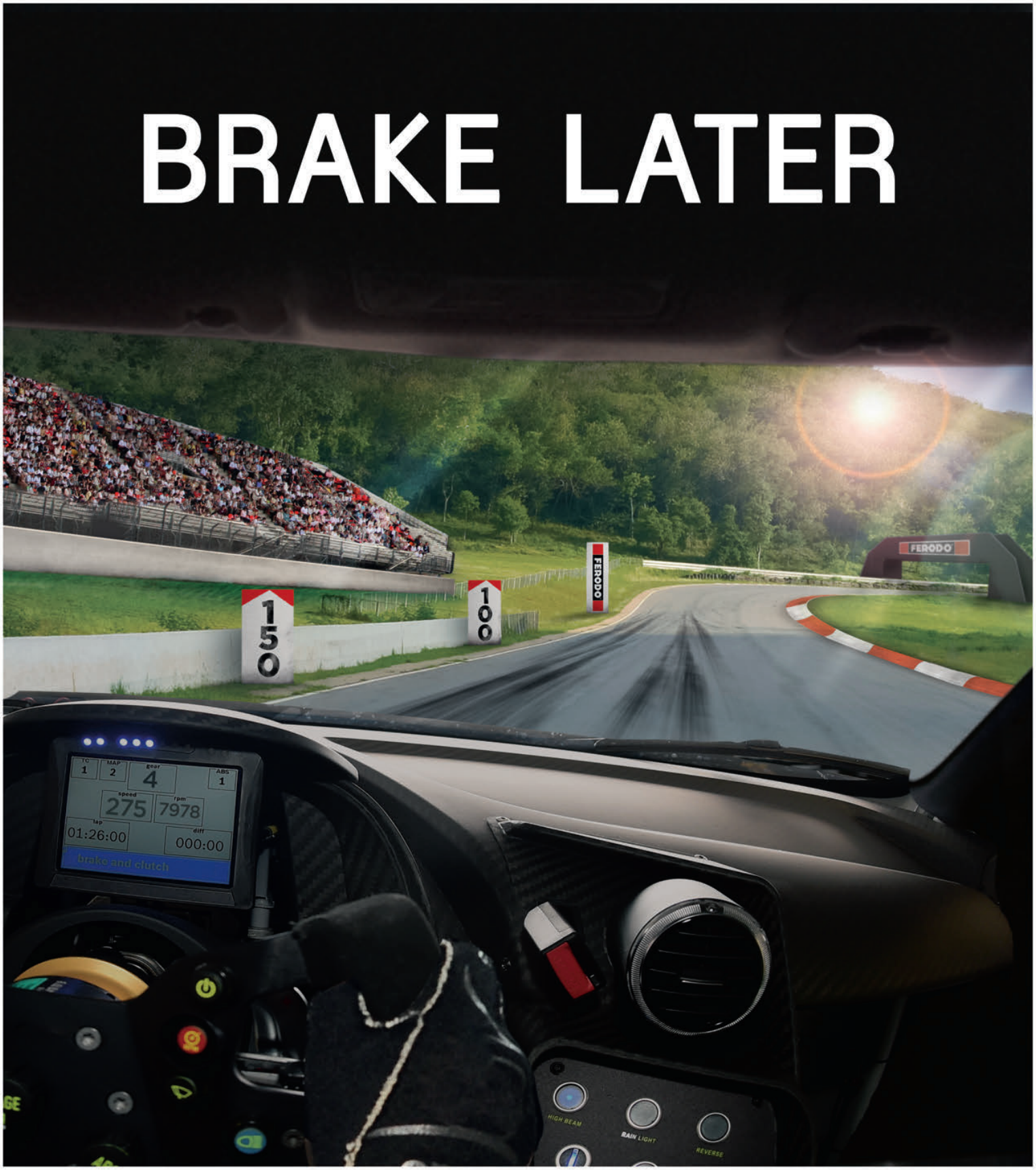

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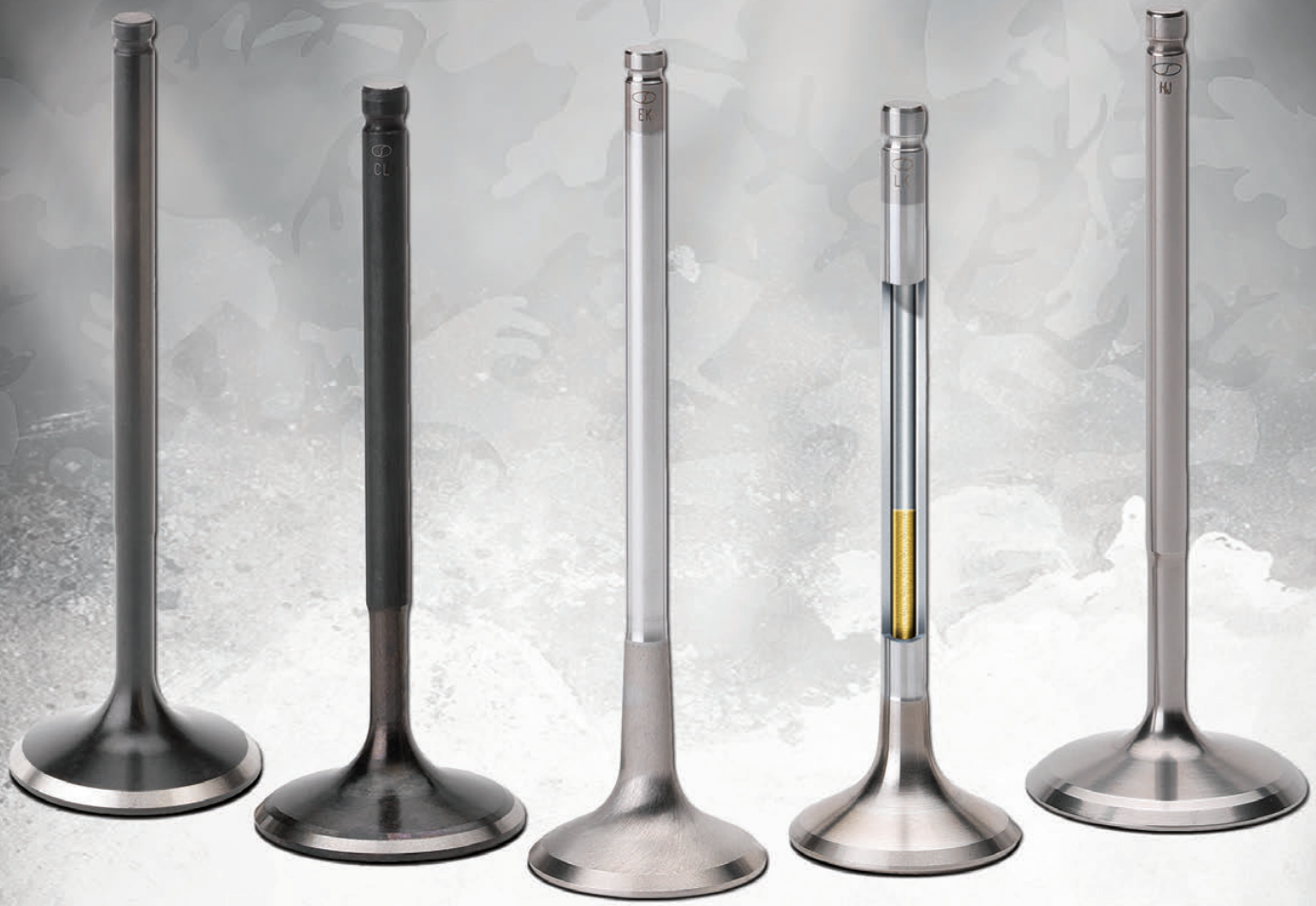

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NEVER SAY NEVER

I AM going to be very self-indulgent, so please excuse me. Rather than commenting on an issue that has caught my eye, I'm so excited about our own current state of affairs that I cannot contain myself.

Where to begin? Perhaps with *Automotive Engineer*, the latest addition to our magazine portfolio. As many of you will know, I edited this publication for 10 years until I got the call from *Race Tech* a dozen years ago. While I was ecstatic about joining this magazine, I was nonetheless sorry to leave *Automotive Engineer* as it was a publication that along with others, I had nurtured back to life and was leaving in a prosperous state. I never thought it would cross my path again.

It's a long story, but here we are, a month away from re-launching it as part of the Kimberley Media Group and it's exciting times for us. Along with R*ace Tech, Historic Racing Technology* and *Track Car Performance*, it neatly squares the circle for us. It also gives us useful conduits from one part of the industry to the other, which at a time like this is so very important.

I'm also excited about the next World Motorsport Symposium. I tend not to touch upon our annual event until much closer to the time, but this year's is turning out to be so topical that in its 13th year, it's as if it has been created for these times. As I wrote in the last issue, with so much anti-car feeling in Europe in particular and the announcements from various governments, including the French and British, about the ban on petrol and diesel cars and vans from 2040, where does it leave motorsport? Is it going up the wrong path by being wedded to the internal combustion engine or should it be embracing the challenges of battery and electric car racing or indeed anything else? The topic we chose "Can mature technologies make a comeback?" could not have been more topical.

At the same time, while the engine is obviously in the limelight, we cannot overlook the other aspects of the racing car. Take aerodynamics. The blame for the lack of overtaking in Formula 1 in particular is often laid at the door of the aerodynamicists. They do their job so efficiently that it detracts from the racing itself. Is this fair, though? After all they are only working to the rule book, one of which stipulates that you cannot have two cars in a wind tunnel, so what else are they meant to do?

With 2021 coming up when things are changing, now is the time to discuss how aerodynamicists can play a positive role in making racing more exciting and I'm thrilled to announce that Willem Toet has agreed to play an active part in proceedings. What many of you may not know, because it was only announced today at the end of August, is that he's back on the Formula 1 scene with Sauber F1.

We are also holding our event at the Institution of Mechanical Engineers in Westminster, my old stomping ground when at *Automotive Engineer*. For those who haven't visited it, it's a really splendid building with a great lecture theatre and a wonderful library where I used to bury myself for hours.

We have been incredibly honoured to have such wonderful people as Pierre Fillon, president of the Automobile Club de l'Ouest along with ACO sporting director Vincent Beaumesnil, along with Andy Cowell, managing director of Mercedes AMG High Performance Powertrains, James Key, technical director of Scuderia Toro Rosso, Thomas Kraemer, manager, Porsche's engine LMP1 engine design, the well known and highly respected F1 engine designer Gilles Simon and Rodi Basso, motorsport director of McLaren Applied Technologies, along with our two indomitable chairmen Ulrich Baretzky, Audi Sport's engine development director, and Formula 1 aerodynamicist John Iley commit to attending the event. I think all in all, it should lead to two days of very interesting talks.

I apologise if this has sounded like a sales pitch, but I just can't hold my enthusiasm for what's in store.

William Kimberley
EDITOR

BELOW Electric cars could soon be seen competing on World RX events

Electric World RX but not at the expense of the engine

Hal Ridge

LONDON, UK: Electric vehicles are set to be introduced into the FIA World Rallycross Championship and could form part of the series' structure as soon as 2020, promotor IMG has revealed.

World Rallycross managing director Paul Bellamy has confirmed that the promotor is working with a number of undisclosed manufacturers and the FIA to form plans for integrating electrically powered cars into World RX.

The news is the first solid indication that the mixed-surface racing series is investigating the concept, following a number of individual announcements from manufacturers last year – Peugeot, Audi and Volkswagen – that they would be interested in electric technology being introduced to the sport.

"We're talking to a number of manufacturers and working with the FIA about what it [electric rallycross] might look like. We're having those initial conversations now. It will be 2020 at the earliest but we're in discussions about what format the concept might take, what the cars will be like and where it will sit in the World RX weekend," said Bellamy, who reiterated the series' commitment to the current Supercar category, where four-wheel drive cars are powered by 2.0-litre turbocharged engines.

"It's very important for us that the internal combustion engine is here to stay in World RX. We've invested heavily in rallycross as it currently is, and we're not going to walk away from that. The current formula is a fantastic spectacle and that won't change, in the same way that Formula E coming in hasn't changed Formula 1."

That confirmation has also ruled out the prospect, in the short term at least, of electric vehicles racing against internal combustion engine powered machines in head-to-head contests. "The FIA's position is that electric vehicles and internal combustion engine cars will not race together. They can race at the same events, but not in the same races within those events," said Bellamy, without giving any indication as to how the regulations for an electric category may develop.

"We're looking at electric rallycross because it's what the manufacturers are asking for," he continued. "They understand and see how rallycross lends itself perfectly to electric motor racing, because the races are over quickly and the cars being used relate to the cars that you see every day on the road. Because rallycross fans are of a younger demographic than most other forms of motorsport, that demographic is more open to change and to pushing the boundaries of new technologies."

Last year, Austrian firm STARD revealed the first electric rallycross car prototype, boasting similar performance figures to that of a conventional Supercar (as featured in RT193). Bellamy has experienced the machine first hand "I was very impressed, especially with the acceleration and performance," he said. "It was much better than I expected. Certainly as a mode of transport, electric technology is coming much quicker than people perhaps anticipated. We have to embrace it if it means that the cities around the world become cleaner places to live because of that – absolutely it has to be the way forward."

The news comes on the back of shock announcements in July from German marques Porsche and Mercedes which respectively quit World Endurance and DTM programmes to move to Formula E, and that the French and British governments' plan to ban the sale of new petrol and diesel cars by 2040.

The American-based GRC announced last year that it would feature an electric support class from 2018, while a proposed new series called E/RACING, set to take place in North American cites from October 2017, was announced earlier this year, but no further details have been revealed on either. RT

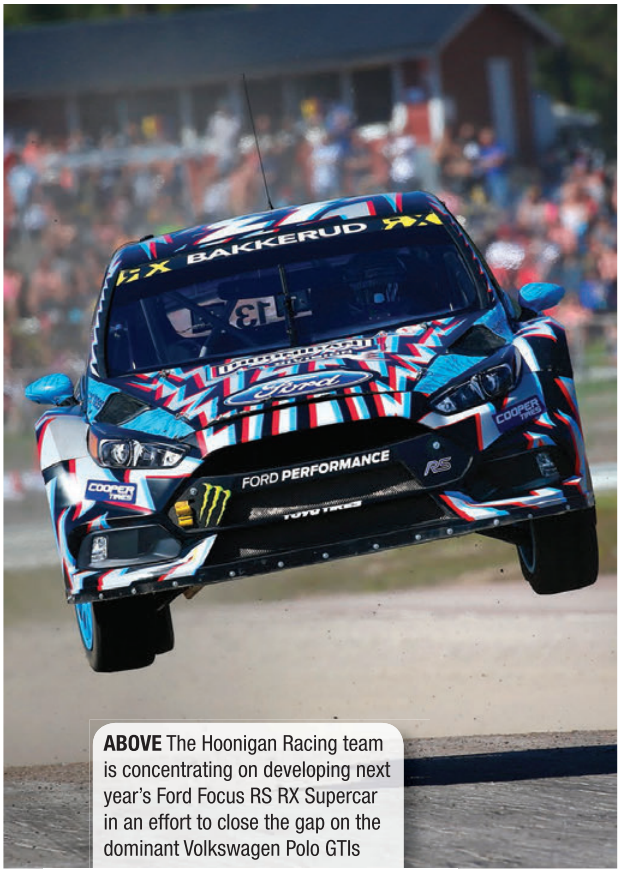
Block 2018 Focus

Hal Ridge

PARK CITY, UT: The Ford-backed Hoonigan Racing Division World Rallycross team has transferred its focus to 2018, with the development of its Ford Focus RS RX Supercar. The Ken Block-owned squad introduced the M-Sport built Focus RS RX at the start of 2016, and Block finished on the podium in only its second event at Hockenheim. His team mate, Andreas Bakkerud, claimed a trio of wins through the campaign, at Hell in Norway, Holjes in Sweden and Rosario in Argentina. However, despite undertaking an unprecedented amount of pre-season testing for 2017, like all of the works-backed World RX teams, the squad hasn't been able to match the pace of the dominant Volkswagen Motorsport-built Polo GTIs, run under the PSRX Volkswagen Sweden banner.

"I think the development that we're doing now is really looking to pay off for next year," said Block. "We didn't have the car exactly where we wanted to be at the beginning of this year and haven't had the results that we wanted, so everything we're doing now is kind of to make sure that we're more competitive (next year). Our goal has always been with this team to try and win races and a title, either an individual title or a teams' title. We've still got that goal in mind and we're doing everything we can to set us up for next year to do that."

While the majority of front-running Supercars in World RX use a McPherson suspension design, the Ford Performance-developed Focus RS RX uses a double-wishbone setup at each corner. RT



ABOVE The Hoonigan Racing team is concentrating on developing next year's Ford Focus RS RX Supercar in an effort to close the gap on the dominant Volkswagen Polo GTIs

Audi World RX rear wing gains

Hal Ridge

NEUBURG-HEINRICHSHEIM, Germany: Audi Sport was responsible for developing a new-look rear spoiler on the EKS World Rallycross team's Audi S1 Supercars for the high-speed Trois-Rivieres circuit in Canada last month, the squad's three cars running a new carbon fibre single-element rear wing to compliment louvered front and rear arches and re-profiled bumpers introduced earlier in the year.

With four teams now receiving manufacturer-support in World RX, gains are being found in areas previously untapped by traditional small-scale rallycross constructors, using the knowledge of the manufacturers' R&D departments.

"The [Trois-Rivieres] track has a bit of a different layout to the other tracks and for sure we always try to optimise. As in most racing series, you try to optimise for the track and the downforce. Therefore, we did some calculations at home and saw that this rear wing is an advantage here, so that is why we brought it," says Andreas Roos, rallycross project leader at Audi Sport, who notes that the changes are possible due to the open nature of the World RX regulations. "You don't have to homologate the car, so the car only has to be in according to the regulations. If you could, you can bring a new car to every race basically. However, I think this is not the way it should be and also not the way we handle it at Audi because for us it's a works-support [to EKS] not a works entry from our side." RT

ABOVE Audi Sport has taken an active involvement in developing the new-look rear spoiler for the EKS World Rallycross Audi S1 Supercars

All photos: IndyCar

ABOVE Aero advantage: Juan-Pablo Montoya tests the 2018 superspeedway aero kit on his Chevrolet-engined Penske

Positive response to 2018 IndyCar aero testing

BELOW On course: The three pictures here clearly show the differences between the 2018 universal aero kits for Superspeedway and short oval/road/street courses. Compared to a current road course kit the 2018 version is also a much cleaner design with the removal of the various external aero aids

Andrew Charman

INDIANAPOLIS, IN: The universal aerodynamic kit to be introduced to the Verizon IndyCar Series in 2018 has successfully come through its first track testing. Drivers Oriol Servia and Juan Pablo Montoya undertook tests on three different track formats with the new aerodynamic kits mounted on their Honda and Chevrolet cars.

On 25 July the Superspeedway configuration was tested at the Indianapolis Motor Speedway, followed by a test of the variant for short ovals, road and street courses at the Mid Ohio Sports Car Course on 1 August. On 10 August the same kit was tested at the 0.894-mile Iowa Speedway. During each test both drivers tried a range of downforce settings as part of IndyCar's research programme to determine the most effective specification for when the kits make their race debut in 2018.

Officials reported that changing the settings on the new components varied the downforce levels generated from similar amounts to those recorded by the current manufacturer-specific kits, to around 20 per cent less.

"It's interesting how you can run the same lap time and in one downforce level you're completely flat out and the other one you are lifting off the accelerator in the turns," Montoya said following the Iowa test. "We're trying to understand what's the best way to bring the best racing."

The universal kit has been developed by Dallara, which also produces the DW12 chassis used in IndyCar, and a major aim has been to transfer much of the downforce generated to under the car rather than by means of various aero devices such as winglets mounted on the body. As well as producing a much more attractive, traditional exterior look to the car, this format should result in less disturbed air behind it, improving the opportunity for a following car to make a passing attempt.

ABOVE Right road: Drivers of both Chevrolet and Honda-powered cars with the new aero kits, here in road-course form at Mid Ohio, have reacted positively to the changes

Servia believed this aim was being met. "It was very consistent, especially if we end up going on the lower downforce package. You have to drive it, which is fun – you have to lift and you're still doing the same lap speed (as with more downforce), which is interesting.

"I was able to run a decent distance behind Juan Pablo, and the car just loses a little bit of grip. It's not like the front loses a lot of grip or the rear loses a lot, which is the problem with the current car."

Montoya reported that at the Iowa oval the new higher downforce settings produced around 7 mph difference between the corners and the straight. "The other one (new kit with less downforce) is like 20 mph difference, so you get to see acceleration out of the corners and I think it's going to create better racing."

IndyCar competition head Bill Pappas is pleased with progress on the 2018 aero kits. "We wanted to analyse the downforce level we've been running here the last couple years versus what we thought was a target lower downforce, and both drivers responded favourably to the lower downforce," he said at Iowa.

"Servia and Montoya thought they were able to drive the car a bit more, rather than hanging on, so that was very encouraging. As far as running in traffic, the car never felt like it was going to get away from them – to spin out or have any issues with stability. They were both very happy about that."

Observers predict that the intentional reduction of downforce will lead to significantly higher speeds in the series in 2018, increases that could reach close to 10 mph. As a result. the final 2018 test at Sebring in September will focus on the front brake ducts for road courses. IndyCar intends to adopt the current Chevrolet front duct as the standard fit from the 2018 season.

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ABOVE Learning lessons: BTCC personnel analyse accident-damaged shells

BTCC looks to learn from biggest crash in years

Andrew Charman

LONDON, UK: Representatives of leading motorsport bodies were invited to an inspection by the British Touring Car Championship of three cars involved in the most serious accident to occur in the series for many years.

Drivers Aaron Taylor-Smith, Jeff Smith and Luke Davenport were all hospitalised following the accident during the second free practice session at Croft on 10 June. Davenport was placed in a medically-induced coma for some days and while all three have since been released from hospital and Taylor-Smith returned to competition, neither Smith or Davenport will race again this season.

BTCC organiser TOCA invited representatives of the FIA's Global Institute safety body, UK motorsports governing body the MSA, series administrator the BARC, chassis component supplier RML, fuel cell supplier ATL, and TOCA's technical group and BTCC teams to the working group session.

The shells of the MG6, Honda Civic Type-R and Ford Focus involved in the crash were thoroughly inspected, and comprehensive logged vehicle data, onboard and external video footage analysed to recreate the angles of impact and how the damage to the cars was sustained.

Speaking to *Race Tech* after the session, BTCC technical director Peter Riches described it as very useful. "We did the tests because the FIA hasn't got that much information on such impacts in this type of car – much of their saloon research has been on rally cars which are built very differently with completely different side protection," Riches said.

"The tests showed us that we are doing things very well – had the accidents been in Super 2000 cars (used in the BTCC before the introduction of the current NGTC formula) I think the consequences would have been rather more serious. We've done things other series haven't, such as moving the drivers into the centres of their cars, that have proven their worth."

BTCC series director Alan Gow said that the session had aimed to benefit not just the BTCC but Touring Cars generally. "Safety is a constantly progressive subject and the primary purpose of this exercise was to both see what could be learned and if current safety requirements could be developed further," he said.

A consequence of the Croft incident has seen many teams adding extra strengthening to the side impact protection on their roll cages. Versions using two diagonal protection bars in the door have always had strengthening gussets included above and below the point where the two bars meet in the middle of the door. However, shell manufacturer Willy Poole told *Race Tech* that some teams are now adding additional gussets on either side of the meeting point. RT

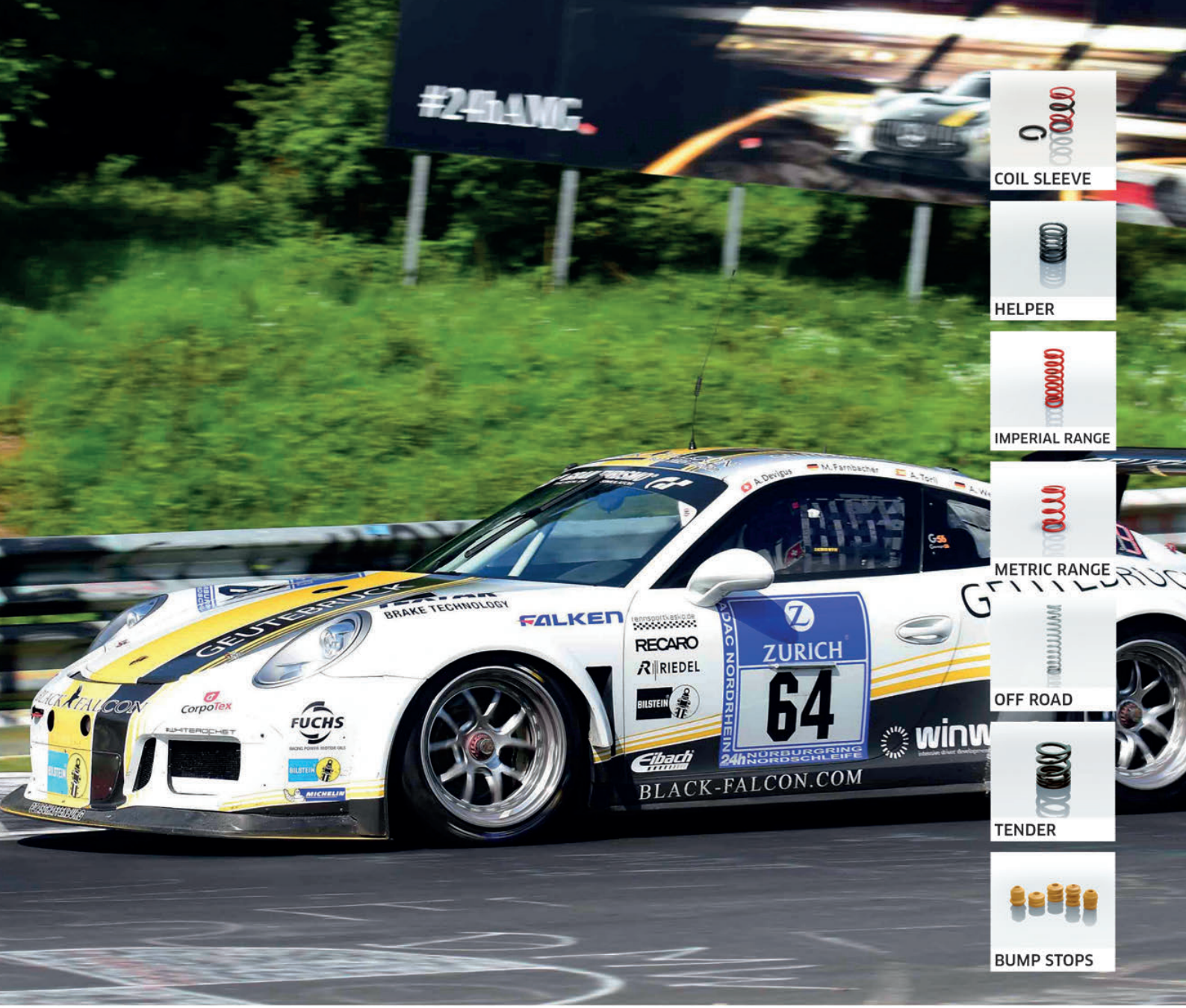

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Photo: DTM

ABOVE Falling numbers: BMW and Audi, seen here at the DTM's Moscow races on 23 July, could be fighting the future series on their own following the withdrawal of Mercedes-Benz

DTM moves to quell fears after Mercedes exit

Andrew Charman

WIESBADEN, GERMANY: DTM series organisers are trying to stem fears for the future of the category following the withdrawal of Mercedes Benz. The manufacturer, which provides a third of the 18 cars competing in the series, announced that it is to quit at the end of the 2018 season, in order to run a new programme in the FIA's all-electric Formula E series alongside its Formula One commitments.

Mercedes' major German road car rivals BMW and Audi, which both also compete in the DTM, have already announced Formula E programmes, with Audi withdrawing from the World Endurance Championship as a result.

In a statement DTM organisers the ITR said that the long notice given by Mercedes-Benz provides time to secure the future of the series.

"We have to respect the decision in a sporting and fair way. The DTM is one of the world's most significant Touring Car series. Mercedes has announced its withdrawal at the end of the 2018 season well in advance – that gives the ITR the time to analyse the situation and to prepare a sustainable concept for the future," the ITR stated.

Both Audi and BMW have expressed regret at the withdrawal of Mercedes-Benz, while adding that they were committed to the long-term future of the DTM. "Top international Touring Car racing is a very important component of our factory motorsport strategy," Audi posted on Twitter.

DTM chairman and former F1 driver Gerhard Berger has stated that he believes the series can survive with two manufacturers, pointing out that only Audi and Mercedes-Benz competed against each other between 2006 and 2011.

One potential solution could be the long-mooted switch of the DTM to Japanese Super GT regulations. This series uses 2.0-litre turbocharged engines and enjoys manufacturer support from Honda, Lexus and Nissan. RT

More teams, more cars in TCR

Andrew Charman

LONDON, UK: The head of the TCR UK Series, set to debut in 2018, has expressed continuing surprise at the level of interest in the category.

Jonathan Ashman told *Race Tech* that his "serious" list has now reached a potential 30 cars. A number of teams competing in the British Touring Car Championship have announced their intention to run TCR campaigns alongside their BTCC programmes.

Team Hard – which competes in the BTCC, British GT and the VW Cup, is set to campaign at least three TCR cars, and has entered into a partnership with Brisky Racing to administer all of its programmes.

"This will extend the combined operation to in excess of 50 cars and with an extensive infrastructure already in place, this will only strengthen each individual championship we compete in as well as all of the off-track activities," a statement from Team Hard said.

Leading Ford BTCC team Motorbase Performance is evaluating a TCR programme, as is Maximum Motorsport. Meanwhile two more potential TCR brands have been unveiled, involving BAIC Senova and MINI.

Chinese manufacturer BAIC Senova revealed its D50 model at the Chinese Touring Car Championship round at Shanghai on 6 August. Based on Saab hardware, the rights for which were acquired by BAIC, the car is only set to race in the TCR China series.

Reports also suggest that US team LAP Motorsports has gained support from MINI USA to build a version of the car for TCR. Which version of the MINI will be used is still to be decided, with not all models meeting the series' minimum length rules. RT

Hyundai Motorsport commits to WRC with driver programme

ABOVE Hyundai Motorsport is going through the process of selecting a winner from its driver development programme to compete in a New Generation i20 R5 in selected WRC2 events next year

ALZENAU, Germany: Hyundai Motorsport has reaffirmed its commitment to the FIA World Rally Championship (WRC) by announcing plans to support a potential WRC star. Run under the existing Hyundai Motorsport Driver development Programme (HMDP), the company is embarking on an intensive selection process.

From a pool of 16 candidates invited to Alzenau, who have already been identified, only a maximum of eight will be invited to remain onto the second stage of the process. Ultimately only one winner will represent Hyundai Motorsport on the global rally stage, participating in selected WRC2 events in 2018 in a New Generation i20 R5 car.

An initial pre-selection event took place in August with prospective hopefuls being assessed across a range of criteria. Covering technical understanding, English language, PR skills, and communication with mechanics and engineers, it is an all-encompassing activity with a group of the most well-rounded candidates going onto the next step.

The drivers, along with their respective co-drivers, will undertake tests on tarmac and gravel in September, before a final decision is made on the prize winner. Hyundai Motorsport will also nominate a team to run the programme on its behalf throughout 2018.

A dedicated panel of team management will be involved in the selection process, including team principal Michel Nandan, team manager Alain Penasse, customer racing manager Andrea Adamo and director of marketing and PR Stefan Ph Henrich.

"We have been developing our rally activities over the past few years with our successful WRC and customer racing activities," said Nandan. "The Hyundai Motorsport Driver development Programme is a further example of our commitment to rallying. We are excited to begin our search for a future WRC star. There is so much untapped talent; we want to help nurture the stars of tomorrow. We will put initial candidates through the ultimate assessment to identify the best on the market. The winning crew will be announced later in the year with a comprehensive itinerary planned for 2018. We look forward to starting the process of this exciting initiative." RT

IN BRIEF

AS the proposed introduction of the 'halo' cockpit protection device causes much controversy in Formula One, the Verizon IndyCar series intends to resume testing its aeroscreen variant after the end of the 2017 race season. A prototype version has been manufactured, designed alongside the 2018 universal aerodynamic kit, but no date has been set for the introduction of the aeroscreen.

GROWING speculation suggests that organisers of the FIA Formula E Championship are planning an electric Touring Car series to run as a support category. The new championship could debut as early as October 2017 as part of the 2017-18 Formula E season.

NASCAR experimented with same-day qualifying at its recent Monster Energy Cup rounds at Pocono and Watkins Glen. At the Glen race on 6 August drivers qualified just three hours before they raced.

THE co-owner of veteran NASCAR entrant Richard Petty Motorsports believes that the sport needs a spending limit. Such a cap, Andrew Murstein says, would create a level playing field and lead to better racing and more entertainment for spectators.

NASCAR is seeking to improve the driver development aspect of its second and third level Xfinity and Camping World Truck series. From 2018 drivers with more than five years' experience in the top level Monster Energy Cup series will only be permitted to race in seven Xfinity and five Truck events. While unable to score points, many Cup drivers routinely race in the two series, usually dominating the results.

SOURCES close to NASCAR insist that contrary to reports, Fiat Chrysler Automobiles has not abandoned plans to return the Dodge brand to the sport. A second, unnamed manufacturer is also said to be in the early stages of researching a NASCAR programme.

THE Irwindale Speedway in California is expected to close in January 2018 and to be replaced by a shopping mall. Opened in 1998, the track includes banked half and third-mile ovals and an eighth-mile drag strip. Its naming rights were owned by Toyota between 2008 and 2011 and it formerly hosted NASCAR K&N Pro and Whelen series events. RT

War of words over NASCAR 'sandbagging'

BROOKLYN, MI: A remarkable war of words broke out in the NASCAR Monster Energy Cup Series at Michigan on 13 August after leading Ford driver Brad Keselowski claimed Toyota entries in the series were 'sandbagging' in order to earn favourable equalisation changes before the 10 season-ending playoff races.

Speaking after taking pole position for the Michigan race, Keselowski claimed that the team had suspected that Toyota would "tone down" its performance to ensure perceived advantages were not dialled out by NASCAR in a post-event inspection process.

"Our team hasn't done much differently and those guys (Toyota) are just not as fast as they've been the last few weeks," Keselowski said, comments which produced an expletive-laden reply from leading Toyota driver Kyle Busch of Joe Gibbs Racing. Branding the Ford driver "a moron" Busch pointed out that his team had produced a new engine package for the Michigan race.

NASCAR put the whole episode in its place following the Michigan event. Series chief racing development officer Steve O'Donnell told SiriusXM radio that the whole concept of taking an example of each manufacturer's car to the sport's R&D Centre in Daytona to analyse their equality in performance was a rumour, put about by NASCAR to see the reaction.

"We actually found it kind of comical this weekend because we put a little bit of the rumour out there and candidly, it worked," O'Donnell said, adding that anyone bothering to research the subject would have discovered that the wind tunnel NASCAR uses is undergoing maintenance work at present, so a test would have been impossible.

"We feel comfortable with how we review the cars – we have a process in place but we're not going to telegraph when we would do that at a certain racetrack." RT

Sean Gardner/NASCAR

ABOVE Sour success: Brad Keselowski took pole position at Michigan, and then accused his Toyota rivals of deliberate sandbagging

Composite bodies coming to NASCAR Xfinity

Andrew Charman

TWIN LAKES, WI: NASCAR is beginning a move towards replacing steel car bodies in the second division Xfinity Series with composite versions. The move represents a major change for teams in the series – steel body panels are welded to the car's tubular chassis whereas composite versions are bolted onto flanges on the chassis, and are therefore much easier to remove and replace.

Teams will be permitted to use the composite body panels at the Richmond, Dover and Phoenix rounds of the 2017 Xfinity Series. The shells will be optional for all races in 2018 except at Superspeedways and are likely to quickly become the norm – 90 per cent of teams entered for the Richmond race on 8 September have already indicated they will run the composite items.

NASCAR's development programme for composite bodies has seen teams running them in the regional K&N Pro Series championships for the past two seasons. The Xfinity variants will be similar to those on K&N cars, but will include extra bracing.

Five Star RaceBodies, based in Twin Lakes, Wisconsin, has gained the contract to produce the bodies, though bonnets, upper nose sections and bumpers will still be supplied by the manufacturers racing in the series, Chevrolet, Ford and Toyota. NASCAR does not expect the use of composite panels to require any changes to the pre-race inspection process, though it will monitor any potential damage to panels from race use.

There has been no indication of any plans to progress towards using the composite panels in the top-level Cup series. RT

Chevrolet returns Camaro to NASCAR's top division

Andrew Charman

DETROIT, MI: Chevrolet will race the Camaro ZL1 in NASCAR's headline series, the Monster Energy Cup, from the 2018 season. The latest version of the Camaro body shape replaces the current Chevrolet SS, which has been raced since 2013 when NASCAR introduced its 'Gen-6' cars with bodies displaying much closer affinity to their road car inspiration.

Like the latest Toyota Camry introduced for the 2017 season, the new NASCAR Camaro boasts a much more aggressive, bolder front-end treatment. Development of the car involved computational fluid dynamics analysis and reduced-scale and full-scale wind-tunnel testing.

The ZL1 designation relates to the top performance version of the Camaro road car. Chevrolet has also raced the Camaro SS model in the second-division Xfinity Series since 2013. RT

Photos: Chevrolet

ABOVE Sister car: Pictured alongside its road car inspiration, the family resemblance of the 2018 NASCAR Chevrolet Camaro ZL1 is obvious

NASCAR stuck on treating tracks

Andrew Charman

LOUDON, NH: NASCAR is expected to widen its use of track surface treatments, after generally positive reactions to trials of the process. Races at the Charlotte, New Hampshire and Bristol Speedways this season have all been run after a custom formulated resin traction compound, PJ1 TrackBite, was laid in corners, with the aim of increasing grip for drivers and widening the amount of track or 'grooves' that would prove effective during the race.

While the compound received generally negative responses from drivers at Charlotte in May, opinions were much more positive at the New Hampshire race in July. Kyle Larson, who finished second in the New Hampshire race, was enthusiastic over the use of PJ1.

"In the past here, you ran the same line all race long, and today everybody I got around was running somewhat of a different line, and I thought that was a really cool thing," Larson said, adding; "Restarts were way more exciting… you could run three or four different lanes, and a lot of times I found myself in a three-wide situation – it was fun."

Bristol decided to use the treatment for a third successive time at its Monster Energy Cup race on 19 August. A meeting of the sport's Driver Council, held on 11 August just before the race at Michigan, discussed which further tracks on the schedule should also be treated.

Michigan did not treat its surface but did make use of the 'tire dragon' – effectively a trailer with four wheels designed to lay rubber in the racing 'groove'. Already employed during the 2017 season before both the Kentucky and New Hampshire races to 'rubber in' the surface and aid grip, use of this device is also expected to be widened. RT

RACE TECH

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Delighted to announce that Sauber F1 aero expert Willem Toet joins a fantastic line up

Willem Toet
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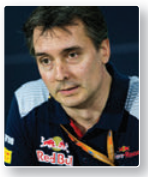

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BACK TO THE DRAWING BOARD

Can Mature Technologies make a Comeback?

Following the announcements by the French and British governments that they are going to ban the sale of new diesel and petrol cars and vans from 2040, what does it mean for the automotive industry and what does it mean for motorsport? What also does it mean to young engineers who are starting their career in the motorsport and automotive industries knowing that their future is unclear and clouded?

What about the racing itself? On the one hand the work of the engineer and the aerodynamicist is to make the car go as fast as possible while that of the regulator and promoter is to make sure that the racing is exciting - and that means close racing with a lot of overtaking. The two aims are not necessarily incompatible.

The blame for the lack of overtaking in Formula 1 in particular is often laid at the door of the aerodynamicists. They do their job so efficiently that it is detracting from the racing itself. Is this fair, though? After all they are only working to the rule book, one of which stipulates that you cannot have two cars in a wind tunnel. With 2021 coming up when things are changing, now is the time to discuss how aerodynamicists can play a positive role in making racing more exciting.

In these revolutionary times, motorsport needs to have a voice and that provided by the World Motorsport Symposium is becoming increasingly more authoritative due to its independence.

Join the debate and be part of that voice, so put **Thursday, 30th November and Friday, 1st December** in your diary and join us in Westminster at the Institution of Mechanical Engineers.



LEAP INTO THE UNKNOWN

Reigning World Rallycross Champion **Mattias Ekström** welcomes the inclusion of electric vehicles in the discipline – and reveals some hard-hitting views on the future of motorsport

I'VE said from the first day we started the EKS World Rallycross project that I wanted to have electric rallycross. I grew up as a kid with Scalextric and radio control cars and have seen the power you get from those electric motors. In real life I can see it will be so extreme and even greater to drive than the cars we have now. Today you always have a turbocharger, so you have turbo lag. With electric you have none of that.

People will say 'but there is no sound'. I agree there is no sound, but in all fairness I've done racing for 20 years and I'm not so sure I will be really sad that the sound is not so loud. You want a special sound, yes, but in modern life I think you're also pissing a lot more people off. You will lose some hardcore fans but you will piss less neighbours off because [currently] it's so loud.

For me, if the cars have the performance that it looks like they can, they will be faster than the cars we have today and people will very soon forget about all this anti-lag 'bang-bang-bang' and enjoy the cars themselves. I'm not sure that disturbing people with the sound is for the success of motorsport for the future.

With the Wi-Fi capabilities today, there is no magic anymore. Maybe each fan can decide which sound each car should have. I got a CD from Audi with all

EKS

ABOVE Hard at work in the EKS Audi S1 RX quattro

Jaanus Ree/Red Bull Content Pool

BELOW Glass half full: Ekström has raced across the globe for 20 years but welcomes the wake-up call electric motorsport offers

> *"My dream is to make the championship eight electric races and 10 [internal] combustion; you have to be a part of both to be the World Champion"*

the different sounds of their race cars on, and put it on the sound system at home. I pressed play and listened only to sounds. There you can see with different sounds you have different memories.

There are many ways with modern technology. I'm sure that nearly every single fan that comes to a race will have a phone. So in theory you could have an app where you can choose which sound each car would have for you, and put your headphones on.

You could have the track speaker [commentator] too, and you can listen to the radio traffic to the driver. I think you can make it even better than it is today.

I think that is where the excitement will come from in the future versus sitting with earplugs and 'Mickey Mouses' [ear defenders] to try and reduce the disturbing noise.

If you see how many people use Mickey Mouses to reduce the sound to a comfortable level, you should ask yourself if maybe it's too loud to be healthy.

If a World RX Supercar makes a launch and you are right behind, you don't really put your ear out and say that's enjoyable. If you have headphones on, you're like 'that's pretty nice.'

For sure someone will have the solution for it. I'm not worried about the sound because there are so many ways to solve it. I want to see electric cars be faster than today's because that will blow the mind of drivers or, if you do taxi rides, anyone. I can't wait to drive a fully electric Supercar with proper power for the first time.

The chassis we have now are way too good, so we need more power. The cars tend to be too easy to drive; we need to come back to where the cars are more difficult. Adding more power is one of the best tricks to make it difficult. The speed gets higher, acceleration gets higher, tyre wear is higher so everything else gets worse.

I can't see the future with the current amount of power because every horsepower counts so much in development. If you add another 150-200 horsepower, the percentage for the last five is not so important.

Electric cars need to be more powerful so not every horsepower at the top end is a major factor, because [if it is] then you get really boring sport in the end. The driver has to have a weapon in their hands which is really difficult to handle; then the sport becomes great.

I really hope that when they [FIA] make the rules, all the aids need to be forbidden. If you allow all the possible gimmicks – four motors, regen, traction control, ABS, active differentials – then the sport will die before it ▶

gets big, because this will help nothing. The cars need to produce entertainment and that is by not helping the drivers drive the cars.

I think Formula E is just going to explode with all the manufacturers going there because the world says electric cars are the future. I read some comments from Gerhard Berger who said, 'For me, Formula E is not motorsport'. I must admit when I saw Formula E cars driving a couple of years ago, I thought they were slow. That is what disturbs me – the cars look so slow. If I had an electric Supercar that laps two seconds quicker than an actual [internal combustion] Supercar, put Gerhard Berger in it, give him a lap and I will ask him, 'Is this motorsport or is this an outdoor car exhibition?' I will be very surprised after a lap in Holjes or in Barcelona if he will say, 'No, that felt like an outdoor car exhibition'.

It comes down to the cars; how fast they are and what people's perception is. I try to be enthusiastic about Formula E, but somehow I don't get it.

That's a sign that I'm old. Next year I'm turning 40 and I think when you are getting old you have an experience where you say, 'Mum, was everything better in the good old days?' Probably not, but at least when you hit

> *"I try to be enthusiastic about Formula E, but somehow I don't get it. That's a sign that I'm old!"*

or lift off the gas, you want to have a bit more respect for the car. It's [FE] great racing, but even rental kart racing is great. It's too little to be like a premium sport in my eyes. But, if they make a Formula E car with triple the power, straight away I would have more respect.

If I travel along the road in my Audi SQ7 and I see an electric Polo GTi, I don't say, 'Wow it's electric'. Then you see a Porsche GT2 RS, for example. Which car do I think is cool? You know, I'm old school; I don't fancy those slow electric vehicles versus a Porsche GT2 RS. Tesla has something they call 'Insane Mode' where you do 0-100 in three seconds. I never tried it, but now we are talking!

You need to do something that's cool, otherwise I will not buy it. I will not only say it's great just because it's electric – it has to have something more. Don't get me wrong, I don't say Formula E is shit, only that it doesn't attract me. The cars need to be faster so I get impressed by it.

There will always only be one World Rallycross Champion, so should that be with the electric cars or with the [current] Supercars? My dream is that if you would make the championship 18 weekends instead of 12, and you say eight are electric and 10 are [internal] combustion, you have to be a part of both to be the World Champion. You have to have a good electric car and you would need to have a good [internal] combustion engine car. For me, that would be the compromise for quite a while until the world has changed.

I read that in 2020 they want to separate it [ICE and EV rallycross]. I would say no, don't separate it, just do add-ons. So 12 World RX and then add six. Those six could be together with Formula E, and the 18 makes the World Champion. Now you're talking; something which I would say, "Wow, that's cool!"

If you're going to win as a manufacturer you have to grow some balls and make two competitive cars. They'll say, 'Oh, it's expensive'. Yeah, for sure it is, but you wanna tell the world something unique, there you have it. RT

ABOVE The Audi-backed EKS squad has helped elevate World RX to new heights. It currently holds both the drivers' and teams' titles

FIAWorldRallycross.com

ABOVE & BELOW RIGHT 2020 vision: By 2020 the likes of STARD's HIPER rallycross prototype (below right), which reaches 90 percent of its full torque in 0.034 seconds, could be unleashed on the same circuits on the same day as the World RX elite (above) to enable a comparison

THE COMPARISON WE'VE BEEN WAITING FOR?

Hal Ridge reports on the revelation that World RX is poised to showcase EV technology on the same bill as ICE rivals

To be factually correct, time only passes at a consistent rate, unless of course your name is Doc Brown and you travel in a modified DeLorean. But, as the saying goes: time flies. This year marks the 20th anniversary of Toyota's Prius Hybrid being released to the automotive market in Japan.

Owning a Prius – and, more recently, similar cars such as Nissan's fully-electric Leaf – has been as much of a status symbol for the rich and famous wanting to highlight their 'green' credentials, as it has a device for consumers desiring to get from A to B as efficiently as possible.

As Mattias Ekström quite correctly states in his column on page 20, vehicles that are not propelled by high-powered petrol engines are not generally considered 'cool'. But, as much as time flies, times also change, and motor racing is in the midst of a seismic shift away from the use of the traditional internal combustion engine.

The momentum of such a shift has increased significantly over the last 12 months. Volkswagen and Audi withdrew from major programmes in the World Rally Championship and World Endurance Championship respectively at the end of 2016, both citing a potential future in a possible electric rallycross venture. In July this year, Porsche, a brand synonymous with endurance racing, jumped ship from WEC to Formula E. Within a week, fellow German firm Mercedes also announced a move from the DTM to Formula E. BMW has also pledged works support to the series from late 2018.

July was a critical month for the long-term future of internal combustion. The UK government followed France in announcing a ban on new petrol and diesel cars from 2040.

With motor racing largely a marketing tool for manufacturers to ultimately sell more products, the switch to Formula E is unsurprising. However, for many, while both

> *"We have the perfect sport for electric motorsport"*

advanced and positive in the development of new technologies and increasing awareness of the use of alternative energies in motorsport, Formula E doesn't yet wow the masses with its appeal.

About to enter its fourth term, the single-seater series doesn't allow for direct comparisons to be drawn between its machines and more conventional racing cars, competing on bespoke street-based circuits in standalone events. Even in the confines of Monaco, the electric racers have used a different, shorter version of the historic course.

ABOVE The Andros Trophy series plans to include its electric cars in the main category

QUEST TO BE COOL

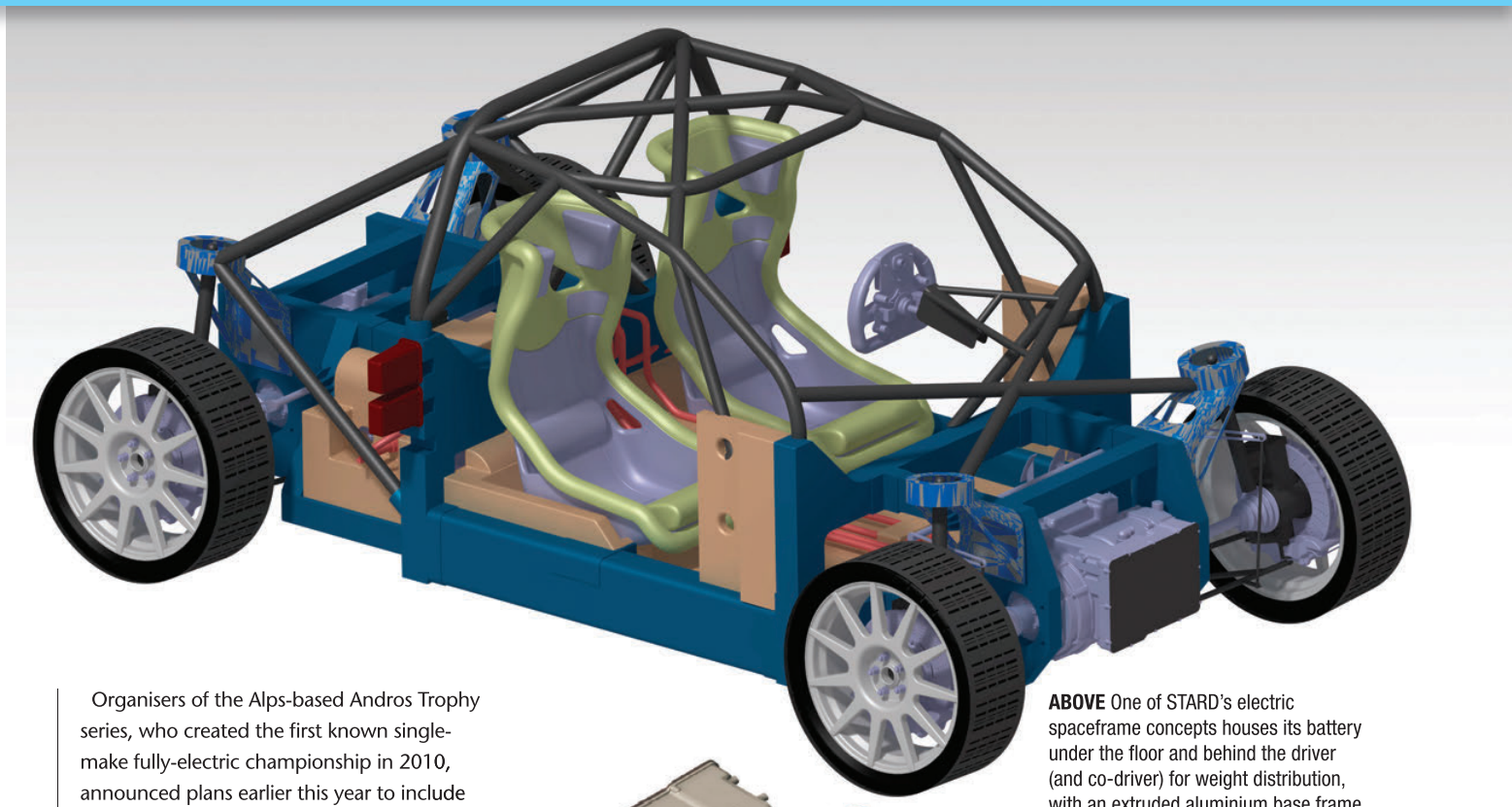
To really gauge how good electric technology can be, not only in motor racing but in the potential replacement of burning fossil fuels to power our motor cars on the road, direct comparisons need to be made. Furthermore, if manufacturers are going to reach the kind of sales figures they desire, electric cars need to be made 'cool'.

The growing World Rallycross Championship might just have the answer. Another week on from the shock announcements by Porsche and Mercedes, World Rallycross promotor IMG revealed that it is working together with a number of manufacturers and the FIA on introducing electric technology into World RX. According to World RX managing director Paul Bellamy, discussions are at an early stage, but the concept could be introduced as soon as 2020.

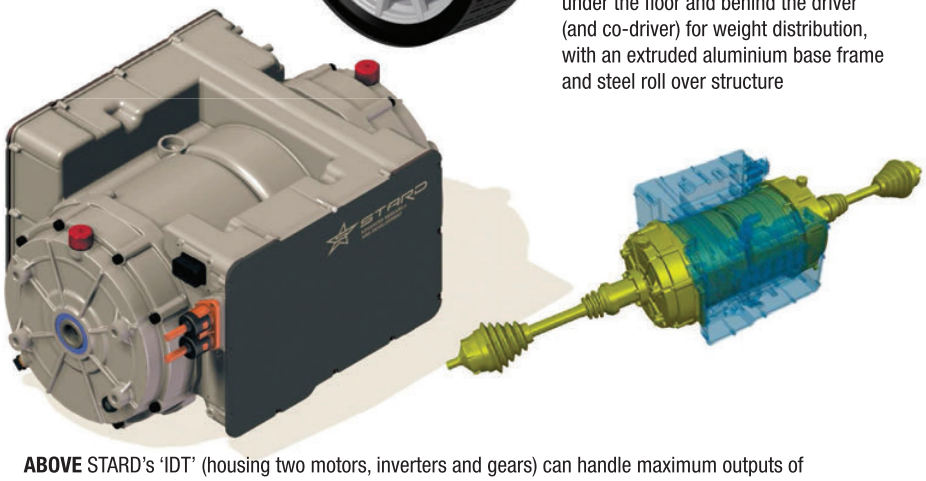
Although the cars won't initially be allowed to run together in the same races, by competing in the same events, on the same circuits, direct comparisons will be inevitable, depending of course on the similarity of the technical regulations: the number of driven wheels, total power output etc.

Austrian firm STARD's HIPER rallycross prototype (featured in RT193) already delivers impressive figures, with performance to rival that of a current World RX Supercar: the 1250 kg, two-motor, four-wheel drive car produces the equivalent of 544 horsepower and 760 Nm torque, crucially reaching 90 percent of its full torque in 0.034 seconds. Manfred Stohl's firm is also working on more advanced concepts too (see sidebar).

IMG has stated its intention to maintain the existing World RX Supercar category for the foreseeable future. However, at World Championship level at least, it's not inconceivable that electric technology could take over. If the EVs quite obviously out-perform their internal combustion ancestors in the same environment, that shift may be organic. ▶



ABOVE One of STARD's electric spaceframe concepts houses its battery under the floor and behind the driver (and co-driver) for weight distribution, with an extruded aluminium base frame and steel roll over structure



ABOVE STARD's 'IDT' (housing two motors, inverters and gears) can handle maximum outputs of 180 kW (power) and 2600 Nm (torque) in rally trim, but this is increased for rallycross requirements

Organisers of the Alps-based Andros Trophy series, who created the first known single-make fully-electric championship in 2010, announced plans earlier this year to include its electric cars in the main category – which uses V6 mid-mounted engine, four-wheel drive, four-wheel steer silhouette cars. But pending a surprise development, as the series' electric cars are some way off in performance, the playing field wouldn't be level enough to make direct comparisons.

Manufacturers have been increasingly enticed by rallycross' young demographic and quick-fire action broadcast in compact television programmes since the formation of World RX in 2014. But, for how much longer can the likes of Peugeot, Ford and Audi advertise the burning of fossil fuels in the anti-lag induced popping and banging fury of current day turbocharged rallycross machines?

COULD YOU SEE YOURSELF IN THIS CAR?

Electric motor racing is coming, of that there is no doubt. It also seems clear that with its short duration of races, jumps and door-to-door action, rallycross offers manufacturers the ideal medium through which to promote cars that consumers can visualise driving on the road. After all, while Formula E is clearly advancing its technology each year (in season five one car will be used by each driver for an entire race) its single-seaters look little like a consumer's road car.

On its withdrawal from WEC last year, Audi (which backs Ekström's EKS team in World RX) was one of the first marques to suggest that it was interested in an electric rallycross future. "We are very interested in electric rallycross and for sure it's a target for us where we want ▶

STARD's pioneering work

THE STARD R&D operation has been developing a number of new concepts in recent years. With regulations yet to be determined for an FIA-sanctioned rallycross series, the team's work has pre-empted a number of possible directions in which the sport might move.

STARD's developments include a fully-spaceframe electric rally and rallycross chassis, a four-motor setup drivetrain and a fully-integrated drivetrain.

"Since we initialised 'HIPER MKI' and collected experience with it, we have worked on multiple concepts ranging from one motor to four motors with a completely sequential torque distribution for each wheel," says STARD CEO Michael Sakowicz. "We've also developed our own compact drivetrain package, integrating all axle-related components (two motors, two inverters and two planetary gears) in one, minimising space, weight and complexity (with only one DC HV interface, one COM interface and one cooling interface which also cools the gears).

"We have had automotive applications in mind from the beginning of the project. The IDT is applicable for both passenger road cars and racing utilisation – we have a big focus on EV systems for both high-performance and racing applications."

With each motor in the IDT driving its own wheel, full torque vectoring is achievable.

to be and which direction it has to go for the manufacturers," confirms Andreas Roos, Audi Sport's rallycross project leader. "I think you can't do it so that it's [electric regulations] completely open from the beginning.

"Maybe a concept similar to what Formula E did at the beginning, with quite a lot of common parts, and then see how it develops and maybe give more free areas where you can develop. But from the beginning it would not be good to really open with everything because then the costs will also be too high and this must be the key, that the costs stay on a decent level."

Roos insists that backing the EKS squad with works-support is Audi Sport's number one target in 2017, but doesn't deny that Audi is also involved to gain knowledge about rallycross for any future projects. Asked if he expects the German firm to be involved in FIA-sanctioned electric rallycross from the start, the former DTM and WEC engineer says: "For sure we are very interested and we are looking deep into it. At the moment I can't say that we will do it or not, but we will have a closer look at it."

There are those who are of course deterred by change, the lack of noise from an EV car being a recurring theme. Ekström lists his own ideas to deal with that issue in his column, but there are also unlikely candidates who are behind an electric movement, if it's for the benefit of the sport.

> *"Maybe a concept similar to Formula E: a lot of common parts at the beginning, then more free areas where you can develop"*

"IT COULD BE HUGE"

Kenneth Hansen is the most successful driver in rallycross history, with 14 European crowns to his name. Today, he heads up the works-backed Team Peugeot-Hansen squad in World RX and won the teams' title in 2015. As one of the longest standing members of the paddock, Hansen is refreshingly open to the prospect of change.

"As the world moves on with electric road cars, it needs to come. I don't think it will change Supercar, but we need to be open and let it (EV) in," says Hansen. "If it has the manufacturer interest that we see in Formula E, then it can be huge and help the sport to keep a high level.

"When something arrives, when there are new regulations, like when we got the turbo restrictor, it's always, 'Oh, we don't need that'. There are always people against new things but over the years I have learned that you can't stop development. Rallycross is not the same as it was when I was in the car, but I don't think we need to be afraid. I have tried electric road cars and it's amazing what you could do with that. Imagine four electric motors, you wouldn't need differentials anymore for instance. I think it's very interesting; I'm really open to it."

Forming regulations will be one of the time-consuming factors in implementing electric rallycross, where concerns over safety are no doubt high. Of course, safety is paramount, and *The Grand Tour* presenter Richard ▶

EKS

ABOVE Audi, which backs reigning champion Mattias Ekström, is one of the heavy-hitters keen to have an electric rallycross showcase

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Hammond's high-profile accident where he crashed the Rimac Concept One electric Supercar on the Swiss Hemburg Hill Climb in June did nothing to dispel those fears. But, it's worth remembering that a conventional racing car to an outsider may appear nothing more than a bomb waiting to explode. After all, most ICE vehicles have a unit that creates fire (engine) mounted in the front, fed by flammable liquid via a series of lines that pass the driver inside the car from a tank containing a mass of that liquid in the rear.

Safety can't be disregarded, far from it, but basing safety rules on the platform already created by Formula E could be a solid start for rallycross' regulations.

Gymkhana, rally and rallycross star Ken Block is another member of the World RX fraternity who, albeit begrudgingly, accepts that the introduction of electric technology is both interesting, and inevitable.

"I kind of have a love-hate relationship with the idea. I love the idea of new technology and development of things and I love seeing it in consumer cars. But unfortunately, I love the sound of rallycross cars, I think that's something that will be really missed once the combustion engine completely goes away at some point," says Block, whose motorsport career has been built on the success of his Gymkhana videos, where he has 'hooned' (drifted and donuted) various extreme high-powered cars for YouTube videos viewed by millions.

> *"Electric cars can also be cool"*

"I've thought for a long time about how can I make a Gymkhana car using electric motors and I think that would be a really fun challenge to develop something like that. But, at the same time, my favourite Gymkhana car is the Hoonicorn (a 6.7-litre twin-turbo, four-wheel drive, 1,400 horsepower Ford Mustang) which is the loudest, most obnoxious of my Gymkhana cars.

"I think in general the world has realised that global warming is happening and we've got to do something about it, and unfortunately the combustion engine and everything that goes with it is probably going to go away for the good of our children. At least we got to live through the height of that era of motorsport engines; from the 12-cylinder F1 engines to these really high horsepower two-litre, four-cylinder turbocharged engines, it's just a cool time to be alive and hearing these kind of noises."

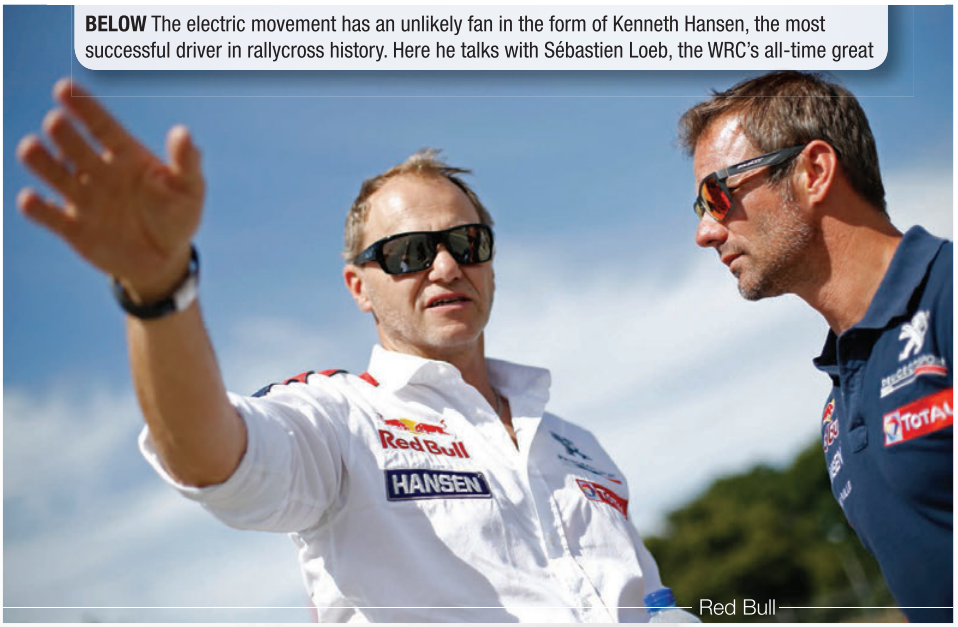
America will likely be one of the hardest markets to break into for new technologies, in both motor racing and the consumer markets, due to a culture of large capacity gasoline-guzzling machines and the seeming lack of desire for change.

But, while more fully-electric motor racing than just Formula E is looming large, things should not be rushed either. It's far better for things to be done right than too soon. While electric propulsion is the talk of the motorsport town, the process of producing mains electricity isn't as environmentally friendly as some may claim. In the future, the potential for further alternatives exists. Those that don't jump to use electric cars in the next decade may skip the concept altogether.

"We have the perfect sport for electric

motorsport, but it needs to be done in the right way," says Andreas Eriksson, owner of the OlsbergsMSE team that has won titles in World RX and the GRC. "I'm a firm believer that it will come and stay, but I think the two (EV and ICE) should be split for a while. Every new technology should be in motorsport as we are only here for one reason. Today rallycross sells cars because of the image, and electric cars can also be cool."

BELOW The electric movement has an unlikely fan in the form of Kenneth Hansen, the most successful driver in rallycross history. Here he talks with Sébastien Loeb, the WRC's all-time great



Red Bull

RUN ON WATER

Eriksson is open to other propulsion methods too. "What is the future? Is it electric, hybrid or what?" he asks. "I think we can drive cars on water. I mean, we drive on ethanol which is basically distilled water – there's many things you can drive a car on. Is electricity the only thing? No, I don't think so. Is it one way? Yes. I think we could have more classes on many different levels. Just five years ago in America, the V6 and V8 was a big thing. Now Volvo is selling SUVs with four-cylinder turbo engines. We're getting somewhere. Rome wasn't built in a day."

Series like DTM and WEC's loss could be rallycross' gain in the quest to become electrified and attract manufacturer entries. But, even if electric rallycross takes over at the highest echelons of the sport in the coming decade, that doesn't mean the whole structure will change immediately, especially for privateer teams. There will still be options to race more conventional rallycross machinery at both national and international level.

As an esteemed member of the World RX paddock said recently: "The horse got replaced by the car, but horse racing today is huge, so why can't we have both petrol and electric in the future?" RT

BELOW America might be a hard market to crack for EV motorsport, but the Red Bull Global Rallycross series has registered its intent to have an electric support category for 2018

Red Bull

Photos: Porsche

FORMULA E DREAM IS WEC NIGHTMARE

Gary Watkins examines Porsche's defection from the World Endurance Championship to Formula E, a move likely to send shockwaves through both series

EVERYONE knew it was coming, but it was a bombshell nonetheless. Porsche's decision to withdraw from LMP1 at the end of this season and head for Formula E has blown the future of the World Endurance Championship wide open at the same time as cementing the FIA's electric-vehicle series as *the* place for the world's major motor manufacturers to race.

Porsche's departure gives the WEC a problem, the one that everyone feared after Audi's decision last October to quit the prototype scene after 18 years of continuous representation at the Le Mans 24 Hours. The WEC was left with two manufacturers at the front of the grid after the winner of the French enduro in 13 of those 18 seasons departed – and that left the series vulnerable. The nightmare scenario for the WEC and its promoter, Le Mans organiser the Automobile Club de l'Ouest, has come to pass with the withdrawal of Porsche.

The decision of the Porsche board to join the FE grid at the start of season six in 2019 doesn't just leave the WEC with a single P1 factory team in Toyota. It raises question marks about the new rule book for 2020 that Porsche helped formulate. If a manufacturer that played a central role in devising regulations that include zero-emissions running decided that FE is the better option, then what hope is there that a newcomer will decide to take the plunge?

There is clearly a feeling of unease in the offices of the ACO and the WEC organisation. The WEC didn't pull its punches in its official reaction to Porsche's news. It described Porsche's move as "precipitous" and stated that it regretted the abruptness of the decision by a manufacturer that had made a public commitment to LMP1 and the WEC up until the end of 2018 two years ago.

The anger felt in Le Mans and Paris is easy to understand. Porsche had just played a major part in devising the broad tenets of the 2020 rules and most pertinently the regulation that will demand that the cars complete one kilometre on electric power after every refuelling stop, which will go hand in hand with the introduction of rapid plug-in charging. These were intended to freshen up the P1 rulebook and to give the class a new relevance in the changing landscape of the automotive world.

Everyone around the table clearly had an eye on FE and the threat posed by the electric-vehicle series. Don't forget that Audi will be racing in FE as a manufacturer from the start of season four at the end of this year, though it had already announced that it would be firming up its commitment with the Abt team before its departure from the WEC.

It is incorrect to say that Audi left the WEC for FE, but the emergence of FE as a threat to the WEC was obvious. Those involved in devising the new rules believed that they had to come up with something truly relevant to the automotive industry. The new ▶

ABOVE & INSET The lure of an electric racing series ultimately proved too big to resist for a manufacturer that had announced it would roll out a range of all-electric vehicles based on its Mission E concept

"WEC allows a manufacturer to showcase the technology of today; FE gives it the opportunity to shout about the technical solutions of the future"

ABOVE Porsche helped frame the future regulations for the World Endurance Championship, in which its 919 Hybrid set the benchmark for rivals, only to cut and run to Formula E

Audi

ABOVE Audi's progression from toe-in-the-water exercise to full factory assault is indicative of Formula E's unstoppable momentum right now

rules, they believe, will produce the fastest electric racing cars in the world, albeit over a solitary kilometre.

"We want to showcase a high level of electric performance," says Toyota Motorsport GmbH technical director Pascal Vasselon, before adding mischievously, "because there are some series in the world that race quite slowly on electric power."

That wasn't enough to persuade Porsche to stay. Not the racing bosses in Weissach, but the board members at company HQ in Zuffenhausen. And they are the ones with the final say.

The WEC allows a manufacturer to showcase the technology of today, and will continue to do so in 2020. FE gives it the opportunity to shout about the technical solutions it will be using in the future. That was a compelling argument for a manufacturer that announced earlier this year that it would be rolling out the first of a range of all-electric vehicles based on its Mission E concept of 2015 before the end of the decade. FE became the obvious choice for its primary racing programme once that decision had been made.

FE MOMENTUM

Formula E, with a queue of manufacturers lining up to step over the threshold, has a seemingly unstoppable momentum right now. Most pertinently, FE has attracted four major brands from the European powerhouse of the automotive industry in Germany. BMW, Audi, Mercedes and Porsche will all be on the grid in 2019/20, the year after the practice of drivers swapping between cars is abandoned. Ferrari has even hinted that it could one day join the series.

It is a situation that series boss Alejandro Agag never imagined in his wildest dreams when he was trying to sell the championship to investors, teams and car makers in the lead-up to season one in 2014/15.

"I remember going around with a Power Point presentation making this prediction of the involvement of three OEMs [original equipment manufacturers] in season five," recalls Agag. "It was there in my presentation, and I thought I was being optimistic. But we have wildly exceeded our expectations."

FE has captured the automotive zeitgeist of its age. Electrification is the new buzzword in the industry, as more and more manufacturers signal their intent to move into the EV market. The automotive landscape has changed since the Formula E Holdings organisation created by Agag was awarded the contract to promote the EV series in August 2012.

"The industry has changed and the technology revolution happening in electric vehicles has moved in our direction," he says. "More and more manufacturers are betting on electric vehicles. That has put us in a unique position as the world's only EV championship."

The growth in Audi's involvement illustrates Agag's point. The German manufacturer slipped its foot in the door at the start of the championship by allowing the Abt team, a partner in DTM touring cars, to use its name. It subsequently handed over the hybrid powerplant from its 2014-spec R18 e-tron quattro LMP1 contender to Abt's technical partner and sponsor, Schaeffler, to develop into a FE ▶

Audi

powertrain for season two in 2015/16. And then last year, the German manufacturer announced that its relationship with Abt would turn into a full factory engagement in season four.

"It is not by chance that FE has such momentum because electric mobility is becoming more and more important," said former Audi Sport boss Wolfgang Ullrich between the announcement of its FE entry and its WEC withdrawal. "It is important to be part of the world's only EV series and entering in season four fits in well with our road car strategy."

WHAT CAN THE WEC DO?

Some are suggesting that Porsche's decision sounds the death knell for LMP1 as a technological proving ground for the manufacturers. But is that right? The German marque hasn't departed the top-flight of international sportscar racing because it no longer wants to promote a message. To the contrary. It just happens that the message P1, Le Mans and the WEC were offering is not as attractive as the one presented by FE to a manufacturer that has just announced a commitment to electric road cars.

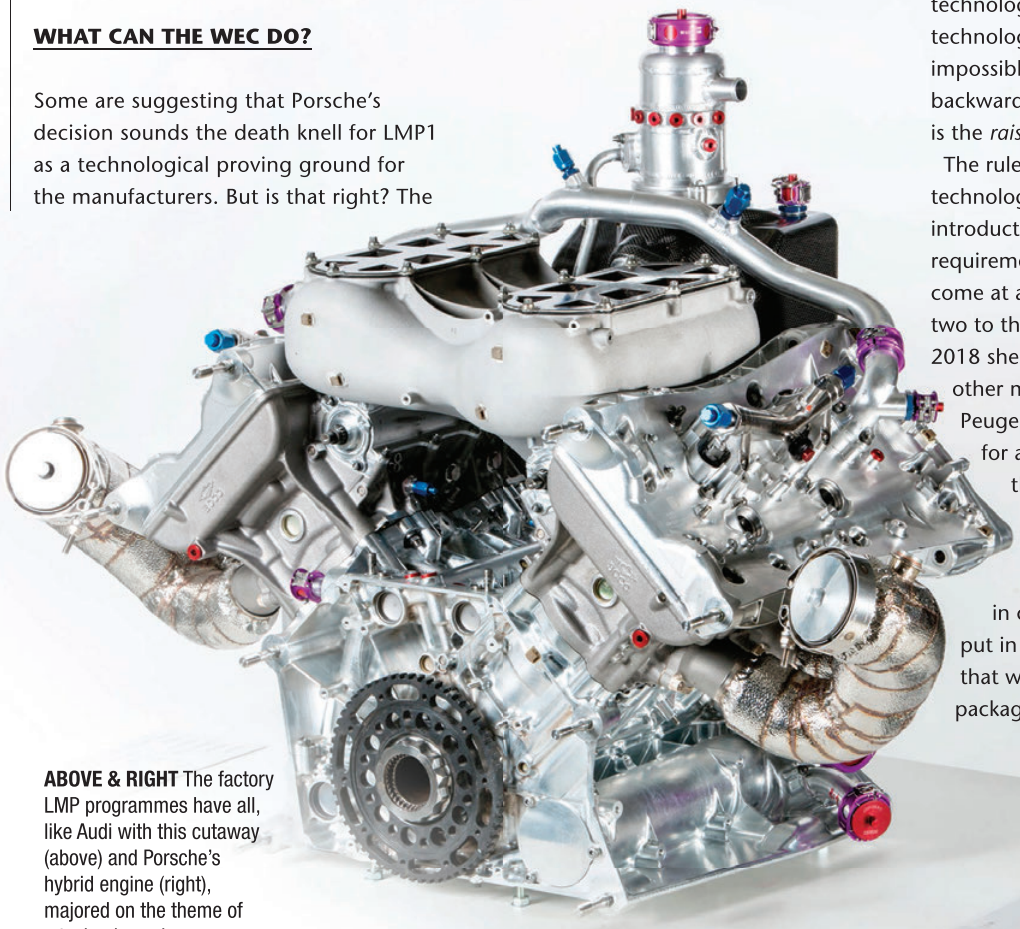
Manufacturers need something to shout about when they go racing. Look at every LMP1 factory programme since the middle of the last decade, Aston Martin excepted. They have all been about technology. Even Nissan, in a roundabout way, was attempting to trumpet its technological prowess with the front-engined GT-R NISMO LM. It was shouting 'We're an off-the-wall car maker that dares to be different' with that ultimately unsuccessful project.

"Everyone wants to save costs, but not at the expense of emptying the technological tank," says Vasselon. "We don't want a super-Daytona Prototype international, because then we would stop.

"The main reason for Toyota to participate in the WEC is to develop technology and specifically hybrid technology, so it would be nearly impossible for Toyota to accept a step backwards. Developing hybrid technology is the *raison d'être* of the programme."

The rulemakers have added to the technological scope of LMP1 with the introduction of the zero-emissions requirement, though it will almost certainly come at a lower cost than the step up from two to three energy-retrieval systems for 2018 shelved after Audi's withdrawal. The other manufacturer around the table, Peugeot, appears to have been lobbying for a reduction in the technology in the name of cost.

What exactly Peugeot wanted isn't clear, except that it was looking for a major reduction in costs, one far greater than that put in place by the raft of measures that were also part of the 2020 rules package outlined during Le Mans week ▶



Porsche

ABOVE & RIGHT The factory LMP programmes have all, like Audi with this cutaway (above) and Porsche's hybrid engine (right), majored on the theme of a technology showcase

in the summer. A spec battery and the idea of lighter cars with only one hybrid system appear to have been on its agenda.

Peugeot Sport boss Bruno Famin, speaking earlier in the season, denied that the French manufacturer was insisting on anything. "We are not saying that if the rules are not like this, we are not coming," he said. "But the fact is that if the cost of entry is not cut, then we are not coming."

Famin was insistent, however, that Peugeot wasn't against hybrids. "We need hybrid cars, for sure," he said.

NOTHING NEW UNDER THE SUN

It is easy to forget, as a classic era of sportscar racing draws to an apparent close, that manufacturer participation at Le Mans has traditionally been cyclical. That classic period arguably began when Peugeot joined Audi in LMP1 in 2007 and continued through the rebirth of the WEC in 2012 with the arrival of Toyota and then Porsche. Even more easy to forget is the fact that there were two years in the mid-2000s when there were no manufacturers battling for outright honours in the 24 Hours in the days before the rebirth of the WEC.

Audi might have triumphed at Le Mans in 2004 and '05, but it did so after the end of its factory programme. The German manufacturer perhaps got lucky at a time when it was heavily supporting well-funded privateer operations, with the backing of local importers, in Team Goh and Champion Racing. The absence of manufacturers made their job easier, as did the fact that Audi had come up with such a good car in the R8 in the first place, one whose lifespan went far beyond that envisaged when it first raced at the 2000 Sebring 12 Hours.

The ACO knows the importance of the privateers from the long and chequered history of the 24 Hours. Which is why rules stability and a package of performance breaks were put in place for the current season with a view to drawing in more independent teams. It seems to be working. Russian entrant SMP Racing and its BR Engineering off-shoot and Ginetta Cars have on-going projects aimed at next season. British start-up Perrinn Limited also announced its intention to join the grid with an undisclosed partner, though its plans have subsequently fallen over. It is believed there are more projects in the offing, however.

But Le Mans and the WEC need manufacturers. They are required to give the race and the series the halo that cannot be provided by factory entries racing down the order in GTE Pro. They have also been essential from a financial standpoint. The marketing spend of the LMP1 manufacturers around Le Mans in particular over the past 10 years will be difficult to replace.

Toyota is keeping its powder dry about its future plans right now. Its post-announcement statement made no mention of 2018. The Japanese manufacturer does have a firm commitment to P1 for next year and has always stressed ▶

ABOVE It's easy to forget that Audi's Le Mans successes of 2004 (seen here) and 2005 were actually achieved with privateers

Audi

Red Bull

ABOVE The new breed of LMP2 has impressed, nearly winning this year's Le Mans 24 Hours, but the WEC's flagship event needs manufacturers

that there is no end-date to its participation in the class. But Vasselon concedes that the commitment was made on the basis that it would have factory opposition.

Speaking at the Nürburgring WEC round in July, as the rumours about Porsche's departure were growing, he said that the manufacturer's future strategy might need to be re-evaluated if "the conditions change".

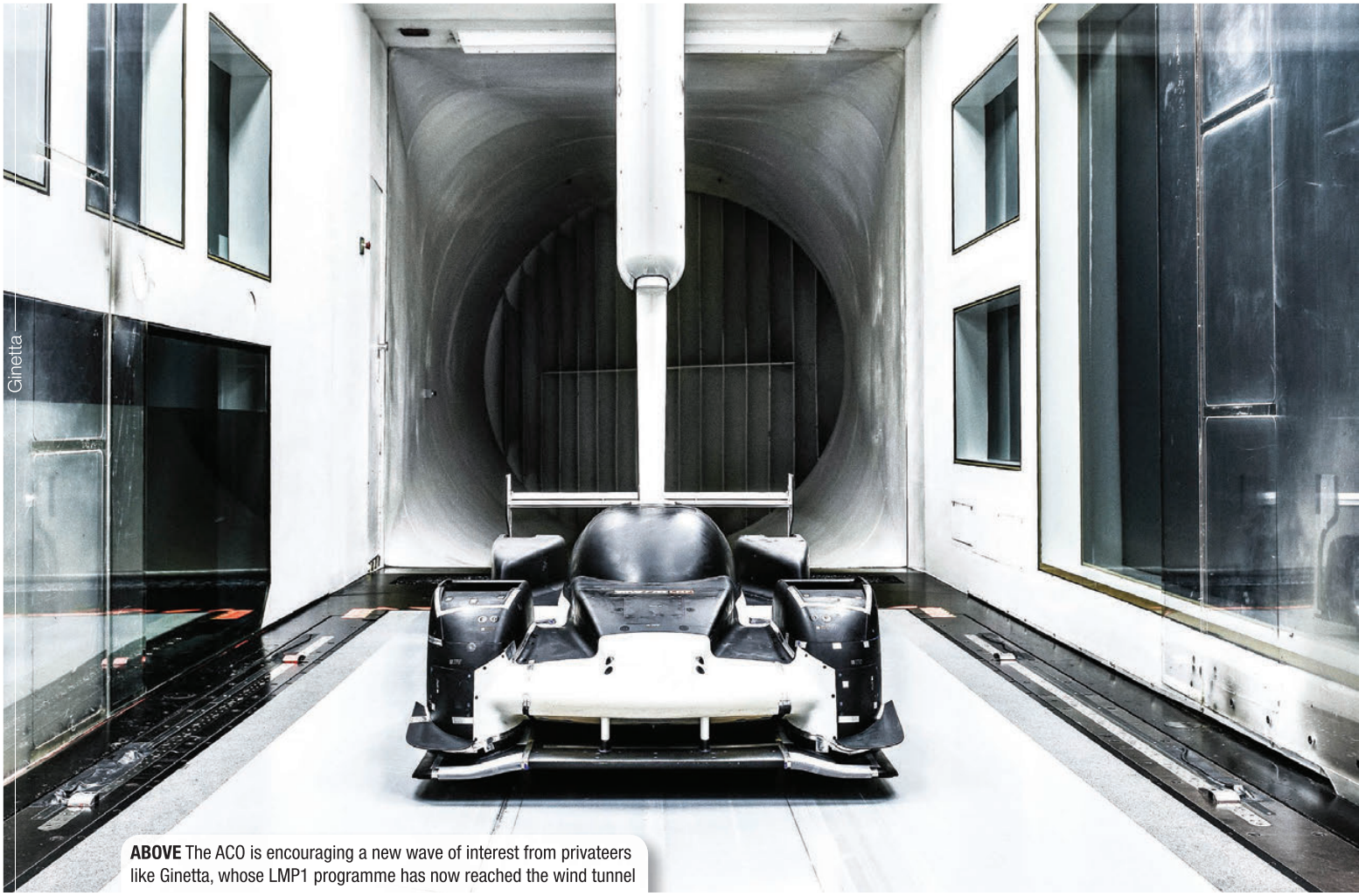
Toyota's LMP1 programme is very much about research and development. There has never been the same marketing push - or spend – of Porsche or Audi. But Vasselon still insists that competition is required.

"Yes we can develop technology, but you know where you are when you have competitors," he says. "It makes sense to continue for this reason and also the reason that we expect others to probably arrive."

But will they arrive? The FIA, the ACO and the WEC need multiple commitments – two would probably suffice – for 2020 to push ahead with the new rule book. They can't continue on their current course in the hope that someone will eventually turn up.

Could the new breed of super-fast LMP2 machinery become the top class? Probably not, because as already stated, P1 needs manufacturers. Could the Daytona Prototype international category introduced this season in the IMSA SportsCar Championship provide the basis of a new top prototype category? It might draw manufacturers from North America, but probably wouldn't fit with the needs of the WEC. Could manufacturers be persuaded to fund a world programme with machinery that doesn't give them that all-important technological message?

There are many questions outstanding. It was doubtful that the big ones would be answered when the WEC reconvened in Mexico for its five-race flyaway leg at the start of September, even though the WEC was promising to reveal more news about the future. ▶


Ginetta

ABOVE The ACO is encouraging a new wave of interest from privateers like Ginetta, whose LMP1 programme has now reached the wind tunnel

FIA/Formula E

ABOVE Formula E could control a potential arms race by using the rule that a manufacturer must make its powertrain available should an independent come knocking. Techeetah is currently supplied by Renault e.dams under this arrangement

CAN FE LEARN LESSONS?

Budgets remain modest in FE for the moment. The big spenders, Renault with e.dams and Jaguar, are probably spending in the region of €20 million and the better-funded independents perhaps €12 million. Even the upper budget is the faction of what a manufacturer would have to spend for a 2020 WEC P1 programme.

That is clearly going to increase as the technology ramps with 'one-car' races and the arrival of the heavy-hitting German marques. Remember that Audi, which has been increasing its involvement in the Abt team since season two, doesn't officially enter FE as a manufacturer until the start of season four later this year, one year before the arrival of BMW with the Andretti team.

Mercedes and Porsche will become the 11th and 12th teams on the grid, taking the slots that have become available with the end of the need to ship 40 cars around the world. Merc had originally been given first call on one of the additional entries for year five, but delayed its entry

Porsche

ABOVE The lure of Formula E has ripped the heart out of a WEC grid that relied heavily on the marketing clout of Porsche and Audi

FIA/Formula E

ABOVE Oliver Blume (chairman of Porsche AG's executive board), Formula E founder Alejandro Agag and Michael Steiner (member of Porsche's executive board for research and development) shake on the deal that will see the German giant enter FE

> *"My presentation predicted the involvement of three OEMs in season five. I thought I was being optimistic"*
>
> *FE founder Alejandro Agag*

because it will not be leaving the DTM until the end of 2018.

There is said to be pressure already from at least one German manufacturer to increase the scope of technology for season seven in 2020/21. Front motors to make the next-generation of FE racer four-wheel drive appear to have been proposed.

PREVENTING AN ARMS RACE

That might be one way forward, but Agag in particular is adamant that anything that doesn't drive forward road-car technology should not be allowed. He is against abandoning the single-make chassis and the spec battery on which the series has been based since its inception.

The second-generation Spark Racing Technology chassis, like its predecessor developed in conjunction with Dallara in Italy, is envisaged as a four-year car. The FE technological road map gives the new McLaren Applied Technologies battery to be introduced in season five the same lifespan.

Agag believes he can keep a cap on costs with a rule that demands that a manufacturer must make its powertrain available should an independent team come asking, and for what is understood to be a peppercorn rent. This arrangement – which Techeetah exploits with Renault – is believed to come at a cost not far north of €100,000 a season.

The key for Agag will be resisting the political pressures that come with the involvement of multiple manufacturers. Only then does Formula E have a chance to avoid the boom-bust cycle to which sportscar racing has been so prone.

TURNING THE MOTORSPORT WORLD UPSIDE DOWN

Craig Scarborough examines the appeal of Formula E and asks: what, beyond the marketing message, will the new manufacturers learn from it?

As the third season of FIA Formula E drew to a close at the Montreal double-header finale, the biggest story wasn't the success of Lucas di Grassi and Renault winning the drivers' and constructors' championships respectively, but the very future of motorsport.

In the week of the final ePrix, Audi, Mercedes and Porsche all confirmed their participation in the championship's fifth season. With BMW also affirming its commitment to the category, this means there will be no fewer than 10 of the 12 entries supported by EV manufacturers, seven of them Tier 1 OEMs rather than EV specialists.

So why are the manufacturers heading towards such an unconventional series and away from mature, well-supported categories (DTM and WEC) in such numbers?

WHAT'S THE APPEAL?

Formula E got off the ground in 2014, as a pioneering all-electric single-seater category. Not just different with its electric powertrain, but also with the marketing and the format of the race schedule.

All of the races were run on temporary city centre tracks, with a format that saw practice, qualifying and racing all completed within the same day. The attractions for city politicians to support such a format were the positive green image of all-electric racing, no pollution, no noise and the roads closed for just 24 hours. The result is much more like a one-off festival than a traditional circuit-based series. Thus, the fanbase tends to be the urban dweller visiting an annual event, rather than diehard motorsport supporters following the series globally.

The technical format, with the cars being

closer to an F3 spec than F1, is a potential deterrent for the purist. With a max power in qualifying of just 200 kW (268 hp) in an 880 kg car (including driver), running on all-weather treaded tyres, the cars are not incredibly fast. While not quite silent, they inevitably lack the engine roar so loved by petrol-heads. Moreover, the mid-race car swaps to allow the driver to race for ~40 mins (due to the battery specification) is an obvious source of criticism.

In its first year the cars were of a single specification, with the Spark STR01e benefiting from a Dallara chassis, a Williams Advanced Engineering battery forming the mid-section of the structure (in lieu of a fuel tank), a McLaren Applied Technologies motor/electronics and a Hewland gearbox. The 10 teams all ran the same hardware, leaving only software and race engineering to differentiate their performance.

From season two onwards the powertrain has been open to development, the teams being allowed to manufacture everything between the battery and rear crash structure. Thus the motor, inverter, gearbox, differential, cooling, electronics, rear suspension and the supporting structure are all within the constructor's realm, leaving the rolling chassis and battery continued as a fixed specification.

Each constructor's powertrain is homologated, with every driver entry getting one powertrain for each car for the whole season. In fact, each of the driver's two cars runs just a single battery and powertrain for the entire season! This route was taken to reduce operating costs, while directing R&D towards the electric powertrain, rather than into the traditional chassis. The battery remains a spec item, subject to a tender process every two seasons.

The category maintains a minimum weight and electrical output is capped. Measured at the battery terminals, the 170 kW race power and 200 kW qualifying output are the limits available and the 28 kWh battery limits total energy for the race. The challenge for the powertrain constructors and teams is therefore to gain a technical advantage through efficiency, primarily by reducing losses from the battery to the wheels for more power and recovering more energy under braking. Secondary development goals are to reduce the cooling demand to lower aero drag through the radiators, then improved handling from the rear suspension set up and lower centre of gravity at the rear. ▶

FIA/Formula E

Photos: Craig Scarborough

ABOVE The series might do little for the purist, but Formula E has wowed manufacturers desperate for a new marketing message

RIGHT Season one technology: restricting development in the early years capped costs at a time when teams were independent, rather than manufacturer-backed

BURNING PLATFORM

For the OEM motor manufacturers, still reeling from diesel emission scandals and the inexorable shift away from ICE towards hybrid and ultimately electrical vehicles, the series has a strong draw. It offers the chance to market themselves as environmentally friendly, while showcasing technology to the core EV audience.

Looking a bit deeper, the Formula E budgets are a fraction of those required for F1 or even the WEC. In financially straightened times, the appeal of smaller budgets shouldn't be underestimated.

Furthermore, with the traditional series having committed to ICE for the coming decades, the RED outlay involved in developing one or perhaps two new race ICEs in the near future is hard to sell to the beleaguered management boards. Indeed, with several countries now rolling out dates by which they will ban the sale of diesel and petrol vehicles, the ICE could be seen as something of a burning platform. There are, therefore, many compelling reasons prompting OEMs to lean towards Formula E and other upcoming EV race series such as WRX and Electric GT/touring cars.

ROAD RELEVANCE

Beyond the marketing message, though, what will the OEMs learn from Formula E? Is this a marriage of convenience or is the series actually road-relevant?

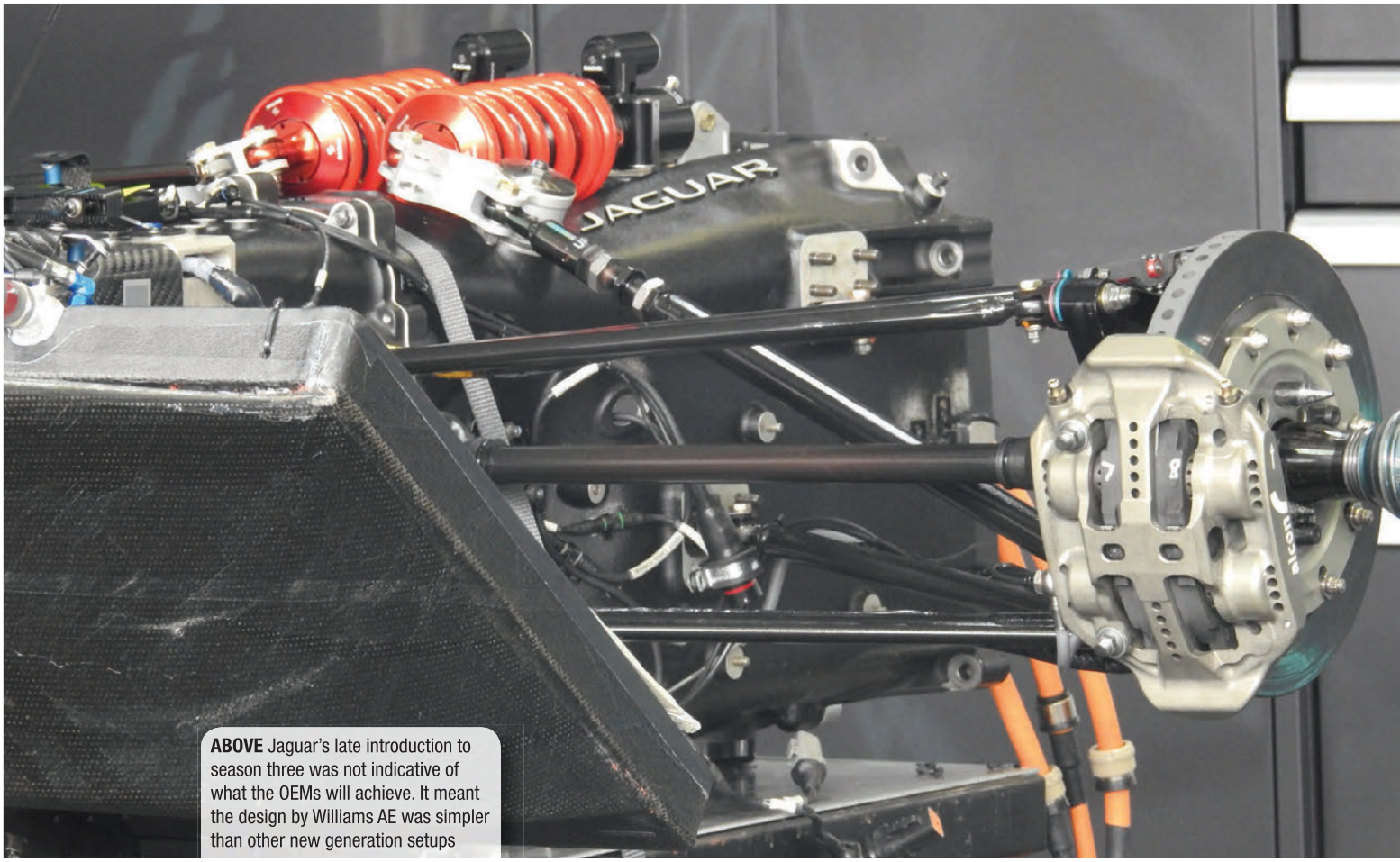
For as long as Formula E runs a fixed specification battery, its true R&D benefit won't be realised. The new battery coming for season five (2018/2019) will be developed by McLaren Applied Technologies, with double the energy output to allow a single car to race without car swaps. That will no doubt be a big plus not only for the sport, but for the perception of the wider industry given that 'range anxiety' has been such an obstacle for buyers of road EVs.

"Over just four seasons, Formula E will have inspired a 100 per cent increase in range – a phenomenal achievement," proclaims Alejandro Agag, CEO of Formula E. "We will continue to push the boundaries of electric car technology and we can expect even greater gains to be possible when the third generation of batteries arrive for season seven."

Crucially, restricting development in the early years has capped costs for the constructors and levelled the playing field somewhat, at a time when the teams were independent, rather than manufacturer-backed. In the longer term, the battery may be opened up for development, but for now it remains a closed system to the teams.

Likewise, the medium-term roadmap demands a differential between the driven rear wheels and no front motor/generator. There are obviously advantages to be had from different motor layouts, offering direct hub drive and front wheel energy recovery or all-wheel drive. These sorts of concepts are pencilled in on the roadmap, but this would be around season seven (2020) at the earliest by agreement between Formula E and the teams.

A positive point about the governance of Formula E has been the consensus by which everything has been done. While very much led by Agag and Formula E, the constructors and teams are involved and listened to. So far this means the category has not lost sight of its aims and ability to run within reasonable budgets. With the arrival of the OEMs, one wonders how this will develop in the coming seasons. ▶



ABOVE Jaguar's late introduction to season three was not indicative of what the OEMs will achieve. It meant the design by Williams AE was simpler than other new generation setups

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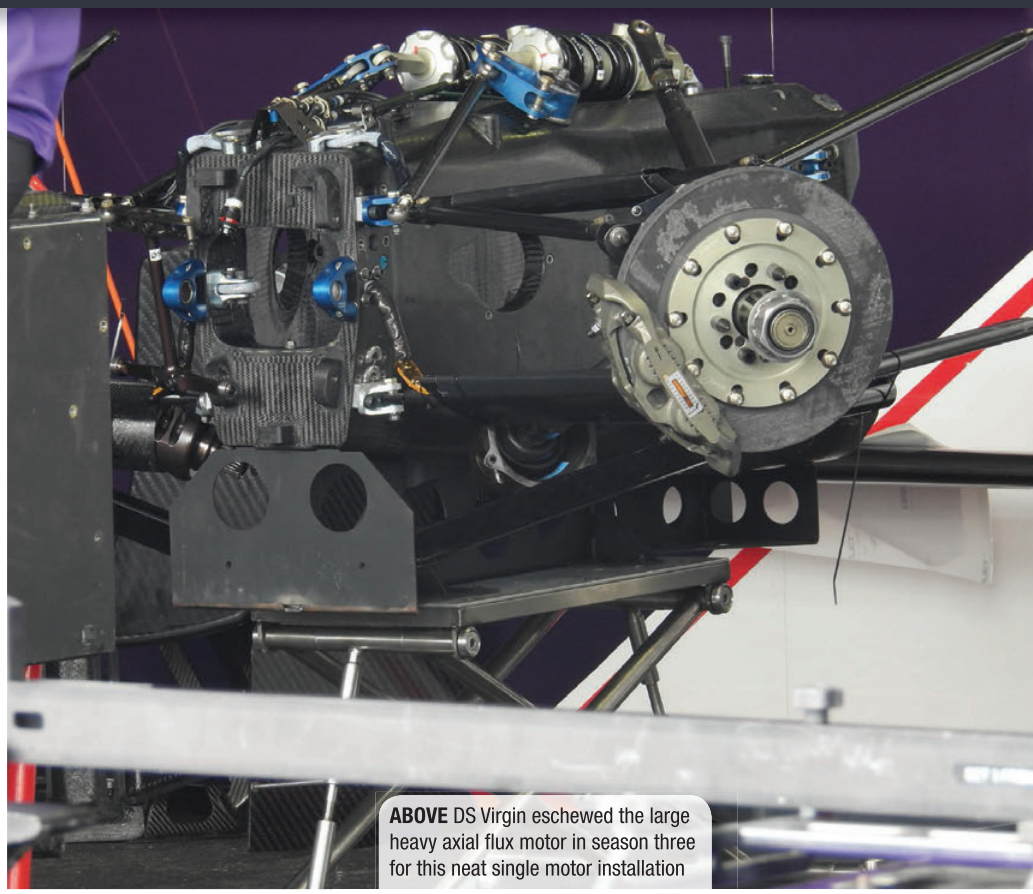


ABOVE DS Virgin eschewed the large heavy axial flux motor in season three for this neat single motor installation

Already, though, the regulations for the next three seasons are largely fixed. Season four, starting towards the end of this year, is very much a continuation of the current format, merely with a step in race power to 180 kW (from 170 kW). Season five (2018/2019) is the next big change with the exciting new car and battery combination. The new Spark chassis is still in development but the brief for it to be an exciting-looking car, not like a typical racecar, has already proved to be very attractive. Greater power and the end of car swaps will be a positive point for OEMS and fans alike.

From season seven, there is a greater opportunity for the OEMs to flex their muscles and for the category to change in its technical, sporting and marketing directions. It's likely to be at this point that the future success of the championship will be decided. Again, its loose roadmap and governance by consensus are likely to prove key factors. Formula E realises that it needs to be road-relevant, so will be directed somewhat by the constructors, largely now OEMs. If road cars are heading towards hub motor drives, all-wheel drive/regen or perhaps another direction completely, this should reflect in the series' future rules.

WHERE ARE THE GAINS?

While the focus has been restricted to the powertrain (motor, electronics and gearbox), there has been significant development over the two campaigns that any freedom has been permitted. Despite the 30 kW difference between qualifying and the race, the teams are generally now racing at the pace of first season qualifying, showing a step increase in efficiency between the battery and the road.

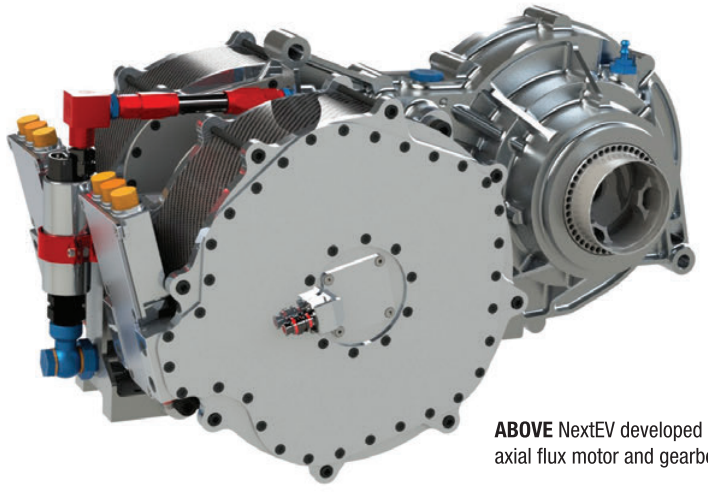
With electrical efficiency paramount, the focus has been on reducing the losses within the inverter, switching the DC battery output to three phase AC for the motor and within the motor itself.

Motor development remains a much more secretive area with regards to materials and the detail of the internal layout. What's clear is that the need for efficiency within regulations demanding a single differential and relatively low energy output has driven development in one direction following season two, which had witnessed a wider variety of motor formats.

Two constructors initially produced powertrains with axial flux (pancake) motors. Both NextEV and DS Virgin ran a pair of these motors on a fixed reduction gearbox (ie no gearshifts). The axial flux format, where the magnets and stator are arranged radially around the shaft, creates a high torque/low rpm motor. This would have had benefits when the series went to higher power outputs, but the weight and efficiency were a handicap within the 170/200 kW rules. For season three only NextEV continued this format, with the design and manufacture brought completely in-house. This resulted in much better installation and performance, but it still remained somewhat short of the other teams.

Meanwhile, the other constructors went for a radial flux motor, what might be considered a conventional format motor with magnets and stator concentric with the shaft. To drive efficiency with these motors you need to spin them faster. Containing the rare earth magnets at high rpm is one of the key secrets and few constructors talk about it, let alone show the internals of their motor technology.

The quest for faster-spinning motors has in turn driven advances with the inverter. This appears to be a richer – or at least better publicized! – area for development. To produce the motor performance, the inverter needs to deliver more volts and quicker pulses. Conventional inverter technology uses silicon IGBTs to switch the power, but the silicon material limits the speed and voltage due to the temperatures created. Both Magneti Marelli and Rohm have announced a switch to silicon carbide (SiC) material in their inverters. This allows ▶



ABOVE NextEV developed its own axial flux motor and gearbox in-house

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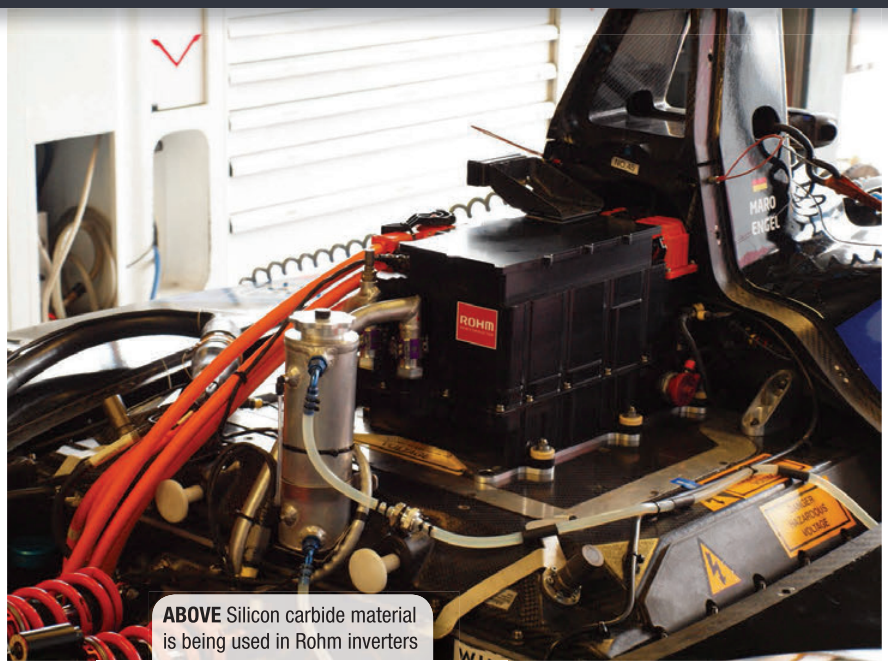
> *"Season four will see silicon IGBTs swapped for SiC MOSFET and a step change in the inverter's performance"*



ABOVE Silicon carbide material is being used in Rohm inverters

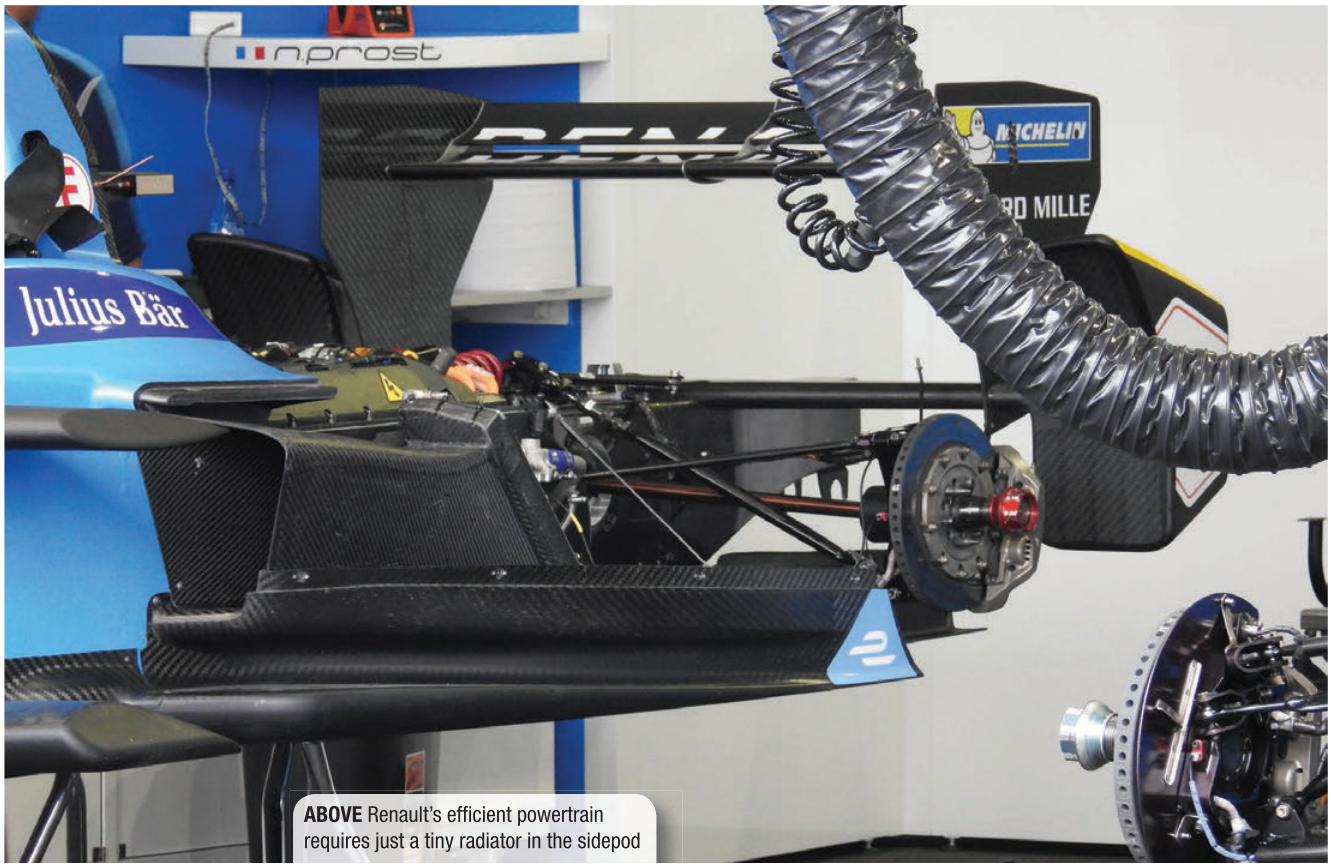
faster switching and improved voltages as the material withstands higher temperatures.

With the Dragon Racing team running a McLaren inverter with Rohm semiconductor technology in season three, there was a small improvement in performance and cooling by using SiC for the diodes within the inverter. For season four the silicon IGBTs will be swapped for SiC MOSFETs, which will see a step change in the inverter's performance. Magneti Marelli will also enjoy this sort of performance improvement, while talking about Gallium as a future semiconductor material. This is not as quick to switch as SiC but withstands higher temperatures to allow greater current to be passed through the inverter.

Both semiconductor materials bring another key benefit for the car: reduced cooling. The left-hand sidepod on the Spark chassis houses the coolers for the motor and inverter. In season one the sidepod housed a large radiator, matching the size of the one used in the other sidepod for cooling the battery. By season three all teams had reduced the radiator size by at least a third; for the Renault the downsize has been of the order of two thirds!

Going forwards there is the potential for the cooling demand to be reduced enough for air cooling alone. This is potentially a huge advantage for the packaging of the racecar and therefore onwards to road cars. Although the series features a fixed chassis and, consequently, fixed aero, there are a number of teams regularly running wind tunnel programmes mapping the car's setup and working out the drag reduction advantage of reduced cooling.

Along with these gains in electrical efficiency, the traditional engineering work of improving mechanical efficiency is also a key R&D stream for the constructors. Hand in hand with the high rpm motor is the choice of geartrain for the car. Season one used a five-speed longitudinal gearbox in an aluminium casing. With this setup the motor could be kept in most efficient rpm range, ▶



ABOVE Renault's efficient powertrain requires just a tiny radiator in the sidepod

FORMULA 1 2015/2016 Technical Analysis

Giorgio Piola

Size: 24,3x27 - Pages: 128 - Photos: over 400 technical drawings in colour
- Softbound with jacket - Text: English
ISBN: 978-88-7911-656-5 - Price: £32.00 + plus post and packaging

AS with previous years, 2015 was one in which Mercedes-Benz dominated both the drivers' and constructors' championships. The German manufacturer confirmed the technical advantage it had derived from the introduction of the revolutionary power unit, which first appeared in 2014. In place of Red Bull, which fell into disgrace after a media conflict with engine supplier Renault, it was Ferrari that attempted to stand up to the Silver Arrows. Side issues were the stories of a Williams wanting to come back and battle for the title; McLaren with a new but not very effective Honda engine, which touched the lowest point in the Japanese manufacturer's long history in F1; and the other leading teams of a season that ended with the official announcement of Renault's return, having acquired Lotus.

Offering a precise analysis of this latest F1 championship, especially from the technical point of view, there is once again Giorgio Piola. A hundred or so all-colour illustrations document the development of the various cars throughout the Formula 1 World Championship, and offer - as always - a wealth of information anticipating the 2016 season.

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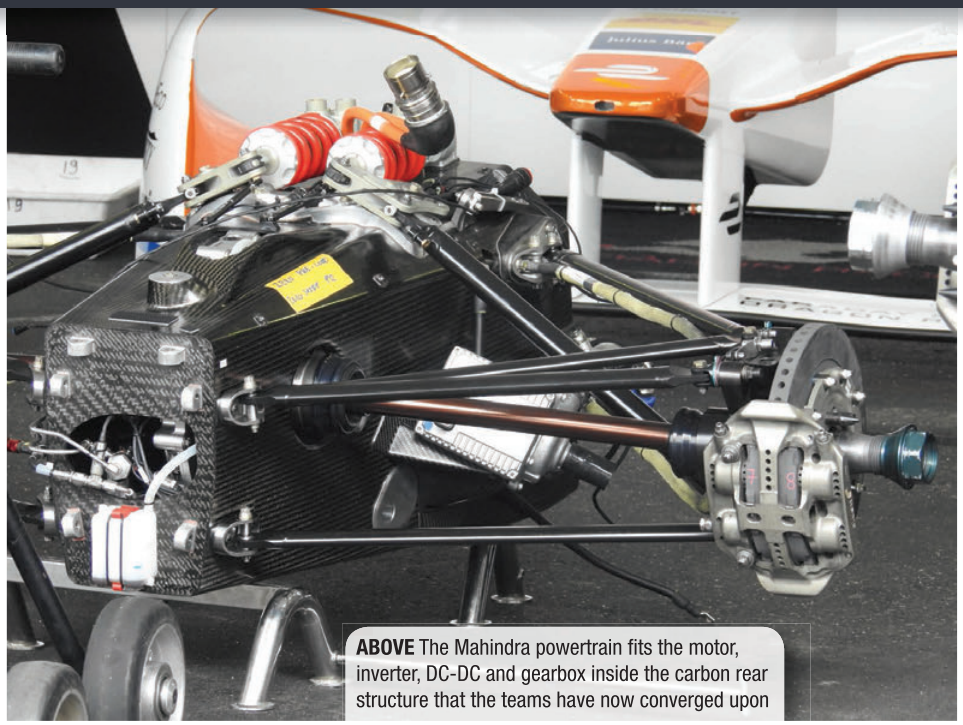


ABOVE The Mahindra powertrain fits the motor, inverter, DC-DC and gearbox inside the carbon rear structure that the teams have now converged upon

albeit with the losses from the geartrain. As the two open development seasons have progressed, the desire to reduce mechanical losses through a gearbox have been aided by the motor having a wider efficiency range, thus requiring less gears.

After the developmental 'scatter' of season two, where many different layouts were produced, season three witnessed a convergence towards fewer gears. Most teams ran just two speeds, placing the motor transversely in the 'gearcase' with single pneumatic selector switching betwixt the two gears to the differential. This layout sacrificed up to three gears and the bevel gear arrangement of the longitudinal season one layout, to the improvement of mechanical efficiency.

Renault ran this layout in season two, with a cable-operated gearshift further reducing losses from driving the pneumatic pump. For season three, the motor performance allowed a fixed gearing setup. This again improved efficiency, albeit at the cost in some circumstances that the car lacked performance relative to its rivals. This was highlighted in qualifying and on the long straights of Mexico, but these deficits were easily countered by the car's far greater race performance.

Within the drivetrain, detail improvements in bearings and seals have reaped benefits. This sort of gain was evident in season two, when some teams ran evolutions of the opening year's powertrain, with this sort of high-cost development spent on the same underlying powertrain. Constructors are employing pressurized rotary seals within the powertrain, as it's been noted that teams are pressurising the differential seals, reducing the friction associated with conventional seals.

F1 levels of detail engineering, allied to the reduction in mechanical complexity and electrical hardware, has reduced the overall weight of the powertrain. Most constructors now have a carbon structure enveloping the powertrain, with the inverter, motor, gears and other hardware all housed within a neat composite case that spans the gap between the battery and rear crash structure. To the extent, in fact, that the entire rear end – powertrain and suspension – weighs in at 125 kg. Such weight reduction allows significant blocks of ballast to be mounted within the casing to bring the car to the minimum weight limit and in line with the front to rear weight distribution rule.

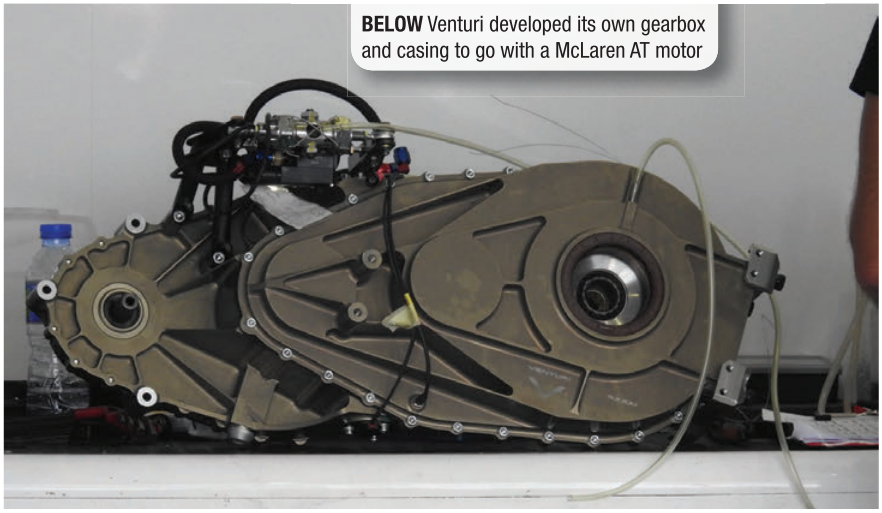
Along with this physical development, software presents the other big challenge. The control software manages the switching within the inverter to power the motor, then in reverse to recover energy under braking. The advances in motor and inverter technology introduced the need to work the software harder to maximize these changes. Constructors, especially the OEMs coming into the sport, cite this as a key learning process for the team, understanding how to extend range with regenerative braking. This is clearly a new scenario for the ICE-based R&D teams and the fast pace of motorsport development allows the OEMs to jump up the learning curve.

If this is an obvious learning process, then perhaps less apparent is the need for the software to control the inverter/motor to manage the battery. With the battery cooled by dielectric fluid (oil) and cycling high currents when deploying and recovering energy, it will get very hot, especially with high ambient temperatures. But the cells inside the battery are temperature-sensitive and will be thermally limited in many circumstances.

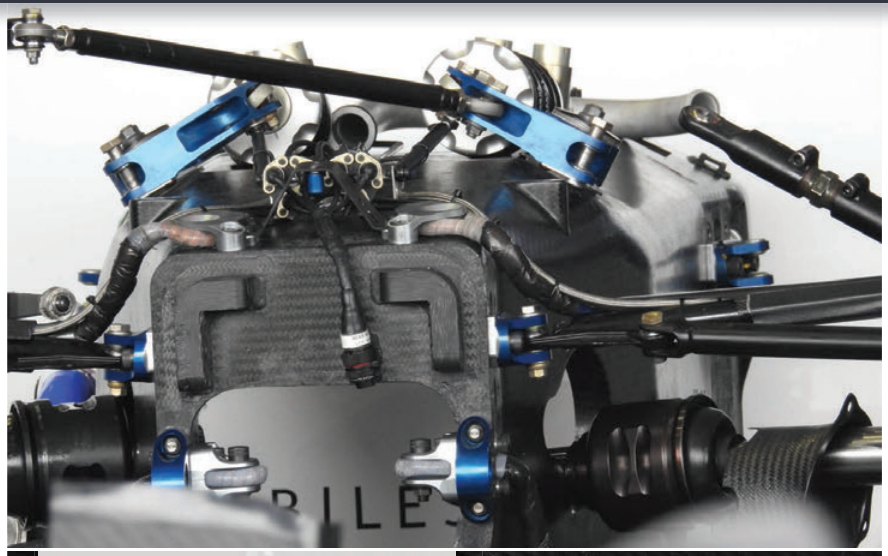
Heat will be created when using hard acceleration and especially when recovering energy under braking. Thus, the ability to extend battery life in the race with braking is compromised and software mapping needs to manage the battery upstream, by not stressing it with too much energy cycling. For Formula E, this extends the race energy; for road cars, this keeps the cells well-conditioned and reduces the need for cooling for the battery and the car's occupants, further improving the car's efficiency.

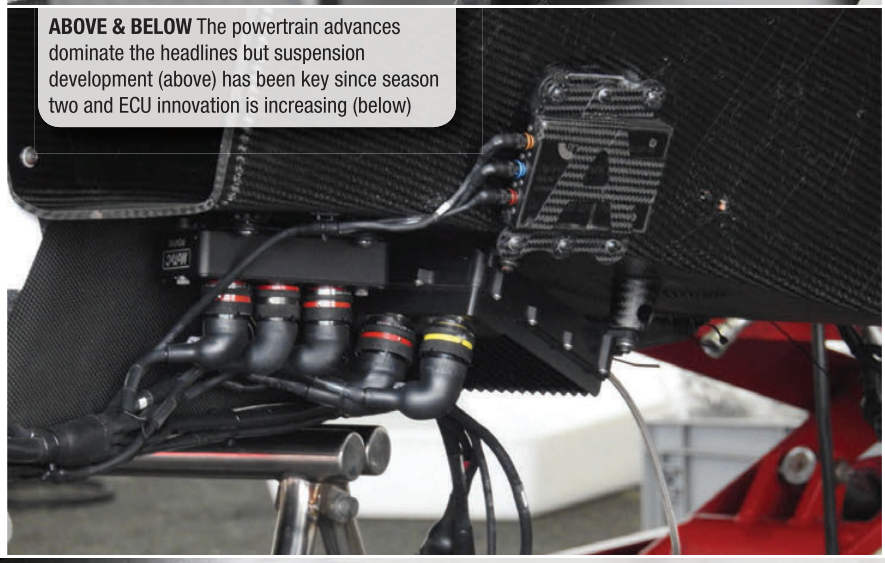
PROGNOSIS

Formula E has caught the attention of the OEMs, major politicians and city dwellers. Its roadmap is designed to deliver its clean street racing format for many years to come. For some, the idea of non-ICE motorsport is anathema and will never excite or engage them. For others, perhaps the younger or



BELOW Venturi developed its own gearbox and casing to go with a McLaren AT motor





ABOVE & BELOW The powertrain advances dominate the headlines but suspension development (above) has been key since season two and ECU innovation is increasing (below)

> *"The mid-race car swaps are an obvious source of criticism"*

urban audience, it is a message that excites them where conventional motorsport doesn't.

What is clear is that Formula E is not the new Formula 1: there's a huge gap between F3 level-powered cars racing in city centres and 1000 hp beasts tearing around purpose-made circuits. Their DNA is different, but they can coexist even if F1 moves towards electrification after 2030 (the next major F1 PU rules change).

Formula 1 made hybrid technology racy. Can Formula E do that for electric? Currently, it is the only category offering that opportunity and is starting to enjoy the interest and investment from the OEMs. The technology exploited in Formula E is being embraced by the OEMs for their road car programmes and no doubt there will be a reciprocal arrangement where Formula E's development of the electric powertrain will be advanced by the OEMs. Possibly this success will spur the creation of other electric racing formats, from touring to sports cars and other single-seater categories. RT

BELOW The season five concept car hinted at an exciting future. The FIA has promised we can "expect surprises"

FIA/Formula E

IMSA RIDING HIGH

With American sportscar racing riding a wave, **William Kimberley** catches up with IMSA president Scott Atherton

WHICHEVER way you look at it, the IMSA WeatherTech SportsCar Championship is doing well. The way the organisers managed to weld together two different styles of racecar and yet make them competitive on the track was a masterclass in the Balance of Performance.

IMSA has successfully blended the involvement of American manufacturers, through the new Daytona Prototype international (DPi) class, with European LMP2 cars. The result may not be a popular concept in some circles and it could have been a disaster. But it wasn't.

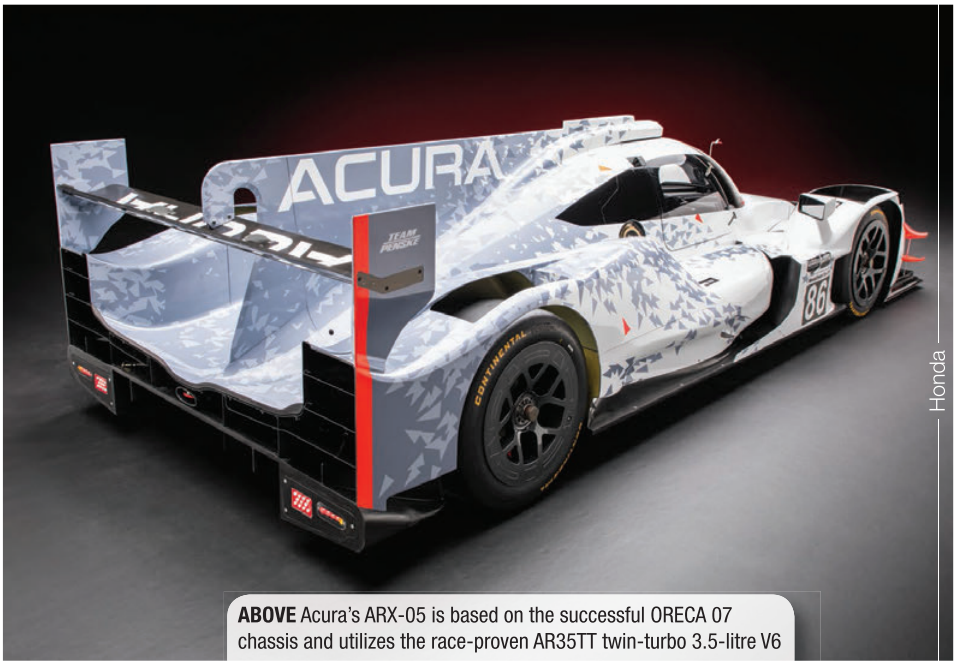
While he would deny it, such is his modesty, it was IMSA president Scott Atherton who navigated his team through what were very tricky waters. Along with Ed Bennett and his board, he took the difficult decision not to accept LMP1 entries, thereby excluding Audi, Porsche and Toyota from competing in the IMSA series.

Honda

ABOVE Penske's return to sportscar racing, with the Acura ARX-05, is a coup for IMSA. The new prototype showcases Acura-specific bodywork and design features, including the marque's signature 'Jewel Eye' headlights

In the light of what has happened over the last few months, he was utterly prescient in his judgement. The Automobile Club de l'Ouest and the FIA have a real problem on their hands with Audi having left the World Endurance Championship at the end of last year and Porsche, despite guaranteeing that it would remain in the series until at least the end of 2018, deciding to cut and run early. It, like Audi, has headed for Formula E. Meanwhile, in the US, both Acura and Mazda have upped their involvement in the IMSA series by commissioning crack teams, namely Penske and Joest respectively, to run their Stateside racing operations.

By the time Atherton made his annual flying visit to the Le Mans 24 Hours, long before the breaking of the Acura/Mazda news, he was already delighted at the way the IMSA series had shaped up. While he would not admit to it, there is no question that IMSA has positioned itself better for the future with the DPi formula which allows manufacturer identity at a fraction of the cost of an LMP1 hybrid.



Honda

ABOVE Acura's ARX-05 is based on the successful ORECA 07 chassis and utilizes the race-proven AR35TT twin-turbo 3.5-litre V6

BEHIND THE SCENES

"There is so much momentum now," he says, "but what we're experiencing now is the result of efforts made by an army of people for the last four years. It looks like it's all coming at once, but it's been a long process.

"The introduction this year of the new Prototype class (see sidebar) with both the Daytona Prototype international (DPi) and LMP2 cars has been very successful. If you go back a year ago at this time, we were celebrating all-new GT content in the WeatherTech Championship. Fast-forward to this year and we are having an equally positive reaction to the new Prototypes.

"The Cadillac DPi, with its custom 6.2-litre V8 engine, established its credentials from the moment it took to the track, the Wayne Taylor Racing team having a remarkable year with five consecutive wins in the first five races. If that's all you knew, you'd say, 'Well, that's quite boring', but the reality is that it's been just the opposite as the LMP2 cars achieved pole positions and led many laps."

Since then, the Mustang Sampling Cadillac won the race at Watkins Glen and the Whelen Engineering Racing Cadillac made it seven straight wins for the marque at Mosport. The Tequila Patron ESM Nissan DPi, powered by Nissan's road car-based 3.8 litre twin-turbo V6 GT-R engine, finally broke the Cadillac stranglehold at Road America.

While the DPi cars have won all the races to date, the competition has been fierce. The LMP2s have closed the gap to their DPi rivals, the JDC Miller Motorsports ORECA coming second in both the Motorsport Park and Watkins Glen races. Strong results with six top-five finishes in seven races mean that the team after Road America sits third in the driver and team championships. It has also ordered a second ORECA 07 so that it can campaign two cars in 2018. This would not have happened if it did not have faith in the BoP.

"Nobody really appreciates the enormous amount of work that went on behind the scenes to achieve that," says Atherton. "It's a thankless job that nobody wants but Simon Hodgson, our vice president of competition, and his technical team have done a remarkable job. When you look at all the variables that are represented, not only with the DPi versus the LMP2, it certainly is a complex set of details.

"It's even more so in the GT categories where there are such radically different sets of architectures, formats and configurations. The relative competitiveness is showcased every time we go racing, such as at the Detroit race where the first seven positions in the GTD (GT Daytona) class in qualifying saw seven different manufacturers separated by three tenths of a second. They raced that way as well.

"It was spectacular, with any one of them capable of winning, and that's exactly what you want. The BoP created a level playing field and the outcome of the race was decided by driver capability, pit stop efficiency and race strategy, all the other variables that dictate the result, and that's how it should be.

"The best news, though, is that we are not done yet. There's more content coming, from both GT and Prototype. I would categorise us as going from strong to stronger."

> *"It looks like it's all coming at once but it's the result of efforts made by an army of people for the last four years"*

As far as Atherton is concerned, significant manufacturer involvement is a critical ingredient for any professional motorsport platform to be successful. "This is especially true when you talk about sustainability," he says. "There was a time when some motorsport championships shunned manufacturer involvement because they felt it was a prescription for escalating costs. And while manufacturers make decisions to come and go, we have been focused on evening out the peaks and valleys.

"We have been very fortunate to have attracted what we believe is a record number and an unprecedented amount of ▶

IMSA/LAT USA

ABOVE Atherton navigated IMSA through tricky waters

manufacturer involvement. If you look at the whole of IMSA, both the WeatherTech Championship and the Continental Tire Challenge, there's a total of 17 automobile manufacturers actively involved, with 14 in the WeatherTech Championship alone.

"When you have a number of that significance, while we would never wish one to leave, reality and history would suggest that it's part of the equation. However, even when one or two go at that point, it's never pleasant but it's not a life threatening situation. In other championships that have perhaps two or three manufacturers involved, if you lose one or more, it *is* a life threatening situation.

"What's important is for championships to create a value proposition that provides all involved with a return on their investment such that the decision to continue is relatively simple, because it does have good value and it is returning on their investment. In IMSA it isn't just the fact that they happen to have a car competing on the grid, but that all participating manufacturers have made significant investments to the marketing side of the equation, and are an invested partner with our television broadcaster, etc. It's a full package that each manufacturer must commit to in order to be involved.

"At our first event this year, the Rolex 24 At Daytona, there were 13 or 14 automobile displays in the infield midway. It looked like an auto show with the highest production values and representation of their brands and not just a couple of cars under a tent. They were acquiring data and whether you were a potential buyer of a car in the next ▶

The DPi concept

A 2017 IMSA DPi car is a standard ACO/FIA-homologated 2017 LM P2 Prototype chassis from one of the four approved constructors (Dallara, Onroak Automotive, ORECA or Riley/Multimatic) fitted with IMSA-homologated, manufacturer-designed and branded bodywork and engines. Each participating DPi manufacturer must partner with one of the four approved constructors and commit to a bodywork and engine package.

The standard ACO/FIA-homologated 2017 LMP2 car must use each constructor's specific bodywork (and at Le Mans, the "low downforce" bodywork kit version is required) with no modifications. LMP2 cars use a Gibson V8 engine with a standard-specification Cosworth electronics package controlling car systems and engine management.

For DPi cars, IMSA has defined specific areas of the bodywork regulations to allow manufacturers design and stylistic freedom to create recognition of their specific brands. These areas include the nose and sidepod areas, rear wheelarch and rear valance. Manufacturers will use this stylised package in conjunction with their eligible specific engine and electronic systems. However, the expanded bodywork freedom will not create a situation of confusion in identification between DPi cars and GT cars. RT

ABOVE IMSA conducted extensive wind tunnel work to balance the performance of the LMP2 cars and DPis

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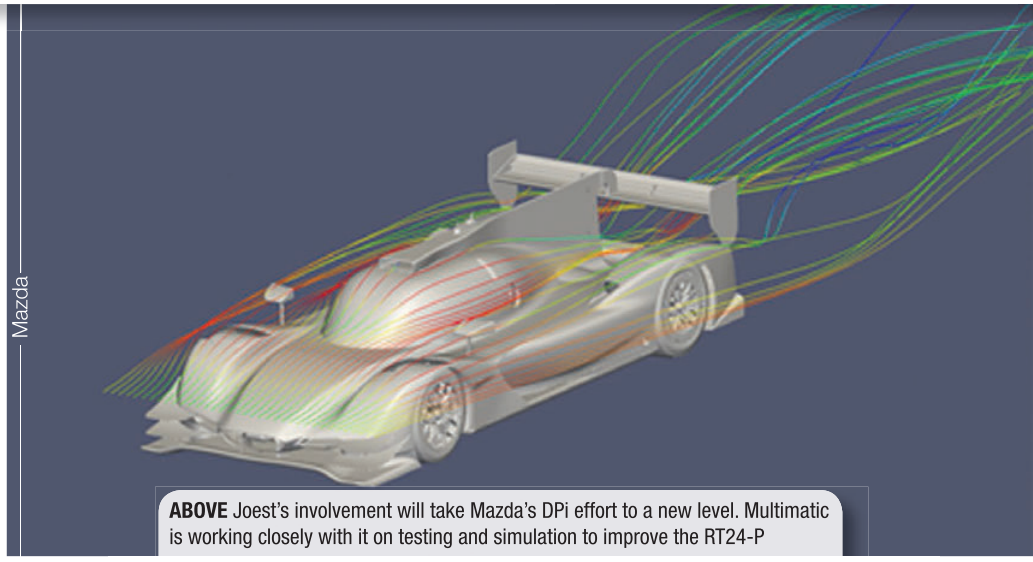

Mazda

ABOVE Joest's involvement will take Mazda's DPi effort to a new level. Multimatic is working closely with it on testing and simulation to improve the RT24-P

six months or year, or whatever.

"While Sebring didn't match the Daytona numbers, there were still eight or nine manufacturers exhibiting their cars and 10 at Watkins Glen, so I would say it must be working otherwise they wouldn't be doing it. All of these manufacturers have been through the same vetting process to determine if an investment in IMSA is worthwhile. We like to say that no two relationships are alike, but all are similar and they each have their own criteria and their own priorities. The challenge for us is to be able to deliver the goods, so to speak, with each one.

"Sustainability, value proposition, return on investment and making sure that our platform is delivering what manufacturers need to realise as a result of making their motorsport investment. That's been our focus and, touch wood, it is working."

Asked whether the changing landscape in Europe, in particular with politicians and governments making announcements about banning petrol and diesel cars and vans from 2040, has made the IMSA WeatherTech Championship more appealing to car manufacturers, Atherton is fairly balanced in his reply.

"I don't think there's any less focus by manufacturers and think they all recognise the absolute demands of the future," he insists. "Look at the regulatory requirements that the US automakers are facing, specifically the CAFE (Corporate Average Fuel Economy) – which is a topic of debate with our new president. The final regulations are undetermined today, but we don't think anybody has been sidelined in their thinking because they know much more demanding regulations are inevitable as we go forward.

"As it relates to our technical regulations, we are and have been great admirers of the LMP1 configuration. However, we are also of the opinion that that level of technical specification is unsustainable at a domestic level. When you have a global stage in which to amortise that investment, it makes much more sense than if it was focused on a much more defined geographic area.

IMSA/LAT USA

ABOVE & BELOW Nissan's win at Road America not only broke Cadillac's stranglehold but was the first for a GT3 engine

> *"At some point GTs will incorporate hybridisation, or go all the way to fully electric or even a fuel cell configuration"*

"As we made our technical specifications, it was with an eye towards sustainability, and with history being our guide to what manufacturers and teams are capable of sustaining. For that reason we very much like our positioning as it relates to the DPi format and LMP2, which is completely connected to that. The same applies to the global configuration that we follow with both of our GT categories – GTD and GTLM.

"What does the future hold? We're certain that at some point, globally, the GT specifications will incorporate some level of hybridisation, or it may skip a segment and go all the way to fully electric or even

ABOVE The pure LMP2 cars have run their DPi rivals a lot closer than the race win tally suggests

a fuel cell configuration. I'm fortunate to be part of the FIA GT Commission and have been part of many discussions amongst the manufacturers along with the FIA officials that define the technical specifications.

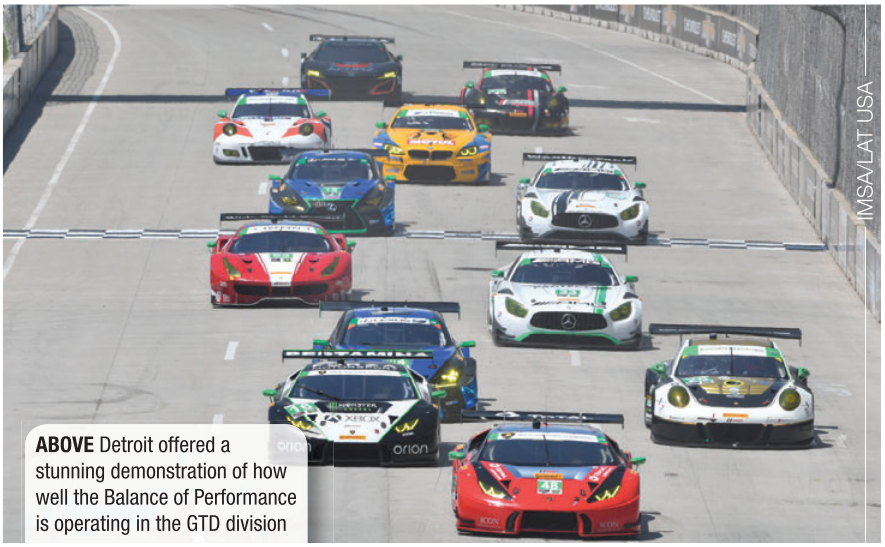
"Everybody is conscious of what's being produced for consumer consumption. However, there are also the implications of adopting more advanced technical specifications and what that would do to the overall cost of competing. While no-one's casting a blind eye to that, looking forward, I think we are also conscious of the financial implication that comes with those decisions that not only embrace relevant technology but also embrace financial sustainability."

Atherton also talks about the difference between the US and European definition of a sanctioning body. "In the States a promoter is the event organiser, but in Europe it's what we'd more likely refer to as the sanctioning body," he says. "Our role at IMSA is as a sanctioning body and our charge is to work with 12 different promoter partners and event organisers to put the events on. It's very much a collaborative effort in working together to bring the maximum number of fans onsite."

Part of that is working with TV broadcasters. In 2013 IMSA signed a five-year contract with Fox Sports, Atherton praising the partnership that has seen year-over-year gains, due largely to additional network TV broadcasts and more live races on FS1. However, with the contract finishing at the end of next year, IMSA is evaluating everything and has been reported to be "actively involved in dialogue" on a 2019 TV deal.

"We focus deeply on the total value proposition, which involves live television coverage, all of the social media, digital elements and live streaming, all of the facets of the overall media plan that have to be delivered," Atherton says. "I would argue that IMSA has always been at the leading edge of live scoring and, outside the US, live video feeds of fully produced event broadcasts, live in-car cameras, live IMSA Radio, etc. You have to make your product available when, where and how people want to consume it.

"Our focus is as much at the track as it is away from it and we like to believe we are doing a good job for our fans. However, we are also aware of what we don't know and have people who live and breathe it (all aspects of media, content distribution, etc) to advise us." RT



ABOVE Detroit offered a stunning demonstration of how well the Balance of Performance is operating in the GTD division

THE END OF F1 AS WE KNOW IT?

Stung by criticism of its decision to introduce the Halo for 2018, the FIA has revealed the compelling results of its research. **Matt Youson** reports

IN 2018, Formula 1 will use the frontal head protection system known as the Halo. The Halo is controversial: depending on who you ask, it is either an important step forward in the field of driver safety or the end of motorsport as we know it. It's not unreasonable to suggest it's a little bit divisive.

Halo has its origins in a number of fatalities and near-misses across the breadth of open-cockpit racing. It is designed to offer protection during car-to-car impacts, car-to-environment impacts and, perhaps most pertinently, foreign object impacts – specifically (but not exclusively) tyres and large pieces of accident debris. It works as a secondary roll-structure, comprising a hoop attached to the shoulders of the safety cell and a strut attached centrally in front of the cockpit opening template.

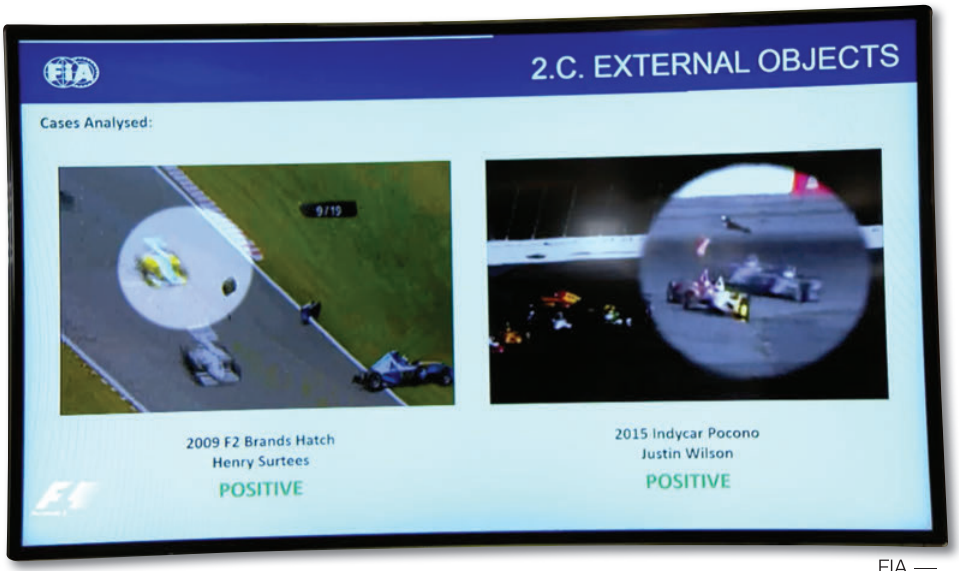
In the wider world, decriers of the Halo tend to be aesthetic traditionalists or come from the Ernest Hemmingway school of sports science, in which anything that doesn't dramatically imperil the participant doesn't make the grade. Within the motorsport establishment, and the F1 paddock specifically, the criticism is rather more measured, with arguments ranging from questions regarding the device's necessity to its potential to generate more harm than good. Within this arena, the informed critics are a minority, with the Halo receiving broad (if occasionally lukewarm) support from drivers and engineers.

Paddy Lowe, chief technical officer of Williams Grand Prix, is one of those to express the opinion that the time for a frontal protection system has come. "Obviously, a

Tee/LAT

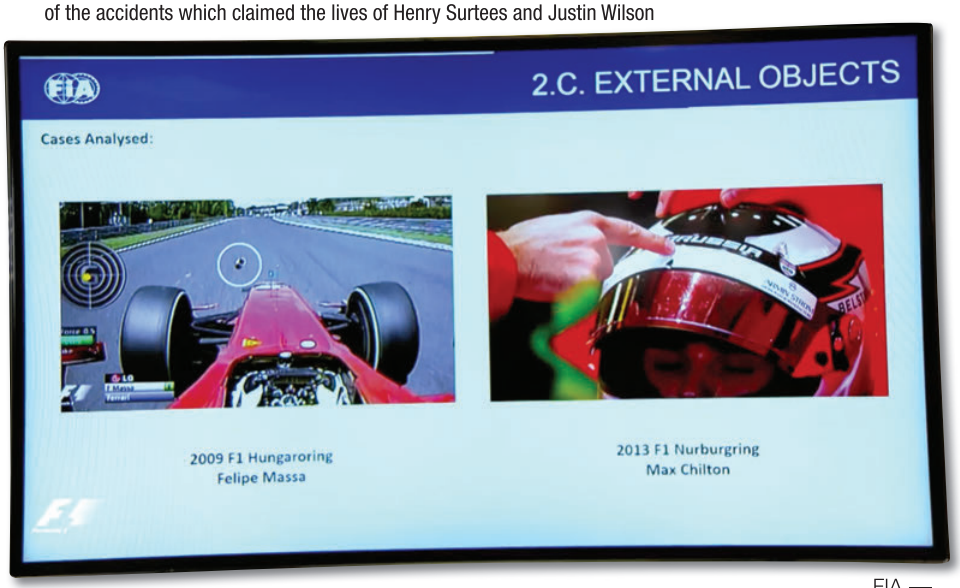
ABOVE The Halo, run here in a recent test in Hungary, will go through a further iteration before it races for the first time

lot has been written about it and it seems to be quite controversial," he concedes. "I think it's worth bearing in mind the context: five or six years ago the TRM (technical regulations meeting) identified the big risk they could see still in the sport was to the driver's head. There were a number of near-misses – typically one per year – that we all saw go by and thought one day that could end in tragedy. That was the background to developing a solution, and we ended up here with the best option being the Halo. I know it's not the most attractive device but I do think it's the right decision to get it on the car. At least then we're started. I'm sure we can improve it year on year but at least we've put in place that protection that we intended from the start."



FIA —

ABOVE Research suggests the Halo would have dramatically changed the outcome of the accidents which claimed the lives of Henry Surtees and Justin Wilson



FIA —

ABOVE Statistically, the presence of the Halo would reduce the chances of a repeat of the Massa scenario. Helmet protection has also been greatly increased

20 KG AT 225 KPH

The FIA began the project in 2011. While many historic accidents were considered, the study was primarily informed by the fatal incident involving Henry Surtees during a 2009 Formula 2 race at Brands Hatch. Surtees died following a high-speed impact with a detached wheel. The aim of the project was to create a structure that would prevent a repeat of this situation. Initially, it looked at an eclectic range of devices from full canopies to various frontal and overhead roll bars, indulging in full-scale testing, with the aim of finding solutions that would protect the driver against the impact of a 20 kg wheel, with a closing speed of 225 kph.

The list was whittled down to three possible systems: an AeroScreen tested at the 2016 Russian Grand Prix, a frontal cockpit Shield, tested at this year's British Grand Prix, and the Halo. While the FIA is not ruling out the other devices for future use, it says the Halo is the only device that passed the most stringent impact tests at the time a decision had to be taken.

Despite many years of testing there was a sense in some quarters that the FIA was rushing into the implementation. This was not helped by the official announcement of the Halo's adoption coming just five days after the first test of the polycarbonate cockpit Shield – a test aborted after three laps by Sebastian Vettel, who complained of dizziness and distortion. Keen to underline its preference for the Halo was not the work of minutes, the FIA presented its exhaustive research at the following grand prix in Hungary. ▶

FIA —

ABOVE Visibility through the Halo is actually much better than that mandated in the WEC

CASE STUDIES

Laurent Mekies, FIA safety director and F1 deputy race director, has been responsible for the latter stages of the cockpit protection project. He explains that, rather than a dry academic study of loads and stress, the research concentrated on simulating real world incidents, both fatal and near-misses, divided into car-to-car contact, car-to-environment contact and collisions with external objects.

Ranging from the fatal F3000 crash of Marco Campos at Magny-Cours to the Formula 3 qualifying race crash at Macau in 2016, the study sought to simulate the incidents as they happened but also to look at theoretical offsets, studying what might have happened had the impact been slightly to the left, to the right, a little further forwards or rearwards etc. From 21 case studies, the FIA concluded the Halo would have had a strongly positive influence in 15 cases, offered a marginal safety improvement in four more, and had little or no effect in the remaining two. Significantly, the study did not see any circumstances under which the Halo made things worse.

"It became clear that the overall results of the analysis gave us little possibility to *not* push on with the Halo," concludes Mekies.

One of the criticisms of the Halo is that, while it offers protection against large FOD, it does little to prevent accidents of the type suffered by Felipe Massa at the Hungaroring in 2009, in which a small suspension component, weighing only a kilo, hit his visor. Mekies counters this, arguing that helmet standards have been improved to reduce the risk from this type of FOD in a separate development, and that a further improvement to the helmet standard is due for 2019 – but also that the Halo still adds value in this situation.

"The Halo was designed to cope with the Henry Surtees accident in 2009 and we later tweaked the geometry to make sure it would cope with the Justin Wilson ▶

Red Bull

BELOW The AeroScreen, trialled by Red Bull, was arguably the most complete solution

> *"The Ernest Hemmingway school of sports science: anything that doesn't dramatically imperil the participant doesn't make the grade"*

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JEP/LAT

ABOVE The timing of the Halo announcement, just days after the 'Shield' alternative made Vettel dizzy, was unfortunate

> *"From 21 studies, Halo would have had a strongly positive influence in 15 cases"*

accident in 2015 [Wilson died in an IndyCar at Ponoco, struck by large debris from a crash ahead of him on the road]," he says. "Because it was designed for that, we believe it would have dramatically changed the outcome of those incidents [but] there is a positive influence for small objects also.

"We know it is not like having a screen, and it is not 100 per cent, but statistically it increases the level of protection. We looked at mathematical studies and played the game of throwing millions of small objects at the Halo from all different angles and from all positions. Statistically, with a structure in front of the drivers, you increase the protection. The number is not spectacular but it is a significant improvement."

A WORK IN PROGRESS

While Mekies acknowledges a screen would provide greater protection, he explains that at the time the Halo was mandated for 2018, the AeroScreen had not passed the impact test: while it would be effective against small objects, it would not meet the primary objects. This does not, however, mean it will not make the grade in the future.

"The AeroScreen was probably the most complete solution," he acknowledges. "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 failing to completely protect against the wheel being thrown at it at the speed we chose, but we [will] always look: that's the purpose of the research – to see what's out there."

HALO V4

The Halo itself is still a work in progress, currently in its third generation with the possibility of a fourth generation to come before it appears on 2018 cars. One of the areas still receiving attention is the central pillar. Currently 20 mm wide, the FIA believes there is scope to reduce this, perhaps to as little as 16 mm, in an effort to improve forward vision.

Based on driver feedback the FIA is happy that visibility through the device is well within acceptable levels (and much better than, for example, that which is mandated in WEC), and the issue is more ▶

FIA

ABOVE The Halo's origins lie not just in fatalities but a number of near-misses across the breadth of open-cockpit racing

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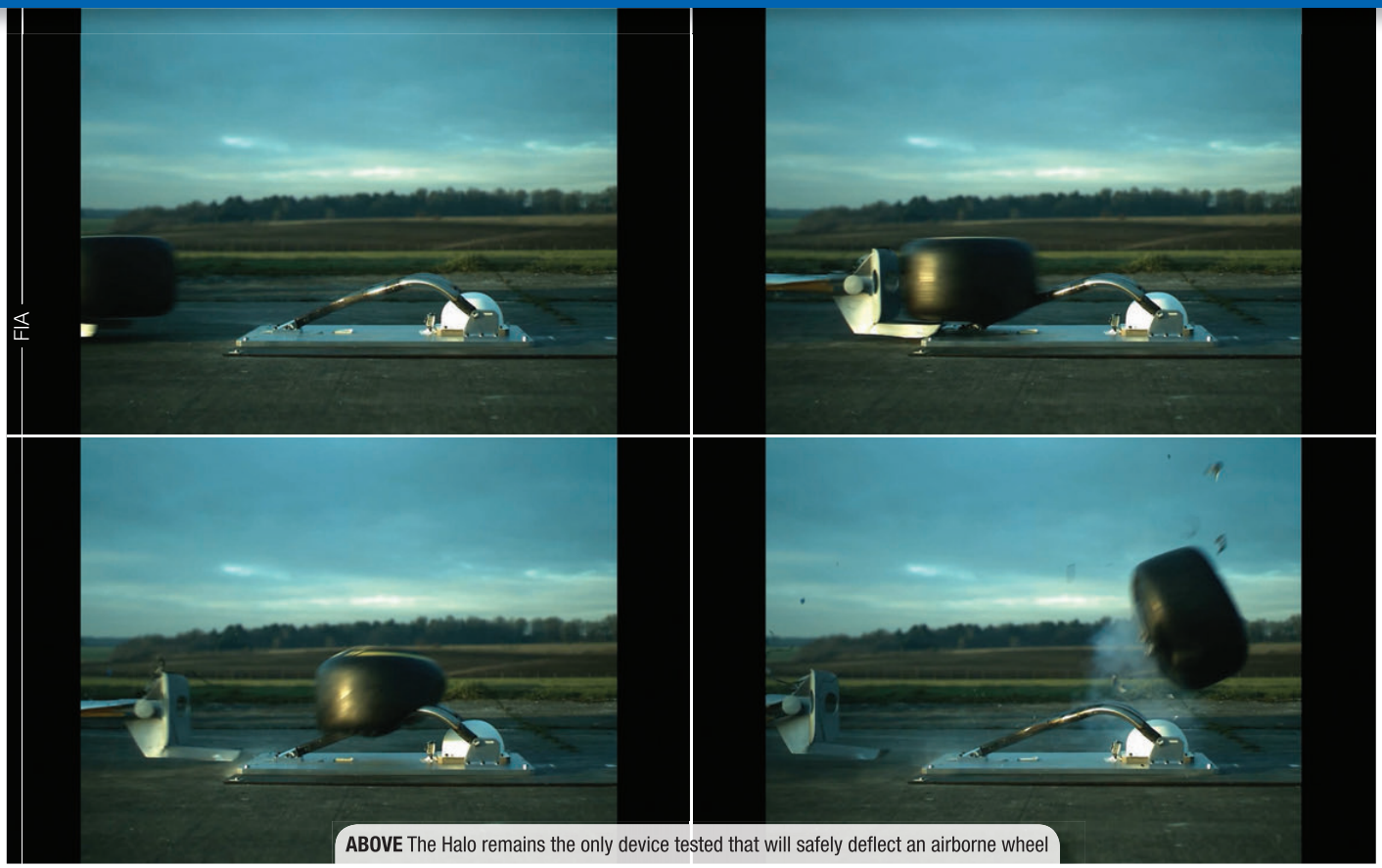

FIA

ABOVE The Halo remains the only device tested that will safely deflect an airborne wheel

one of aesthetics: nobody finds the Halo particularly attractive and the less intrusive it becomes, the less criticism it is likely to face.

The distaste is perhaps a little unfair, with Charlie Whiting, FIA Formula 1 Race Director, pointing out no-one as yet has seen a race-ready Halo integrated with a chassis. "Bar one [liveried device], all the Halos we've seen so far have been raw. I think we should wait and see what the teams come up with," he suggests.

"They have to use the standard Halo, which will come from a single supplier – but we will allow them to use non-structural fairings around the upper part to give them scope to overcome any aero challenges they have, for example with the airbox [where] they wanted to be able to redirect the flow. For sure they will all exploit that extra freedom that they've got – even if it's just for aero reasons. I'm sure they will look more pleasing to the eye once that's been done."

Without a definitive specification, technical chiefs are circumspect on whether there are any differentiations to be made from fairings around the Halo. Nick Chester, chassis technical director at Renault, suggests it isn't likely to be a game-changer: "It's good to have something there that's going to give the driver more protection. Everyone's behind that and wants to put it on the car for that reason – but in terms of aero, if anything it's a detriment and you have to work around it being fitted to the car. I don't think there will be any huge tricks with it. I think everyone will just want to put it on the car and make it the best they can for the drivers."

> *"We played the game of throwing millions of small objects at the Halo from different angles"*

TRICKLE DOWN

The expectation is that, once used in F1, the Halo will trickle down into junior single-seater categories. Mekies sees this as very much in keeping with standard FIA procedures. "It's certainly the intention," he says. "[The Halo will] cascade down as we do with any other safety feature, from safety belt standards to helmets. The Halo will be the strongest part of the car, and it won't be possible to retrofit it to an existing car, so it may take some years in the smaller categories as they don't build a new car every year – but we will be introducing it to every new single-seater that comes after F1."

The Halo may also go beyond the aegis of FIA championships. It is conspicuous that the case studies from which the Halo specification was developed feature CART/IndyCar examples. "We have research groups where all the main categories of motorsport are involved: FIA or non-FIA, it doesn't matter," says Mekies. "We meet four times a year with NASCAR, IndyCar, DTM, V8 Supercars and share all of our research: this is how we could design the Halo specifically for Justin's accident and equally why we collaborate with IndyCar, which is also looking at windscreen solutions. We might not reach the same conclusions but we share everything."

One of the main criticisms of Halo is that it protects against an accident that doesn't happen. Max Verstappen, one of several drivers broadly opposed to the Halo, articulated it in Hungary: "The wheel tethers are quite strong at the moment, so I don't think you will lose a wheel very easily. And when there are parts flying around the car, it's not really going to protect you. I don't really understand why we need it."

Verstappen's point is not without merit: the Halo caters for incidents not witnessed in F1. It is, however, worth considering that all too often safety features are designed in response to a tragedy. It is refreshing to see the standards for once attempting to get ahead of the curve. RT

SWERVING DOESN'T HEAT THE TYRES

Valtteri Bottas's spin behind a safety car prompts **Paul Haney** to debunk one of tyre technology's enduring myths

WHILE lapping behind a safety car at the Chinese GP, Valtteri Bottas managed to lose control of his Mercedes-AMG F1 racecar. He was swerving back and forth across the track at the time, thinking that would help him keep his tyres warm. He acknowledged "aggressive" swerving and an "amateur" error but, actually, he shouldn't have been swerving at all.

After a few laps at speed on a track tyres get hot and it seems obvious that's caused by frictional heating. But that's not how tyres get hot.

I'll get to the details but there are two reasons why swerving doesn't heat the tyres any more than driving at speed in a straight-line. At any one time only a few percent of the tyre's tread surface, some portion of the contact patch, is generating frictional heat. At that same time all the rest of the tread surface is cooling. And, since rubber is a poor conductor of heat, very little of the frictional heating in the contact patch gets into the bulk of the tyre.

TYRES DO HEAT UP

Mainly, tyres gain heat due to hysteresis, energy absorbed in the rubber when it is compressed, stretched or deformed in any way. Hysteresis is a characteristic of a viscoelastic material, which certainly describes rubber. Visco says it's viscous, elastic meaning it will stretch. Being viscoelastic, rubber stretches and bounces back but not all the way back. Energy in not-all-the-way-back is lost in the rubber but you never lose energy, in this case it becomes heat. We need hysteresis in rubber because it gives us grip but that's another story.

We can see the bulge in the sidewalls at the contact patch but we don't notice the straightening of the sidewalls at the top of the tyre 180 degrees from the contact patch. These two deflections rotate around the tyre at the speed of the car. Due to hysteresis some of the energy causing these deflections is absorbed by the rubber in the belts and plies, generating heat in the tyre. So just rolling down the road under load heats a tyre. How quickly a racing tyre comes up to a good operating temperature, at least 180 degrees F, depends on the load, car speed, ambient temperature and the track surface temperature. With lightly loaded racecars it might take a few quick laps to heat up the tyres. Drivers who are quick on cold tyres have an advantage early in a race.

> *"The study showed that swerving increases tread temperature a small amount but less than people think"*

TREAD TEMPERATURE VARIATION

Figure 1 shows that only a very small portion of the tread surface is heating at any one time. The solid line traces the temperature of a spot (maybe only a few molecules deep) on the tread surface of a rolling race tyre ▶

BELOW Valtteri Bottas rued his "silly mistake" in China but it raised an interesting question: does swerving really help the tyres anyway?

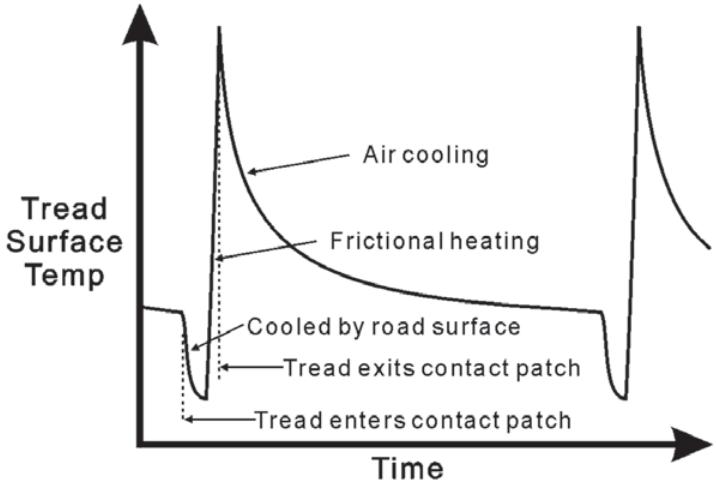
Mercedes F1

> *"96% to 98% of the tread surface is constantly cooling"*

near maximum grip in a corner. There are no values shown because we can't measure tread surface temperature in the contact patch. We can, however, place an infrared sensor looking at the tread surface as it rotates out of the contact patch and recorded data shows temperature as high as 400 deg F.

The solid line shows how surface temperature changes as the tyre rotates. Our spot on the tread is in the contact patch during the time between the two dotted lines. We can see the rubber is air cooling as it comes into the contact patch and is cooled further by the road surface at the front of the contact patch where the tread is stuck to the road. Further back in the contact patch where sliding occurs, frictional heating quickly spikes the surface temperature up as high as 400 deg F. But when the rubber comes out of the contact patch it quickly cools, first by air rushing over the tread and then by the road surface as our tortured little rubber molecules once more enter the contact patch.

FIGURE 1 Only a tiny portion of the tread surface is heating at any one time



HOW MUCH OF THE TREAD IS GENERATING HEAT?

A tyre 26 inches in diameter is about 82 inches in circumference. Inflated to 20 psi and loaded at 500 pounds the contact patch has an area of 25 square inches. You can find race tyres with tread widths between 6 in and 16 in so the loaded contact patch length is between 4 in and 1 in. That tells us our rubber molecule is in the contact patch for 2% to 4% of the time during one revolution. And, of course, that means 96% to 98% of the tread surface is constantly cooling.

RUBBER IS AN INSULATOR

Rubber is a good insulator, about the same as polystyrene foam used in cold drink coolers. The insulating characteristics of rubber is why hysteresis heating in the plies has a tough time getting out of the tyre and frictional heating at the tread ▶

ABOVE Tension builds behind the safety car. If swerving encourages the competitive juices to flow, go for it, but will it really help the tyres?

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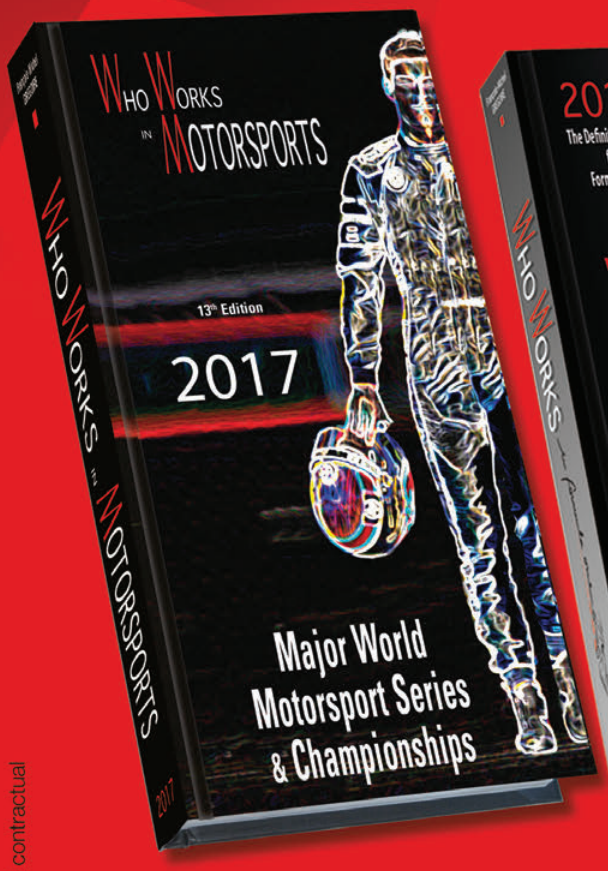

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Hone/LAT

ABOVE Bottas works his way back through the field in China, having dropped from fifth to 12th following his spin

surface can't get in.

Let's say you've got a cooler full of ice and beer. Place a fan so it's blowing air down one side of the cooler. Then put a heat lamp shining on that same side with a timer that repeatedly turns the heat on for one second and off for 20 seconds. Do you think much heat is going to get into that cooler?

IS THERE ANY BENEFIT FROM SWERVING?

One of the people I spoke with on this subject was Arnaud Dufournier, President of Dufournier Technologies, a French company with some specialized tyre testing hardware and software. Here's what he had to say:

"We worked a few years ago on that subject for Formula 1, and the study we did showed that swerving increases tread temperature a small amount but really less than people think. Braking has a very low impact on tyre heating because it doesn't last long enough, one or two seconds. The best way to heat-up tyres is to spin them, but it works only for rear tyres and it's possible to damage the tyres.

"Swerving with quick movements of short duration does very little heating. Longer movements over a wider portion of the track work better but still don't generate very much tyre heating and the driver risks picking up dirt and rubber from the track, degrading tyre performance."

In the end the only benefit from swerving might be some cleaning of debris off the tread surface. A hot tyre can easily pick up any loose rubber bits, dust and gravel that happen to be on the track. Swerving can help roll this stuff off the tyre but the tyre can also pick up more debris in the process.

The guys working track support for brake and tyre suppliers will tell you that drivers should warm brakes and tyres at the same time by driving straight while alternately braking and accelerating.

If swerving gives a driver something to do and helps him gather up the competitive juices, go for it. But it's not heating the tyres! RT

• Paul Haney is author of *The Racing & High-Performance Tire*, co-published with the Society of Automotive Engineers. He works with race teams and presents seminars and webinars on tyres and basic vehicle dynamics.

Dunbar/LAT

ABOVE The grid forms up at the end of a formation lap punctuated by aggressive weaving

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DRIVE FOR TOP FIVE

Best of the rest? Not yet, but as **William Kimberley** discovers when talking to technical director James Key, that's Toro Rosso's target

Red Bull

ABOVE The STR12 sat sixth in the Constructors' standings at the summer break, but would have been higher was it not for missed opportunities

THE term 'best of the rest' doesn't really fit well with James Key. After all, he's a racer and knows only one result counts, and that's winning. However, the reality of the situation at Scuderia Toro Rosso, the team he heads up on the technical front, meant that it would always be an uphill struggle not being a factory team.

"There's a tremendous benefit in being able to design your chassis and engine together whereas if you can't, as in our situation, it's always more of a challenge," he says. "When you're a customer team you don't have the instant communication between the power unit guys and the vehicle performance and aero teams. Having said that, Renault has been good at indicating certain milestones that are important to chassis designers."

With the factory teams in a different class, his and the team's benchmark is therefore Force India which as he admits is doing an outstanding job. That doesn't mean to say that it isn't in his sights and he hopes that his team's fortunes will improve in the second half of the season to offer more of a challenge to the Silverstone-based outfit.

"There are two aspects to where we will be by the end of the season," he says. "We've been trying to compete in the top five for a couple of years, but various things have prevented that, some of them out of our control, and we are in a similar situation now. We know we can do it. If you take Austria, for example, one car qualified in Q3, but without a time due to the yellow flags, but it meant we had a set of unused tyres, and felt we could challenge the cars ahead while we also wanted

Red Bull

ABOVE Key says there is more to come from the team

to get the other car back into the points. The first lap we were P9 and thought we'd have a go at the Force Indias but at the end of that lap it all fell to bits following an incident and an engine problem. At least with one car it meant we really missed a big chance.

"It was similar in Canada and in Baku. I know that other teams have had their problems, but we seem to continue to have the lion's share of them.

"If we can compensate for that in the second half of the season and find cleaner race weekends then judging by what we've just missed, I think we can be far more competitive and stand a chance of being in the top five. That's the objective."

One thing that is helping is that the team had developed a competitive car from the start, which was quite a challenge bearing in mind the raft of new regulations. While generally pleased with the 2017 car, Key concedes there's still room for improvement.

"There are so many aspects to the car this year," he says. "We are very pleased with some of them but not so happy with others. ▶

Craig Scarborough

ABOVE Toro Rosso reacted well to the challenge of constructing a new generation of F1 car for this season

Craig Scarborough

ABOVE The return to a Renault power unit, after a year with Ferrari, necessitated a completely different design philosophy for this season's car

Craig Scarborough

ABOVE Preventing the front tyre wake from interfering with the cooling flow was a key design challenge

There are a couple of interesting things this season in that the landscape of performance levels has slightly shifted. There are two teams which from the start of the season have been some way ahead, and then there is a group of teams that have different strengths and weaknesses.

GREATEST UNKNOWN

"What's worked for us is our simulation. I think that with such a different set of regulations where you don't have any historic data associated with the global performance of the car, we've come up with a competitive package. This was a challenge taking into account the aero and weight changes, although it was the new tyre sizes and compounds that were the greatest unknown because they're absolutely critical to all this. Taking all this into consideration, our simulations were remarkably accurate."

Key explains that without having comparable data, it was a question of using best knowledge and expertise to try and estimate what would happen: "Our tyre group and the vehicle performance group both did a brilliant job of getting that pretty close in terms of raw performance and where we expected the car to be. We learnt about the variability of the tyres last season from circuit to circuit and the same compound of tyre having surprisingly different results. We picked up a good way of understanding what those differences were and gained knowledge of what should be similar and their subtle differences. It's really all about the fine details and a combination of all sorts of different things. While we have seen greater variability this year, we are more on top of it, but it's one thing expecting it and another having to do something about it."

Along with everyone else, one of the aero challenges this year has been dealing with the wake of the front tyre. "If that begins to interfere with cooling flow, then it gets really messy," Key explains. "But we've been able to keep the bodywork a little bit out of the way of that.

"It's slightly more complicated on the back of the car with the exit of the slow-moving air from the cooling system into an area which is more powered up with the rear wing and diffuser. There are far more cooling efficiency issues to consider there, but it hasn't really been a problem."

> *"Our simulations were remarkably accurate"*

Back with the Renault power unit once again after a year out last season with Ferrari, Key says that it led to a completely different design philosophy for this year's car. "On the one hand, we kind of knew what to expect from a general Renault installation in terms of the way certain things are cooled, how the circuits work and their overall philosophy," he says. "On the other hand, we had to learn really important issues such as how the engine's performance characteristics interact with the design installation of the car as they were completely new. We didn't have the luxury of a transition from one year to the next. Things that looked important at the time seem less so now, whereas items that didn't look important became so. It was a bit of a learning experience."

Around about mid-July is when teams have a decent idea of where they are going with next year's chassis. By September/October they want everything pretty well firmed up, but as Key explains, it is on a case by case basis.

"By mid-season what we've learnt so far is the variability we get in our performance and whether we still have the same strengths and weaknesses we've had before and how do we address them. All the lessons we're learning right now are being built as best we can into next year's car. We're also looking at quite a few philosophical changes we're making in certain areas."

One thing that won't be changing is Key's position, having recently extended his five-year stay with the team by penning a new contract.

"STR is unique, facing the challenges of being spread over two countries and fulfilling the roles of both a team in its own right and an important part of the Red Bull driver programme," he says. "They are challenges that the team takes in its stride and, while doing so, continues to grow and improve year on year.

"We have more work to do, and I look forward to taking the next steps with Toro Rosso toward our goals."

"Formula 1 is a team sport, but one in which an individual can still make a difference," points out team principal Franz Tost. "So far, in his time with us, James has proved that he can indeed make that difference." RT

"I WAS ACTUALLY TESTING FOR REAL"

Alan Stoddart reports on a new simulator targeted at race teams as well as the sim racing and eSports sectors

FOR the last two years Exsim UK, an expert in interactive events, digital event services, simulator hire and eSports, has been developing a revolutionary new racecar simulator. Its aim is to deliver unparalleled racing realism in a compact, attractive and self-contained package.

The goal of the project has been to produce a new 'full motion' simulator, delivering the most realistic and accurate driving experience possible. That includes providing the sensation of oversteer, which although crucial to the sense of realism, is lacking in some comparable simulators.

The VR5, which is now available to test at Exsim's headquarters in Burton upon Trent, is both innovative and elegant in its execution of motion. Using a new concept in 4-post motion delivery, which provides pitch, roll, heave *and* rear traction loss from a stable and compact platform, the system accurately reflects the suspension feel of a real car.

Designed from the ground up as a Virtual Reality simulator, the VR5 is primarily configured for the Oculus Rift head-mounted display. This gives a remarkable level of immersion into the simulation. VR means there is no jarring break from the racing at the edge of a display, while the ability to turn your head and look through a turn adds to the sense of being at a racetrack rather than watching a race through a video feed.

As well as being designed for use in the sim racing and eSports sectors, Exsim UK director George Pilkington is also incredibly enthusiastic about the VR5 as a tool for teams. He highlights its use in driver training, allowing them to log hundreds of hours of racing in the off-season and between races, and enabling teams to explore a car's capabilities and hone set-ups before even arriving at a circuit.

Adding to its usefulness in this regard is the VR5's totally self-contained set up. Standing on a remarkably small platform, with the PC housing fully integrated into the design, the VR5 can easily sit in the corner of a team garage, and by using the Oculus headset, it does not need empty white walls for projections or large arrays of monitors.

The 'progressive yaw' system allows the rear of the simulator to step out while the front remains pinned to simulate oversteer. It combines with the underseat ButtKicker transducers, which transfer vibrations from the track and car into the driver, to enable him to feel the momentum of the car and explore the limits of traction through physical feedback, rather than being solely reliant on the visuals.

Compounding the feeling of being jostled around in a real racecar is the simulator's cockpit. After lowering himself through

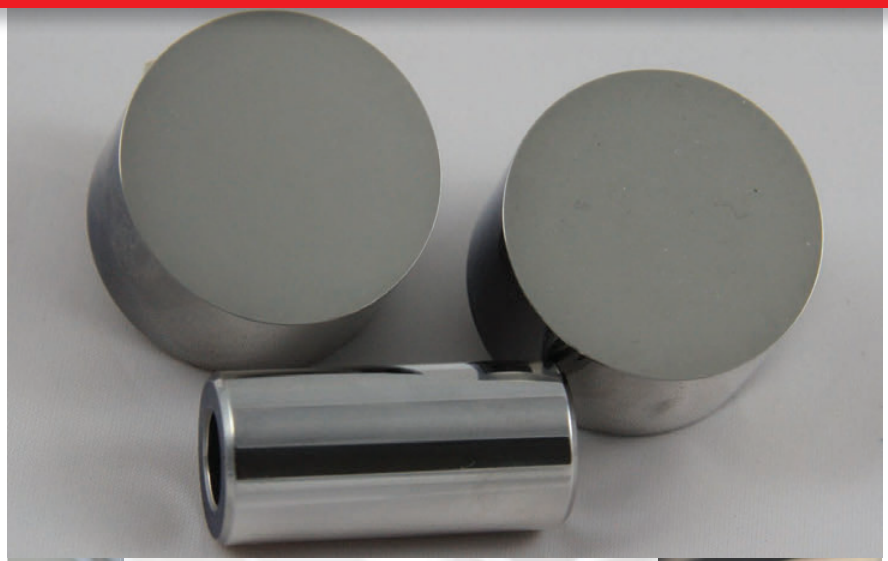
the narrow opening, the driver extends his feet towards the pedals and sits deep in the racing-spec Tillett seat with a Momo steering wheel perfectly placed in front of his chest. In these authentic surroundings, the jarring movements the driver is subjected to when running wide and getting caught up in a gravel trap, or losing the back end and spinning into a tyre wall, feel even more convincing.

Adding even more layers to this sense of realism are the other components used in the VR5. Race-ready FIA-specification parts are used throughout in conjunction with high-end simulation controls, which can be configured to match an actual racecar. The feel of these controls is critical to the overall experience, for example: the solidity and sensitivity of the Heusinkveld pedals allow the accurate control of braking and acceleration, which results in subtle pitch movements, proportionate to input, which in turn enables the driver to have greater confidence in his inputs. The feedback in the VR5 is such that pushing harder on the simulator is not a conscious effort, but is instead an intuitive process, reliant more on the development of muscle memory than on any mental action.

Feedback on the machine from a number of professional drivers, including Andrew Bentley (a competitor in many series and a grade A ARDS driving instructor) and Carmen Jorda (currently a development driver for the Renault F1 team) also meant that Exsim UK could hone in on the VR5's design strengths and eradicate any weaknesses along the way. Bentley states: "I can say with total conviction that the motion and immersion provided by this simulator tricked me to believe that I was actually testing for real, rather than being in a simulator. This is unprecedented in my experience of racecar simulation."

As part of its complete simulation package Exsim UK also offers customers fully customised simulation setup with remote support, whereby the integrated software suite that controls the motion can be easily adapted to fit the specific racecar that the customers themselves use. Furthermore, the VR5, which is a registered EU community design, is compatible with all of the leading simulation software, including iRacing and rFactor.

ABOVE LEFT, RIGHT & BELOW
Beneath the skin of the VR5, which has been two years in the making



ABOVE & BELOW PDJ Vibro's superfinishing expertise has won it a share of both the modern and historic motorsport markets

SCRATCHING THE SURFACE

William Kimberley talks to a company that specialises in surface treatment

WHAT do fencing, as in swords, aluminium engine components, contact lenses, hearing aids, camera cases, lab equipment, insoles for shoes, aluminium aerospace components, yacht components and Formula 1 gudgeon pins have in common? The answer is that they all need enhanced surface treatments to get the best out of them, a service provided by PDJ Vibro in the UK.

A family-run firm with over 100 years of experience in the vibratory finishing business, it has built up an enviable knowledge in metal finishing, vibratory, barrel and high energy centrifugal deburring, polishing and surface finishing machines. Not only does it sell machines for these processes, but it also offers a service to customers who either cannot justify buying such a machine or are otherwise overwhelmed with work and turn to PDJ Vibro to help out.

"We are a machine supplier and we need to have them on display," says managing director David Hurley. "If they are on display, they may as well do some work. What typically happens is that some customers subcontract the work to us but then end up buying the machine. Sometimes a client has a bottleneck and then turns to us to help out."

When it comes to motorsport, it is the superfinishing process that is most wanted. "It's common for the surface of moving parts in motorsport to be improved to reduce friction and heat and give longevity to the components while it also addresses the loss of power in a transmission, so there is a tangible performance benefit," says Hurley.

"There are a couple of different ways of doing this, one being an acidic process which is very popular in the US, but can be unnecessarily harsh on components. We also find it can affect tolerances. Our approach to superfinishing is a process that's become really popular in the last five to 10 years. This is where the parts are put into a machine with a non-abrasive polishing chip of a shape and size that gets into nooks and crannies. We then add a toothpaste-like substance and start the process that generally lasts around 14 hours. At the finish, the parts look dull, but the surface will be good. They are then flushed through with fresh compound and water to clean off all the paste and when they come out, they look like they've been chrome plated."

However, Hurley says that there's a limit to what can be done: "If a part is heavily pitted, nothing can put that right, but if it can handle light corrosion and as long as the chips can go over the affected surfaces, such as the root of a tooth on a gear, we have medias that can do that."

Business can be brisk, and of the three million parts that the company treats on a monthly basis, the motorsport percentage can be quite high. "We can process a single transmission set, a one-off batch of prototypes or some clients send us batches of thousands of motorsport gears," says Hurley. "It may be that some clients already have machines, but at peak points in the season they get a bottleneck so they send the overflow to us."

PDJ Vibro also services the historic racing car industry. "What can typically happen," says Hurley, "is that someone discovers us and uses our surface treatment processes that gives them a competitive edge. The competitors find out what it is and then come to us the following season. This happened not that long ago when we found we were suddenly doing a batch of Mk1 Minis. We also recently did work on a 1980s Porsche and when the engine went back to the builder he told us that he's never had one that went back together so easily." RT

THE END OF DIESEL

Thanks very much to the politicians, says **Sergio Rinland**. Now we can go and spend zillions on EVs instead

EIGHTEENTH-century English poet Alexander Pope has often been misquoted to have said, "A little knowledge is a dangerous thing". To that I would add, 'More dangerous than no knowledge at all'!

This is a thread that seems to unite politicians of the world today. It was surely behind their encouragement for us all to use diesel engines.

Back in 1998, the UK's Chancellor of the Exchequer at the time announced: "Diesel cars should attract less vehicle tax than their petrol equivalents because of their better CO2 performance." Fast-forward to the present day and the Mayor of Paris has just revealed that from 2020 no more diesel vehicles will be allowed into the city as part of an anti-pollution drive. By 2040, only electric vehicles will be sold in France. The UK environment secretary has also trumpeted the fact that Britain will ban the sale of diesel and petrol cars from 2040.

An important fact about diesel: it is more expensive to produce than petrol. From every barrel of oil only 15% can be refined into diesel, therefore the majority is refined into petrol to make it a better business case for the oil refineries. So, the fact that in Europe diesel is cheaper than petrol, and in the UK it is about the same price, is because it is taxed differently, favouring the consumption of diesel.

Not only the UK, but the world over, was convinced that by promoting diesel we were to be better off with less CO2 emissions. It is true, diesel emits less CO2 per kg than petrol and hence, it is more economical. But – and here is a big but – it emits NOx in bigger quantities than petrol, mainly due to the higher combustion temperature. It also emits other particles that are harmful to our health, perhaps even more so than CO2.

It is all a function of the temperature in the combustion chamber. The higher the temperature and leaner the mix, the more powerful and efficient the engine is, it emits less particles and CO2. But it produces higher NOx emissions, as demonstrated by the graph.

Due to the big push for diesel, Audi (from 2006) and Peugeot (from 2008) fielded diesel-powered cars in LMP1, winning every Le Mans 24 Hours between 2006 and 2014. There were two reasons, as usual in motorsport. One of them was marketing (promoting diesel-powered cars) and the other technical, because racing engineers really managed to clean diesel to the point that the exhausts of the Audi and Peugeot were as clean as new after 24 hours of competition. That was due to higher temperatures and a leaner mix, as well as particle filters. This was all very applicable to production engines, making them even more economical, and reducing CO2, which was the prime reason to use diesel.

Yet even the efforts of motorsport couldn't clean *all* diesel engines. VW's 'Dieselgate' scandal did not help either. So once the politicians learned that NOx was more harmful than CO2, they turned 180 degrees.

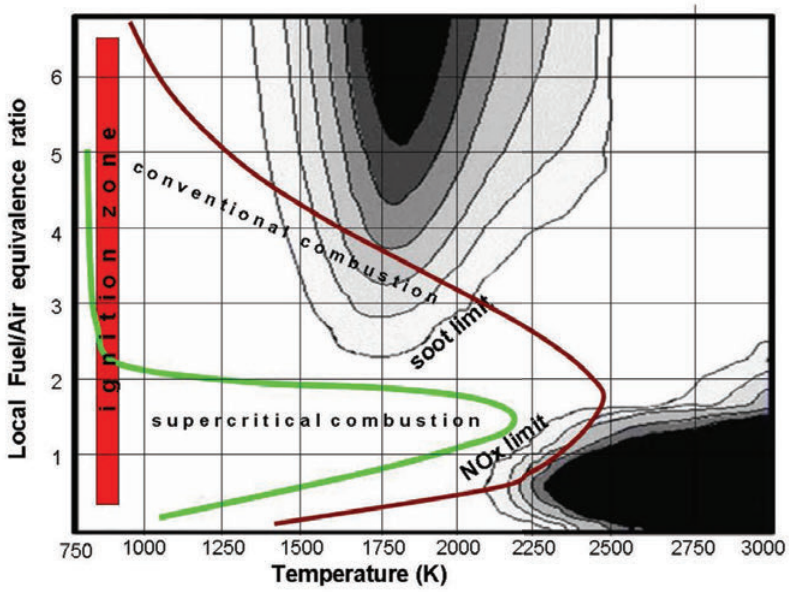
All this brings us to the current phenomenon of electric vehicles. Once the strategy of reducing CO2 emissions with diesel had backfired (literally!), it left only one route for automotive to clean its act: electric vehicles (EVs).

At the same time as the realization of the harm of diesel dawned on us, Tesla came of age with its electric cars. This created the 'Tesla Syndrome', whereby the automotive industry had no choice but to spend zillions in developing EVs. To the point that Porsche announced recently that it will stop producing diesel engines and concentrate on electrification.

The only car company that did not jump on the diesel bandwagon was Ferrari. But, such was the pressure being exerted on manufacturers, you suspected it would be a case of when, not if, that happened. Now, thankfully for the Ferrari fans the world over, we will never see a Ferrari diesel!

Where does that leave motorsport? With Audi (VW Group) and Renault at the forefront, the OEMs soon realized that for the same reasons they once focused on diesel engines, now they have to develop the electric drivetrain.

If we add to that the recent announcement from Porsche that it will stop its participation in the WEC, its natural habitat, and enter Formula E along with BMW and Mercedes-Benz, it's clear who the real winner is. That is what we call '*vision*'; hats off to Alejandro Agag! RT



ABOVE Motorsport's pioneering role in 'supercritical' combustion, when the fuel behaves like liquid and gas at the same time, creates the diesel dilemma: cooler, richer combustion has less NOx but more particles; a hotter, leaner mix has less soot and CO2 and more NOx

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