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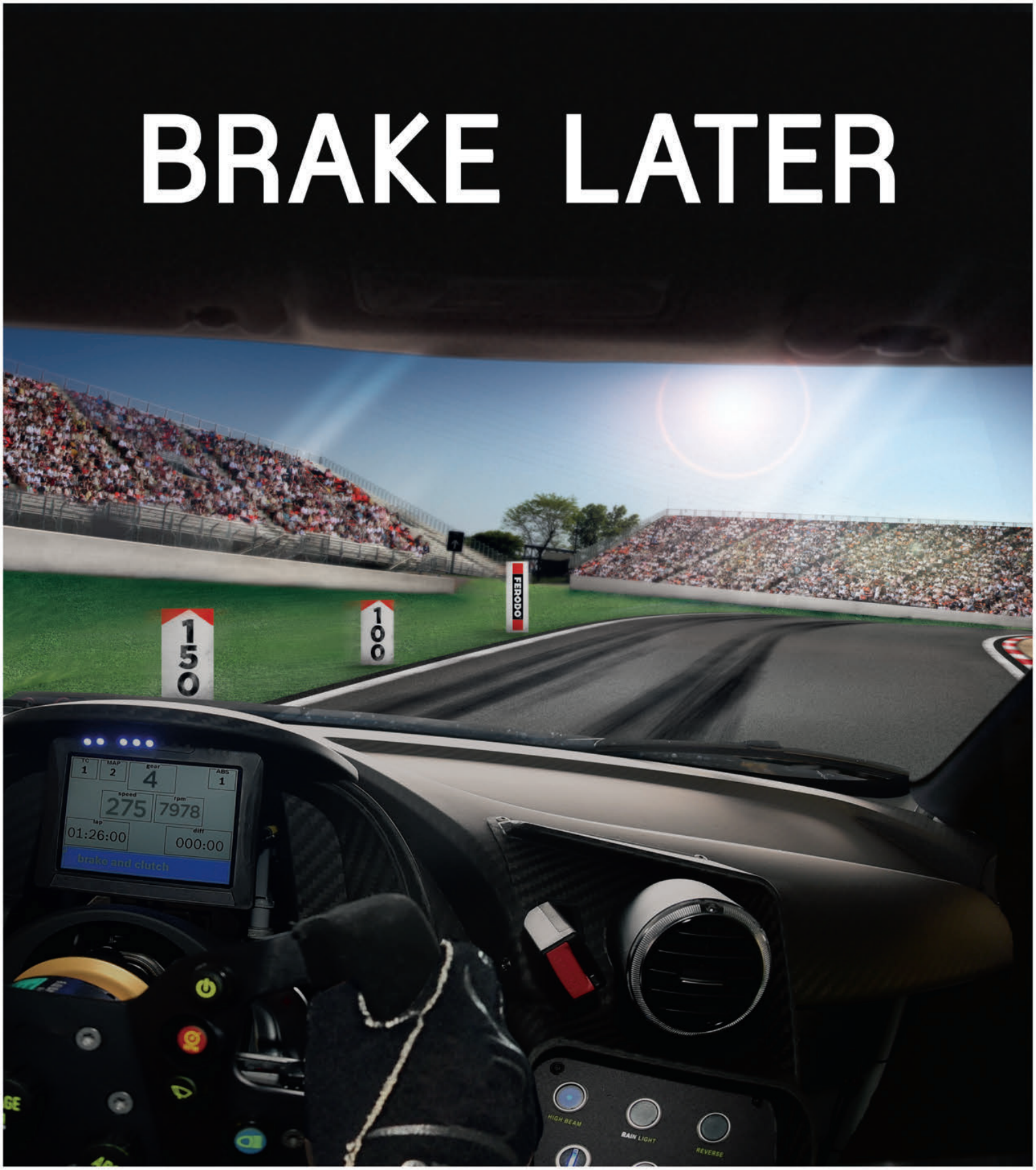

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GETTING INTO TRAINING

OVERWHELMED. Honoured. Humbled. Actually I am not certain what to write because no words can do justice to the way that we all feel at the magazine for the immensely kind and supportive words that have been sent to us as we celebrate our 200th edition as will be seen inside. To me it's a bit like running the Marathon. I remember a few years back going out on a cold winter's morning, when I really didn't feel like it, to train for the London Marathon. I am not a natural athlete but it was just something I felt I had to do and it was three months of really pushing myself before the big event.

However, on the day itself, it was magical. It was payback for all the hard work, running in the rain and sleet and sometimes snow, the aching muscles, the runner's nipple and heaving chest that had gone into preparing for this day. It's still something I look back on with pride.

The same feeling is true with the magazines we produce, especially *Race Tech*. As many of you will know, we are not a big organisation, which means that we have to turn our hands to many things, even unloading lorries when the occasion demands. If we have to put in long hours, then we do it, but so do so many in the industry we cover, so no big deal there. Like preparing for the Marathon, though, we actually see and benefit from the work we put in, and I still get a real kick when the magazine is first delivered from the printers even though I know the content backwards.

However, while publishing director, boss and wife Soheila and myself have personally received a lot of praise, we are nothing but the front people. Those who know me will tell you that I always say that this magazine would not happen without a lot of people in the background who work as long hours if not longer to get it out every month. Mark Skewis, for example, may be the 'consultant editor' but he is the living heartbeat of the publication. His knowledge, contacts and perseverance – and bullying and cajoling me where necessary – bring to you the magazine in front of you now every month. Then there is Paul Bullock, our longstanding designer who has been casting his magic on the publication for longer than I have been lucky enough to be at the helm. Then there are the various contributors who provide us with such wonderful, insightful articles and, of course, the backroom guys and girls who oil the cogs of this small, but highly tuned machine. Thanks, too, to our advertisers. As the captain of a plane says on landing, we know you have a choice, but thank you for flying with us, we really value you.

We may not be one of Ulrich Baretzky's finely engineered engines, but perhaps a bit more like a Swiss watch.

Having bared my soul, so to speak, I can also announce something else about which we are mighty proud. Some of you may remember that before getting the summons from Soheila to join *Race Tech*, I was the editor of *Automotive Engineer* at the Institution of Mechanical Engineers for 10 years. Well, it seems that I am about to become involved with the publication again because it is becoming part of the Kimberley Media Group portfolio. To say that we are all immensely excited at this is an understatement because along with *Historic Racing Technology* and *Track Car Performance*, it really gives us total coverage of the motoring/motor racing scene.

Friends, and this includes Mr Skewis, think we are mad because it's not as if we don't have enough on our plate, but we like to follow the motorsport industry's 'can do/will do' credo.

Training for a Marathon? I think it's now more like training for an Ironman Triathlon. Where are my shorts? RT

William Kimberley
EDITOR

A dream coming true

William Kimberley

SKIPTON, UK: British motorsports engineering company Perrinn has announced that it has received the first order for a brace of its new LMP1 car to race in next year's FIA World Endurance Championship. With the design work already completed alongside preliminary digital and crash test simulations, the as yet unnamed car is expected to be revealed in late November before testing starts in December.

"It's been a very personal ambition to develop a Le Mans car," said Nicolas Perrin, founder and CEO of Perrinn who has more than 15 years' experience across sports cars and F1 projects as well as automotive technology programmes, including most recently an electric supercar. He started the LMP1 project in 2011 after leaving Williams F1 but then fell foul of the collapse in privateer support for LMP1 when the car was more or less ready in 2014. "I used to be involved in LMP1 in 2003/4 when working for Courage and racing at Le Mans with my own car is a passion that still burns inside me and something I have been thinking about for years."

However, with new regulations ensuring the latest LMP1 cars have a lifespan of five years he believes that more and more teams will see the appeal of the category. "Increased support and stability from the FIA and ACO, coupled with programmes from other manufacturers has meant we've had a lot of discussions with teams seeking more freedom than the new LMP2 category. LMP1 offers a route to progress from an engineering and pace point of view."

The first two cars sold will be run by a European race team with its identity and engine details to be released shortly. Priced competitively at £1.2m for the rolling chassis, the car will rely on torsion bar front suspension with coil springs over dampers at the rear and is expected to weigh 'significantly under' the mandated limit of 830 kg.

Perrin will oversee the build at a facility in Northamptonshire using a range of trusted subcontractors. "Motorsport leads the way in advanced manufacturing techniques and we are now capable of producing the car in an innovative fashion," he said. "We will nominate the best suppliers to produce parts and deliver to our subcontractors to undertake the assembly on our behalf.

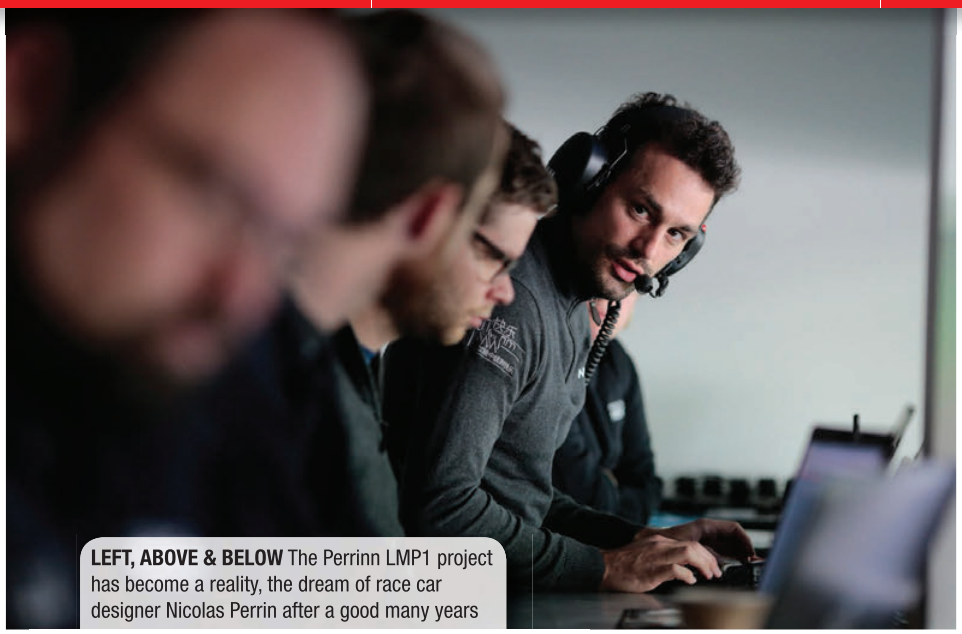
"However, we are very much re-evaluating everything because the initial certification for this car was done in 2014 and things have moved on a bit since then. Nonetheless we have more or less decided on the electronics supplier while something that we have always been firm about is that it will have an Xtrac transmission. The choice of whether to run on Dunlops or Michelins will be up to the teams and while we have a preference it's not yet fixed.

"Initially we designed the chassis to accept a variety of engines, but we have since optimised it for the powertrain that we will be announcing very soon," said Perrin.

He has been working closely with TotalSim which has been the main CFD supplier from the start of the project in 2011. "I have been working with them on a number of projects," said Perrin. "The way we work with them is that we acquire all the hardware while they provide support for us."

Further innovation is evident with Perrinn ensuring the design will be open source. It has a core design team of professionals split between England and France and to facilitate internal collaboration and also with outside partners and the public, the company chose Onshape, the first full-cloud professional 3D CAD system that enables multiple people to simultaneously work on the same design from any location.

Using Onshape allows Perrinn to share its car designs instantly with fans around the world without the need for them to purchase expensive CAD licences or to download or install any software. Non-CAD users can follow the progress of the design without any knowledge of engineering,



LEFT, ABOVE & BELOW The Perrinn LMP1 project has become a reality, the dream of race car designer Nicolas Perrin after a good many years

while designers can access the model anytime in the cloud, using any computer or mobile device. Its branching and merging feature makes it easy to experiment with design changes without worrying about impacting the original model. If changes prove to be desirable, they can later be merged with the original design. Perrin says he finds this feature to be invaluable when doing aerodynamic tests and stress analysis.

"I am using open source as a way to focus resources and talents around our project," said Perrin. "I want Perrinn to achieve success at Le Mans by becoming a much bigger organisation than it can be if we limit ourselves to a centralised closed company. Our workforce is decentralised and global while our team is open and accessible.

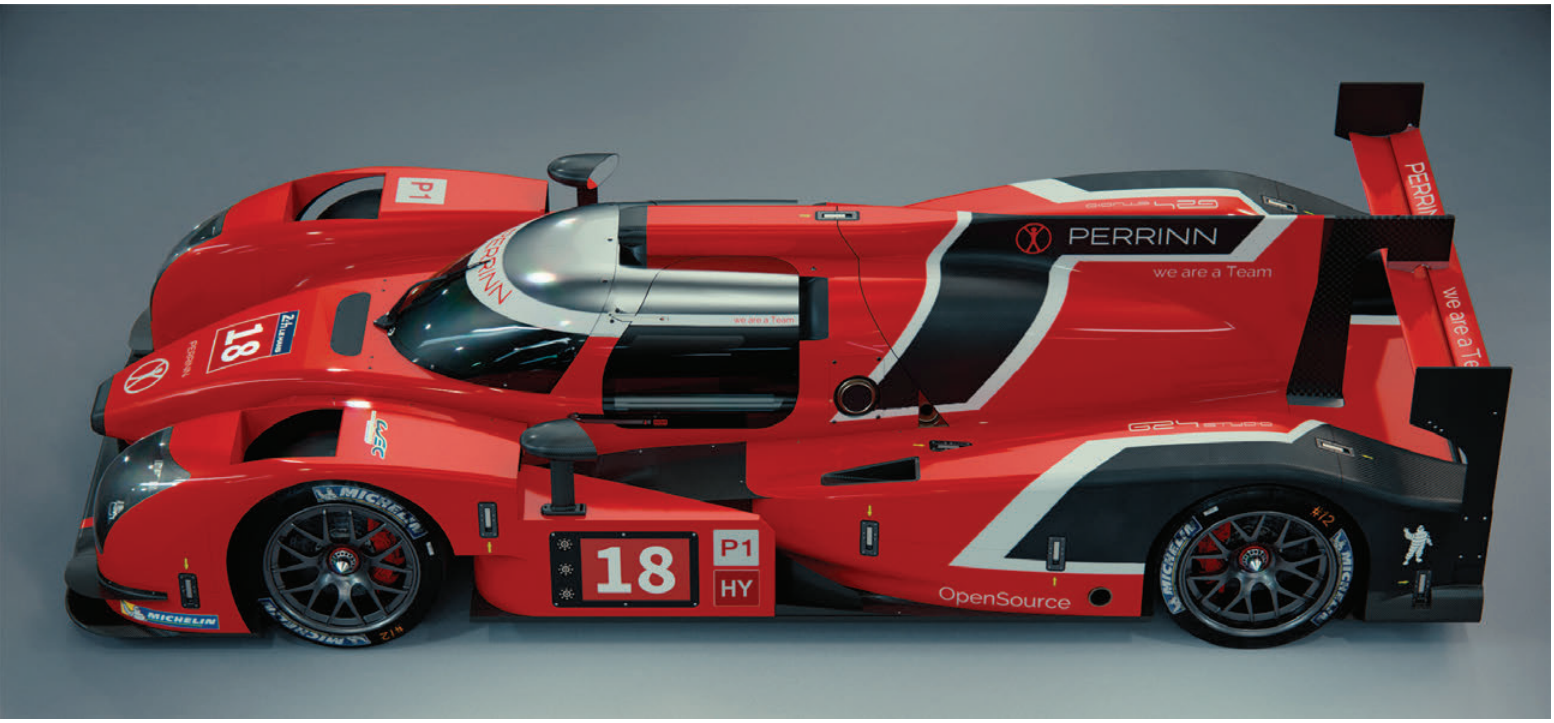
"Up until now we've been designing the car in the traditional way with a small team of experts, but further development will be open source. It's already started in a sense that the design has been shared on the internet for a while, but so far it's uni-directional in that we share what we do. However, it's not a crowd-designed car.

"In the open source software world you find that even the biggest software developers like Linux are maintained by a very small group of experts, so the open source is really a strategy for the medium to long term. It's something that the customer is very interested in and is one of the main reasons for buying our chassis although it did take a little time to understand the implications of open source. However, it does have positive implications for us and the customer."

According to Perrin, both the FIA and the Automobile Club de l'Ouest are delighted that the project is coming to life after so long. "I have had a relationship with both for years and they've known about the project for a long time now. When I announced that we were coming in 2018 they were really happy. Also, when I said that it was going to be an open source racing car, they thought about it for a split second and then realised the potential and were really super-happy about it. The ACO is very enthusiastic about an open source racing car as it can see opportunities with the fan base and the gaming industry."

In just a few short months, the programme has progressed very quickly to the point where there will be two cars plus enough spares to build another car within six months. "We have had to follow a very strict schedule laid down by the FIA to homologate the car which has given us a framework to follow and that is to pass the crash test in October," said Perrin. "It means that we have to start building the tub in July, which is what we are working towards. The car was already 95 per cent done when the customer came to us so it's not a problem. We have also ensured we have capacity to do more should some of our other discussions develop."

With the programme already at such an advanced stage, Perrinn has confirmed it is capable of supplying further cars for the 2018 season. RT



ABOVE M-Sport has been working on updates for the Ford Fiesta R5

Ford Fiesta R5 updates

Hal Ridge

COCKERMOUTH, UK: British firm M-Sport has released the Evo 2 version of its successful Ford Fiesta R5, which includes three different revisions to the car's engine. Nasser Al-Attiyah debuted the first of the upgraded machines on Rally Jordan at the start of May and dominated, winning by over 16 minutes, while Finnish driver Teemu Suninen finished second in the WRC2 category on Rally Portugal two weeks later.

M-Sport has used its three engine homologation jokers by introducing changes to the cylinder head, intake valves and exhaust manifold on the 1.6 turbocharged engine. "We've homologated a modification of the existing cylinder head, a porting modification for optimised flow. We have a new intake valve, again for flow optimisation but also we have decreased the weight, and decreased the inertia and friction of the system," said M-Sport R5 engineer, Laurence Kalavas.

"We also have a new exhaust manifold which is again for the optimisation of the flow of the engine. In general, we have managed a seven to eight horsepower gain at places on the power curve and also a flatter power curve to improve the driveability of the engine."

The Cockermouth-based firm has built 217 R5 Fiestas since the car's introduction in 2013, and continues to produce an average of one per week.

Kalavas believes the latest upgrades to the Fiesta bring it in line with the latest introductions to the category from Skoda and Hyundai. "The Fiesta now compares to the latest entries from Hyundai and from Skoda. We are in a programme of continuous development with the car."

The firm is also evaluating the possibility of changing the R5 Fiesta to the new version of Ford's hatchback, on which the 2017-specification World Rally Car is based. "It's a balance of what we could release now for the current car and what we could keep as a whole new package for a new car whenever that comes out," said Kalavas when asked if the firm would introduce a new car. "For that you're talking about a whole new homologation and it would be supported by a whole new development programme."

Additional R5 projects have also been revealed, based on a Proton Iriz and Opel Corsa. British firm MEM (Mellors Elliot Motorsport) that developed and ran Proton's Satria Super2000, has created the R5 Iriz which is expected to be homologated at the start of 2018, for which manufacturer blessing is required.

The HOLZER Group, which runs Opel Motorsport's European Rally Championship programme, has developed a private Corsa R5 and revealed the prototype car at Rally Portugal recently, but information on if or when the car will be homologated is yet to be released.

PFC wins prestigious award

William Kimberley

INDIANAPOLIS, IN: PFC founder, the late Don Burgoon, along with James Borner, Darin Cate, Paul Rankin and Mark Wagner, all engineers at Performance Friction Corporation have been awarded the prestigious Louis Schwitzer Award for its carbon disc brake system. Presented during a ceremony at the Indianapolis Motor Speedway, this award recognises individuals for innovation and engineering excellence in racing technology associated with the annual Indianapolis 500. The award memorialises Louis Schwitzer who won the first race at the Indianapolis Motor Speedway in 1909.

The winning PFC carbon disc brake system consists of a carbon disc and pad assembly made from single continuously wound strands along with a patented mounting mechanism. The material and manufacturing process of the disc and pads provide a uniform matrix which reduces unwanted vibration and tyre wear by improving the overall balance of the assembly. The disc is mounted to the hat with a novel, yet simple, retaining mechanism consisting of a double rolled ring and locating bobbins. The patented hat assembly greatly reduces stress, bending moments and distortion while the friction behaviour exhibits excellent modulation, cold bite and uniform heat distribution.

ABOVE Standing with the Louis Schwitzer Award trophy (left to right) were John Norton, staff engineer, BorgWarner and Louis Schwitzer Award Selection Committee; Darrick Dong, director of motorsports, PFC Brakes; and Jim Bailey, BorgWarner retiree and Louis Schwitzer award selection committee

"The spirit of innovation drives progress," said James Verrier, BorgWarner's president and chief executive officer. "If you glance in the rear view mirror, you'll see that past award winners have improved performance, efficiency and safety for generations of race car drivers. The engineers we acknowledge today will take their place in history, inspiring new innovations in the future."

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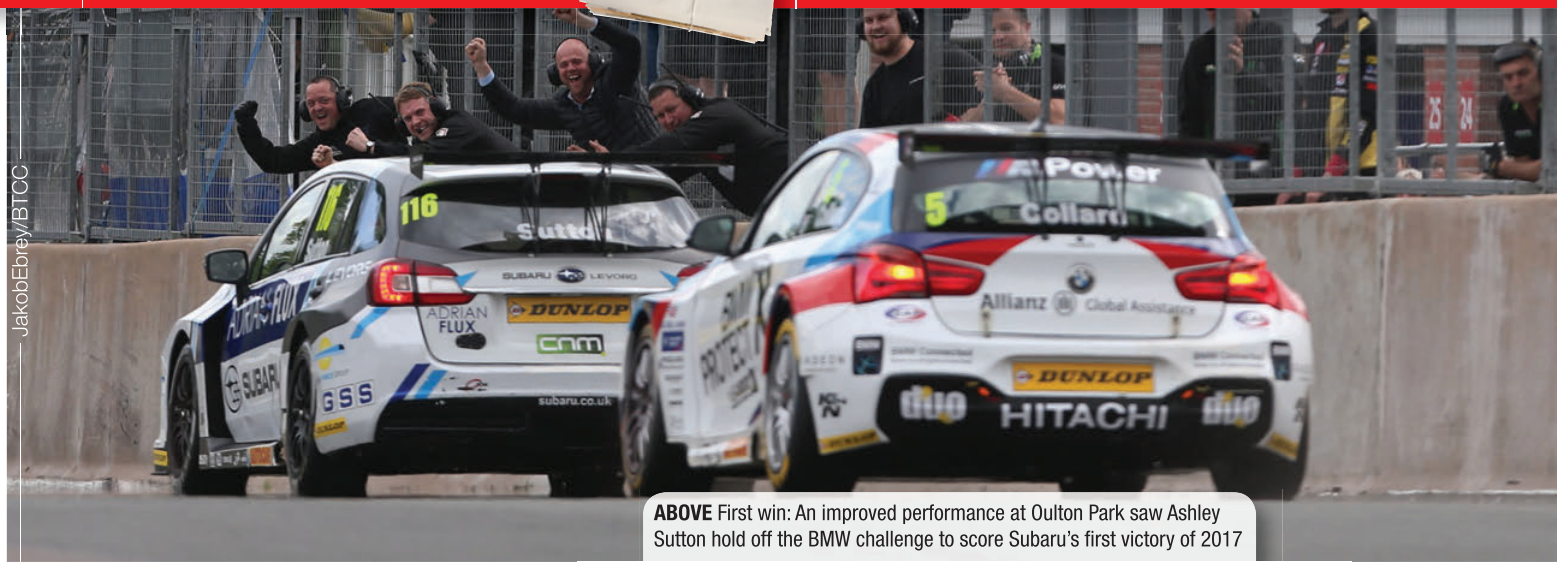


JakobEbrey/BTCC

ABOVE First win: An improved performance at Oulton Park saw Ashley Sutton hold off the BMW challenge to score Subaru's first victory of 2017

Subaru wins after boost probe

Andrew Charman

OULTON PARK, UK: British Touring Car Championship organiser TOCA has taken the unprecedented move of conducting turbo boost monitoring of Subaru and Ford cars during a race meeting, in the latest twist to the ongoing saga concerning the competitiveness of the Subarus in particular.

The analysis, carried out at the Oulton Park meeting on 20 May, appeared to have the desired effect, with Ashley Sutton scoring the Subaru team's first victory of 2017 and the Ford entries also showing increased pace.

Typically boost levels are analysed and if necessary changed after three meetings of a BTCC season. However, TOCA decided on the Oulton Park procedure after stating that it had become aware of "an anomaly regarding the power delivery" of the Subaru and Ford engines – both of which are manufactured by Mountune.

No details of the anomaly were given, BTCC series director Alan Gow stating that to do so would reveal confidential technical information regarding the engines. Similarly the result or outcome of the testing was not revealed, Gow merely telling *Race Tech* that the procedure had proved successful.

However, the Oulton Park weekend saw an upturn in fortunes for both manufacturers, topped by the Subaru Levorg GT of Ashley Sutton qualifying sixth and then following up a third place finish in race one with victory in race two, and fourth in the final race.

The Motorbase Ford Focus of Matt Jackson qualified seventh and took sixth in race one and seventh in race two, while an eighth grid spot for Team Parker Racing's Ford entry of Josh Cook was followed by an eighth and sixth finish in the first two races, promoting him to pole position for race three. A clash with eventual race winner Gordon Shedden's Honda forced Cook into retirement with broken suspension, but it was still a much improved performance from the Parker Racing squad.

Subaru team driver Jason Plato, despite continuing to struggle at Oulton Park in what he declared as "the worst season of my career," welcomed the boost monitoring exercise. "TOCA has listened to us, looked at our data and they agree that there is something weird going on with the engine," he told ITV Sport. "It's not producing the power that they believe it should based on the base level boost settings at the beginning of the year, and they are working with us to try and correct it. You can see how much more the other cars pull out on us on the straight. We took our car, the MG and the Ford to a rolling road and the difference is enormous."

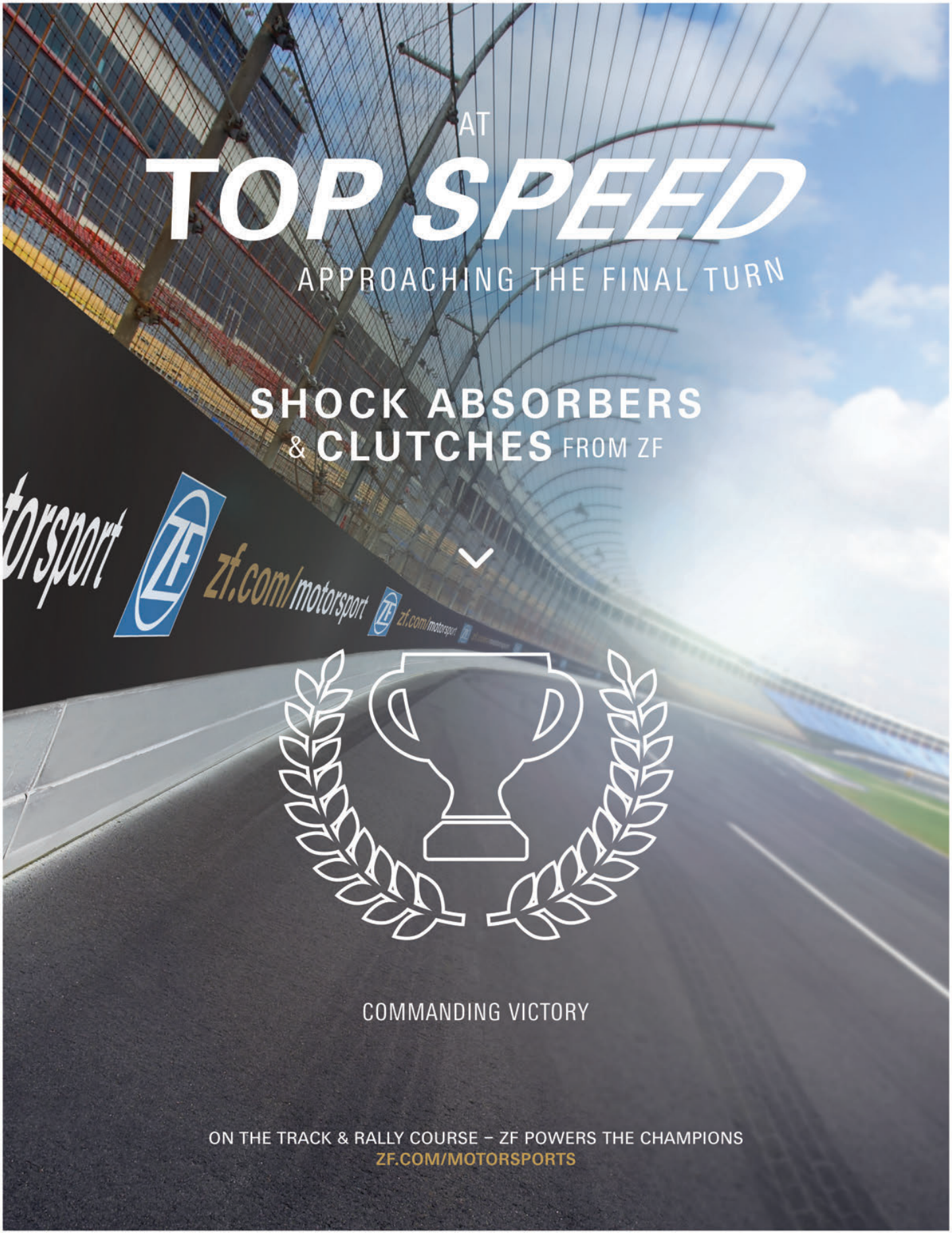
Plato continued his criticism of mandatory centre of gravity changes, applied to the Subarus at the start of the season. Detailed in last month's *Race Tech*, these were intended to bring the unique layout of the Levorg, based around a compact flat-four engine, into line with the more traditional rear-wheel drive cars of BMW.

Plato claimed that only the relative positions of the engine and gearbox had been analysed before the changes were mandated, and the fact that the Levorg is an estate, and that its turbocharger is mounted well in front of the engine, not taken into account. The increase in the centre of gravity had opened up a range of aerodynamic and drag factors that the team was still working fully to understand.

Plato put his own continuing pace issues down to the legacy of a heavy accident he suffered during the opening weekend of the BTCC at Brands Hatch, suggesting that something resulting from the impact had made his car react differently to the other three Levorgs. "The best option would be to dump the car and build a new one, but we can't do that," he said. RT

JakobEbrey/BTCC

BELOW In focus: Josh Cook starred at Oulton Park, his Team Parker Racing Ford Focus contending for top finishes following turbo boost monitoring



MOTION AND MOBILITY

Nigel Kinrade/LAT Images for Toyota Racing

BELOW Compound interest: Kyle Busch used the softer compound option tyres, identifiable by their green lettering, but took the $1 million win on the prime rubber

Tyres compound all-star race strategy

Andrew Charman

CHARLOTTE, NC: NASCAR tested its planned move to introduce a second tyre compound to the headline Monster Energy Cup on 20 May, by making the tyres available in the non-points All-Star Race.

Each team competing in the $1 million race at Charlotte Motor Speedway was allocated seven sets of prime tyres and two sets of the softer compound option tyres. These were predicted to be worth three to five tenths of a second per lap over a short run, and had green instead of yellow sidewall lettering so spectators could tell when they were being used.

Teams were permitted to use the option tyres at any time during the one-off race, which was split into sections, but were told that they had to put on a full set of options during a pit stop, and if saving them from the final 10-lap sprint section of the race they would have to start behind cars on prime tyres.

The race saw some teams experimenting, with Stewart-Hass Racing entrant Clint Bowyer's crew chief Mike Bugarewicz opting for a set of options after the first stage, but then changing just two tyres on the next stop, which left the car with softer options on the inside and prime tyres on the more loaded outside. However, the experiment failed to work and Bowyer's car quickly dropped back down the field.

Kyle Busch won the race in his Joe Gibbs Racing Toyota and speaking after the finish, his crew chief Adam Stevens said that the difference between the two sets of tyres had been more marked in practice than in the race itself.

"Most of us put them (the option tyres) on in practice to get a read on the speed difference," said Stevens. "For some teams it was bigger, some teams it was smaller – it just didn't seem to be as big with our car and setup as it was with other teams. As it cooled off tonight, it seemed like that discrepancy was a little bit less."

Stevens added that race strategy has become "a game – to see who was going to put them on, if it was going to improve their position, who was going to save them, restart behind the other guys for the shootout at the end."

In the event none of the top 10 finishers in the race had saved their option tyres for the final sprint.

Stevens was non-committal over the possible consequences should NASCAR decide to introduce the tyres to championship races, as has been strongly rumoured. "It's just all about experience and practising with them, seeing what the grip difference is, assessing how many lanes there are in the race track, can you pass people, the importance of track position.

"It's all the steps we went through this week – we practised in the day and raced at night and it seemed like that discrepancy closed up a little bit."

Race winner Kyle Busch declared himself a fan of the option tyre. "I thought it was pretty good, pretty fun, gave my car a better sense of feel that I was looking for throughout that run that we had it on the car.

"We could probably go a little bit softer, utilise a little bit more grip in order to be faster, have more split between the two tyres."

Busch added that using the tyres in points scoring races would be an interesting development. "Let us kind of have maybe a warm-up or two sets, use them when we wanted to." RT

NASCAR inspection in spotlight

Andrew Charman

KANSAS SPEEDWAY, KS: NASCAR has agreed to analyse its scrutineering process after more than a quarter of the entries to the Monster Energy Cup round at Kansas Speedway on 13 May failed to make a qualifying run due to failing to pass the pre-session inspection process.

The major issue behind 11 cars being rejected during the inspection process appears to be rear-steer, according to NASCAR competition head Scott Miller when interviewed on SiriusXM NASCAR Radio.

According to Miller, teams are building their cars right to the tolerance limits for the rear-end specification, and have no facility to modify the specification to meet any issues highlighted on NASCAR's laser measuring station.

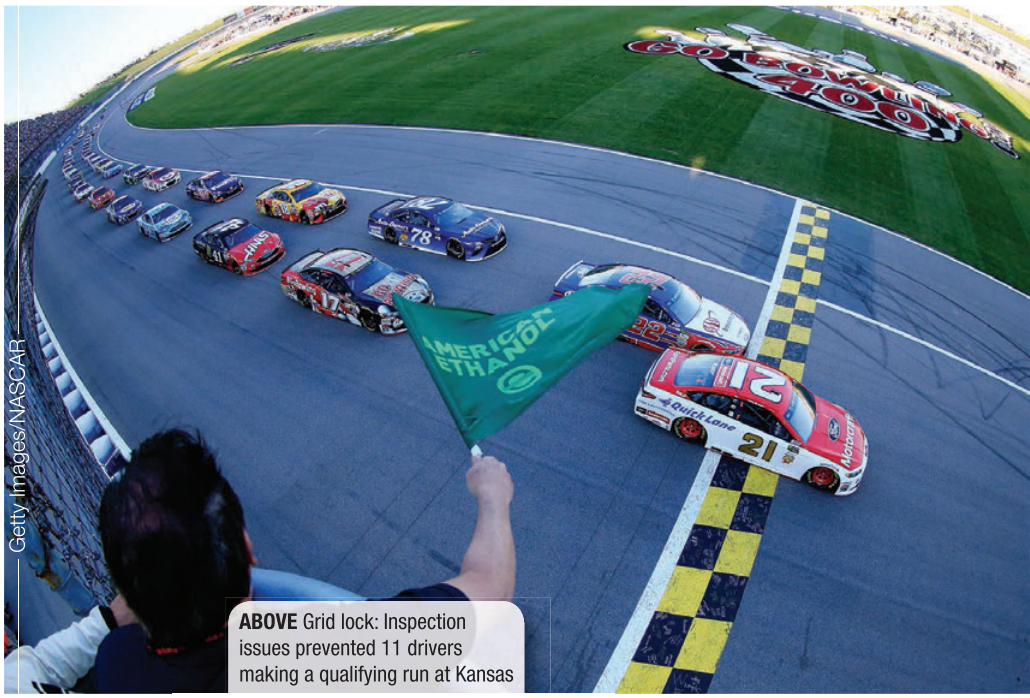
"It's certainly not a great situation for us or the fans or the broadcast partners – we know we can't keep having those situations come up," Miller added.

The rear-wheel steer issue proved expensive for the Richard Petty Motorsports entry of Aric Almirola, the car failing to pass scrutineering following the race at Talladega on 7 May. The team lost 35 points in both the driver and owner championships, while crew chief Drew Blickensderfer was fined $65,000 and suspended from the next three points scoring races.

Meanwhile the Team Penske Ford entry of Joey Logano became the first team in the lead Monster Energy Cup to have a race win 'encumbered', meaning that it cannot be counted as qualifying for the season-ending playoff series – race wins are the lead criteria to making the playoffs.

The penalty was issued following inspection of Logano's car at the NASCAR R&D Centre after the Richmond race on 30 April, a usual process applied to race-winning cars. NASCAR information stated that the car failed under a rule stating that the 'truck trailing arm spacer/pinion angle shim mating surfaces must be planar and must be in complete contact with corresponding mating surfaces at all points and at all times.'

The team lost 25 driver and owner points and crew chief Todd Gordon was served with a $50,000 fine and a two-race suspension. In a statement Team Penske expressed disappointment at the ruling but added that it accepted it and would not appeal. RT



Getty Images/NASCAR

ABOVE Grid lock: Inspection issues prevented 11 drivers making a qualifying run at Kansas

IndyCar releases 2018 "NEXT" concept aero images

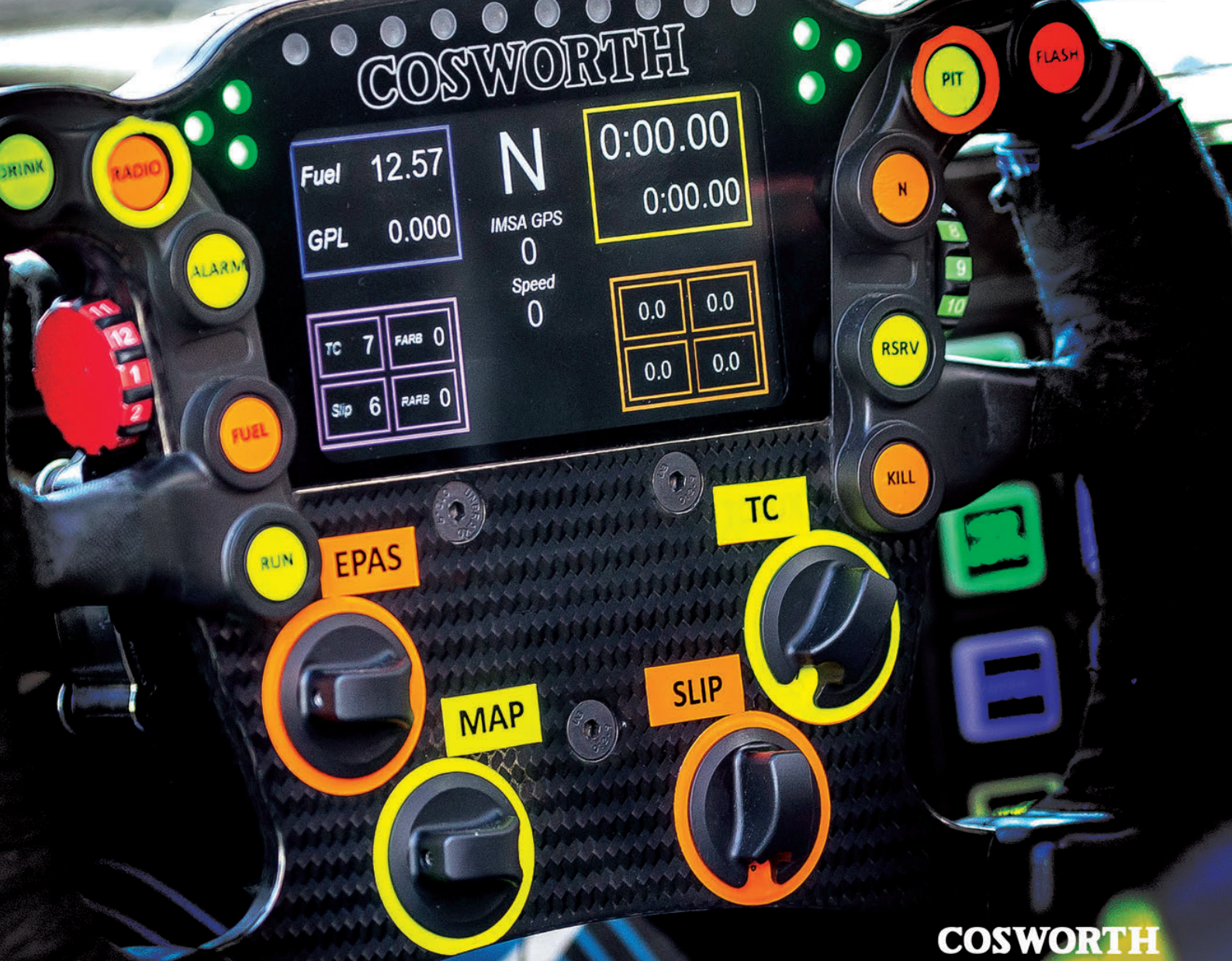
William Kimberley

INDIANAPOLIS, IN: Indycar has released the "NEXT" concept images of the car that will be used by all Verizon IndyCar Series competitors in 2018.

The newest images give more definition to the sleek and bold look of the universal aerodynamic bodywork kit that will fit to the current Dallara IR-12 chassis in 2018. The supplier of the universal kit has yet to be finalised, but it has been reverse-designed to start with a look of past Indy car favourites while also incorporating the latest technological and safety advancements.

Indycar is on target to begin testing the car by mid-summer. Verizon IndyCar Series teams will still choose between Chevrolet and Honda engines for competition in 2018. As with the current aero kits provided by Chevrolet and Honda through the end of this season, the universal car will come in two configurations: one for Superspeedway ovals and the other for street courses, road courses and short ovals. RT

ABOVE Views of the 2018 IndyCar Superspeedway (left) and road course configurations



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A message from the Publishing Director

IT IS not often that I put pen to paper but I am delighted and proud to announce that we are expanding the Kimberley Media Group by adding *Automotive Engineer*, the official publication of the Institution of Mechanical Engineers to our portfolio.

As many will know, our editor William Kimberley edited this publication for 10 years before he joined us when the title was published by the Institution of Mechanical Engineers. Fast forward a few years and William is being re-acquainted with this magazine.

Having brought it into our portfolio, along with the website and all the social media platforms, I want to ensure that it is up to the standards of *Race Tech* and our other publications, not just in editorial terms, which is a given, but also to our production values.

If you would like to know more about *Automotive Engineer*, wish to subscribe or place an advert, then please do contact us on info@kimberleymediagroup.com
Tel: +44 (0) 20 8446 2100 RT

Soheila Kimberley

MIA CEO gives Brexit warnings

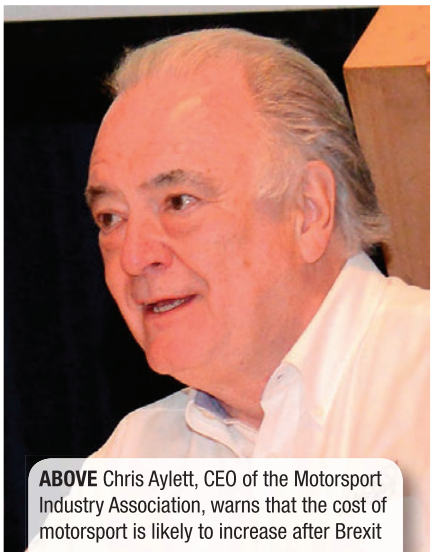
William Kimberley

LONDON, UK: With the UK being a member of the European Union, the teams and motorsport business located in the country have enormously benefitted from the open border policy with the 27 other member states. With Brexit, though, and the country's vote to leave the trading bloc, this is now at risk. As Chris Aylett, CEO of the Motorsport Industry Association, points out, every week Formula 1 and other teams are going to and from the European continent to go racing. His worry, though, is the relative ease with which they do this could be threatened.

"I go back to the 1980s and whenever I took the cars to race in Europe I had to go through all the bureaucracy with carnets, paying deposits, collecting refunds and so on. I can only assume that in the modern world it would benefit both sides that we'll be able to transport racing cars, their spares and team equipment to and from the UK without having to go back to such an archaic system."

He also points out that when it comes to immigration, he hopes that commonsense will be applied, not just for motorsport companies, but all technology and scientific businesses in the UK. "We will still need to employ the very best of technology, technologists and scientists, but could we be facing a very interesting period when companies may only employ non EU technologists and home bred ones?"

He believes that while there may be efforts to pull Formula 1 teams out of the UK, it is not a viable threat. "I would say that taking all the Formula 1 teams and putting them in the middle of Europe so that they can move within the region, as opposed to staying in a country that's connected to everywhere else, isn't really an option bearing everything in mind, not just the fact that there are as many races outside Europe as in, but for all the other infrastructure reasons. Also, our logistical strength is so superior and substantial that it can physically take motorsport to the world and such a thing doesn't exist that easily in Europe."



ABOVE Chris Aylett, CEO of the Motorsport Industry Association, warns that the cost of motorsport is likely to increase after Brexit

No matter what happens Aylett believes that motorsport as a whole will have to pay more for everything. "Tariffs may be put on UK exports to the EU, but all that will happen is that it will be reciprocated. It means that politicians are more than likely to increase the trading prices of high-performance engineering leading to motorsport in the EU becoming more expensive."

As a global industry, though, he believes the motorsport businesses in the UK's Motorsport Valley will be more immune to political interference and having additional 'political' fees added to their products due to their global way of doing business anyway.

"It would be important to assume that we've somehow retained our partnership with the EU, but if it hasn't we will probably become even more global and see more and more companies opening offices in the US to pursue business there. Unfortunately I think we will end up in a more expensive world due to politicians failing to find a way to make it competitive." RT

See Chris Aylett page 42

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THE PINNACLE

P1159 Transverse LMP Gearbox

P1529 Transverse GT Gearbox

P1152 Longitudinal LMP3 Gearbox

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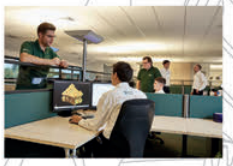

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WILL MOTORSPORT BECOME A PASSENGER?

Our **Expert Witness** – an F1 insider who must retain anonymity – fears the motor industry's quest for autonomy and low emissions will change motorsport's role

ABOVE Defying the odds: for all its detractors, the success of Formula E, seen here racing in Monaco, has snowballed

LONGEVITY is always a challenge, particularly in an incredibly competitive marketplace where brands and participants can come and go and success is so coveted and protected. So, what are the key ingredients to maintaining the required levels of staying power? Adaption to change.

I have been an exponent of motorsport being a force for the greater R&D good for a long, long time. It pushes not just drivers, but also technology, teams and engineers to, or even over, their limits in finding ever better and smarter solutions. This is the very reason it has such strong appeal for both aspiring students and as a marketing tool, affiliating you or your product with true cutting edge success. The trouble is I am

BELOW The World Endurance Championship has been lauded as a laboratory for technology but escalating costs have forced a rules rethink

WEC

FIA/Formula E

now starting to have some serious doubts…

It was with extreme sadness that I read in last month's issue of Race Tech of the voluntary liquidation of FondTech, the Italian aerodynamic consulting company established by Jean-Claude Migeot. The former Tyrrell (the superb trend-setting high nose 019 used to sit proudly in the Casumaro reception) and Ferrari head of aero had established an excellent friendly team and multi wind tunnel facilities for the industry in almost every category.

It was also a natural training ground for many future talented F1 aerodynamicists, model makers and designers. Particularly with Maranello down the road – although this occasionally, not surprisingly, annoyed JCM, rather than him seeing it for the compliment it really was.

With ever increasing spec series, homologation freezes, restrictive rules and reduced permitted aerodynamic development time, it is perhaps not a huge surprise that a consultancy like this was likely to struggle. Even if it was the one entrusted by both F1 and the FIA to conduct the Overtaking Working Group study for the new rules in 2009.

However, during or even slightly before that period, FondTech was already working on an electric Formula 3-sized racing car prototype, six years before Formula E was conceived and eight years before the inaugural series. There were one or two little rumours around, but anyone who heard them thought: "An electric racing car… yeah, right!" At that time, it was inconceivable. It is a great pity that an innovative company, despite being ahead of the curve, has not survived.

Formula E, though, the natural beneficiary of some of this pioneering work, is – despite many detractors – still here and in its third season. Attracting more road car manufacturers, gradually allowing some technical freedom to develop new technology stage by stage, the model seems to be proving the critics wrong, particularly when e-Sports, Roborace and Electric GT add their presence. So, what's the problem?

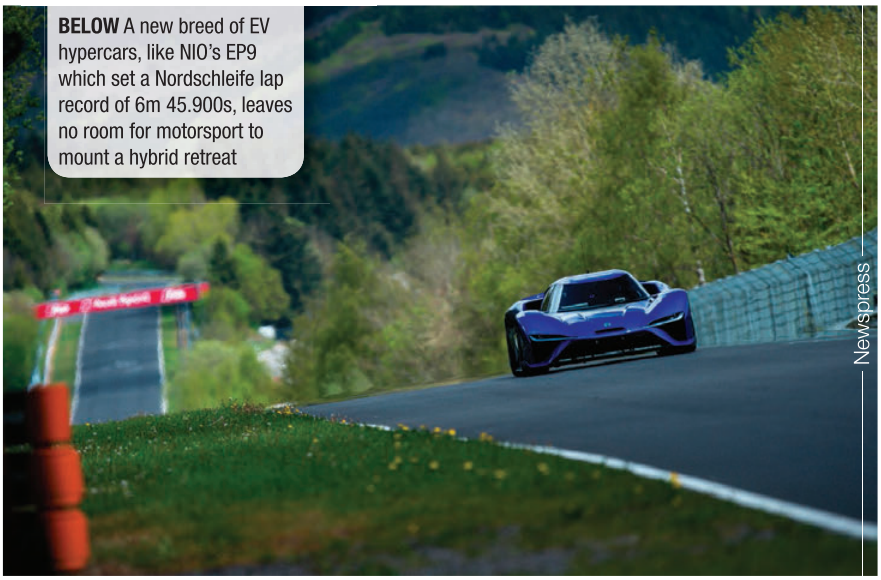
There is a family of super cars, hyper cars out there on the road now that are hybrid, even full electric, starting to break outright performance records, while capable of achieving 'zero' emissions in urban centres. F1 and LMP1 after major recent revamps are also occupying this hybrid space, recovering and utilising energy, but both have been declared prohibitively expensive, not noisy enough and have not engaged or interested the public sufficiently. If that's the case and those categories revert, then do we not see racing and road cars start to diverge?

In this greener, fuel-conscious, lower emission climate, we are actually already there. There has been fuel flow monitoring, capacity reduction and forced induction to boost efficiency, but when drivers complain and have to utilise "lifting and coasting" in order to achieve better consumption figures, that exposes one of the major issues: driving style.

Yes, there is a lot of science, hardware and software out there that improves energy consumption, but while trying to cover a distance as fast as possible pushes that to its limits, it will never be aligned to achieving that same task as cleanly and efficiently as possible. Taken to its extreme, while Roborace may offer entertainment as the software is still being developed, public-used autonomy is much more likely to be developed to be as safe, comfortable, smooth, efficient and low emission as can be achieved. After all, the 'driving style' algorithms can all be programmed for just that. In an environment with speed and pollution control increasing, driving – or should I say being a passenger? – in something fast, noisy and dirty may truly become a thing of the past.

If the motorsport of the future is aligned to the changing motor industry, partially or not at all, perhaps even more focused on entertainment, alternative media and independence, people will still want to hear and learn what and why it is evolving.

Whether that progress will still be reported on printed paper, I'm not sure. What I do know is that in this, its 200th issue, Race Tech has shown that longevity, dedication and insight into the journey so far and I look forward to seeing how the next chapters unfold. My sincere compliments to everyone on their team. RT


Newspress

BELOW A new breed of EV hypercars, like NIO's EP9 which set a Nordschleife lap record of 6m 45.900s, leaves no room for motorsport to mount a hybrid retreat

WHAT *THEY* SAY...

A snapshot of the messages we've received from our friends in the motorsport industry

The FIA is dedicated to technical innovation, and the magazine provides insights into the work of the Federation as new regulations evolve across the many varied disciplines of our sport. It is fitting that the 200th edition celebrations should take place around the 24 Hours of Le Mans – an event which pushes both man and machine to their physical and technical limits. I look forward to seeing how our future advancements are reported on, having greatly enjoyed reading the magazine over its first 200 editions.

Jean Todt
President
FIA

Well done on your 200th edition. I have not missed many of them and hope I will still be reading them until your 300th – Sorry I will be happy with the next 20 years.

Bernie Ecclestone

I love RACE TECH!

Henry Ford III
Global Performance Marketing Manager
Ford Performance

I have been reading Race Tech since its inception and am extremely proud to have been, from time to time, a contributor as well. It is wonderful that the publication has reached this landmark of 200 issues but not surprising as quality inevitably leads to longevity and this magazine exudes quality in every copy.

It is very easy to become insular in motorsport by becoming engrossed in your own formula and not seeing the bigger picture. I urge every engineer and enthusiast to read Race Tech every month to get a truly holistic view of our great sport.

Pat Symonds

Race Tech is an important magazine and particularly useful for young engineers to help them understand the engineering side of motor racing.

Adrian Newey
Chief Technical Officer
Red Bull Racing

The 200 editions of Race Tech have covered motorsport in a very unique and competent way for a very long time. Motorsport has seen dramatic changes in this period since 2000, and not always in a good direction. Compared to that, this magazine, accompanied with the annual World Motorsport Symposium has continuously improved and has become an important voice, which all parties involved in this business should listen to. Congratulations to Soheila, William and their team! Keep on going!

Ulrich Baretzky
Director Audi Sport Engine Development

The 200th edition for Race Tech – the 6th Le Mans edition for our Toyota team, we are youngsters, with so much to learn ... from Race Tech of course!! Thank you very much to Soheila and William for consistently offering us insider views into what is going on in top level motorsport, and once per year, this remarkable opportunity to discuss the future of motorsport at the Symposium!

Pascal Vasselon
Technical Director
Toyota Motorsport GmbH

Race Tech has been an integral part of motorsport for many years; I don't think of it as 'just another' publication, I believe its influence is far beyond that as the Symposiums regularly demonstrate. It is an organisation that is not afraid to challenge the conventional wisdom of motorsport, it presents new ideas and generates conversation and discussion around what is right for motor racing for today and where should the sport head for the future. I think one of the reasons for the success is that it has genuine relationships with key players within the industry; people that are willing to devote their time and energy to the publication whether this is to write articles that provide insight and insider knowledge, or give editorial comment and opinion or even attend the Symposiums. This gives the publication a credibility that many others don't have. These personal relationships, really created and grown by William and Soheila, make all that are involved feel like they are part of the 'Race Tech family'.

Roger Griffiths
Sporting Director/Team Principal
Andretti Formula E

While Race Tech clearly is an international motorsport engineering publication, I have always appreciated the fact that North American motorsport gets regular coverage which helps feed interest in the technical side of the sport here in North America…hopefully keeping us in business for the long term!

Stephen Eriksen
Vice President & COO, Honda Performance Development, Inc.

I think Race Tech is, without question, the definitive source of motorsport technical data and related content. In an era where printed magazines are thought to be obsolete and media "dinosaurs" Race Tech has prospered and it is easy to see why. The quality of the reporting, the insightful analysis, the photography and graphics make it important reading for anyone in the industry. All of us at IMSA congratulate Soheila and William Kimberley on their milestone accomplishment – and look forward to the next 200 issues.

Scott Atherton
President and COO
International Motor Sports Association – IMSA

Congratulations to all at Race Tech on reaching the 200 edition milestone. I have probably read every issue....not because I have any engineering expertise, but it helps me better appreciate those that do.

Alan Gow
Series Director and Administrator of the British Touring Car Championship (BTCC)
Chairman of Motor Sports Association

Congratulations to Race Tech on its special 200th edition. Race Tech has been a global source of leading technical information for the motorsports industry for many years! They are constantly pursuing new and innovative ways to push our dynamic sport forward.

Doug Yates
President
Roush Yates Engines

Race Tech established an extremely high standard for motorsports publications and continues to uphold that tradition. It is our primary connection to the international motorsports community. Thank you for your continued excellence!"

Dr Andrew L. Randolph
Technical Director, ECR Engines

Race Tech's 200th edition: my sincere appreciation and best wishes to all the persons that work for this motorsport magazine – the most influential and unbiased voice from the world of motorsport for racing enthusiasts and professionals.

Luca Marmorini
Engineering Consultant

I believe that Race Tech is the best possible link for engineers involved in motorsport. Race Tech gathers such a wealth of technical information. It is also the best platform to define a vision of the future of motorsport.

Gilles Simon
Engineering Consultant

Race Tech's 200th edition is an important goal to celebrate, but even more important, Race Tech has always been present on our desks as the reference in motorsport technical magazines, reliable and always focused on the analysis and discussion of all main technical issues.

To all the I team, my sincere congratulations for the great job done over all these years and best wishes for the future.

Dialma Zinelli
Head of Aerodynamics,
Dallara Automobili

William and Soheila and the whole staff at Race Tech deserve huge credit for their continual reporting, support, friendship and promotion of the motorsport sector's technologies. The publication has gone from strength to strength and I look forward to its content for many years to come.

John Iley
Iley Design and co-Chairman of the World Motorsport Symposium

Race Tech magazine has been a stalwart of the motorsport industry, informing its readers about the latest technologies on the track and in the motorsport sector. Congratulations to the whole Race Tech team on reaching this 200th edition milestone and I look forward to reading many more informative articles along with wishing them much continued success.

Craig Wilson
Managing Director
Williams Advanced Engineering

So many years of reliably delivering consistently high quality editorial comment and content is a hard-earned testimonial which stands up to any scrutiny. Race Tech serves a particularly demanding and competitive audience which demands the very best in all that they do and their support for this great publication continues to grow. The Motorsport Industry Association (MIA) is proud to have Race Tech within our membership community and we look forward to enjoying the next 200 editions. Congratulations to the Race Tech team!

Chris Aylett
Chief Executive Officer
Motorsport Industry Association

Congratulations on the 200th edition of Race Tech! I have enjoyed reading Race Tech magazine over the years. As a pioneer in the publishing world, Race Tech blazed the trail by creating a magazine dedicated to providing highly technical insight into the racing world. It filled a void for the engineering community that wanted to learn more about the cutting edge technology and innovation that drives the racing world. I look forward to each and every issue of Race Tech.

Jim Covey
Cadillac World Challenge Engine
Technical Manager for GM Racing

Two hundred editions – more than two decades of technical and general information on the world of motorsport technology! In that period, many trends in motorsport have come and then disappeared as fast as they came along. In such a fast changing environment Race Tech is the platform where I can get the most objective information I can trust!

Thomas Krämer
Porsche Motorsport LMP Team
Manager Engine Design LMP1

There are quite a lot of magazines dealing with performance cars and motorsports. But if you are searching for the benchmark you will automatically land at Race Tech magazine. Technical expertise paired with latest news and insights, my perfect lecture for all day!

Congrats to 200 issues!

Norbert Odendahl
Managing Director
ZF Race Engineering GmbH

Congratulations on the publication of Race Tech 200th edition! Race Tech has always been a very effective and efficient way to keep up to date with what is technically new in motorsport. Now that I am almost retired, I can enjoy its many features and articles in the comfort of an armchair, rather than the confines of an airline seat, which is even more enjoyable. Keep up the good work!

Peter Wright
Consultant, Global Institute for Motor Sport Safety

I see Race Tech as the leading magazine for the racing Industry internationally. Passion, competence, humanity and vision are the four pillars of your success and I wish you more of it in the future.

Sergio Bofanti
General Manager, Federal Mogul
Special products division

I'd like to congratulate RaceTech on reaching 200 issues of extremely informative, thought provoking and entertaining reading that is a must for anyone with a technical interest in motorsport. Whenever I take a flight to an event somewhere, and I take quite a few, it's always in my bag and I'm looking forward to the next 200.

Dominic Harlow
Dominic Harlow Consulting

Congratulations to all at Race Tech on producing its 200th edition. A magazine that is revered internationally for bringing to the fore the behind-the-scenes ingenuity of engineering and technology that makes motorsport what it is today.

I very much look forward to many more future editions. Congratulations!

Lord Astor of Hever
Honorary President
Motorsport Industry Association

It´s always a great pleasure to read your magazine! I like the variety, the technical expertise and the focus on the professional motorsport market, especially in the combination with your conference it is quite more than just a newspaper. A tribute also to the perfect design of your magazine!

Dr Klaus Boettcher
Head of Motorsports (BEG/MSD)
Bosch Engineering GmbH

Race Tech is a worldwide recognised publication that we have taken pride in partnering with for so many years. Technology is at the heart of what they write, and they always seek to bring technical discussions and innovations to light that will shape the future of racing. That is something worth being a part of for years to come.

Nina Burgoon
President
Performance Friction Corporation

Congratulations to Race Tech for their 200th edition! An important achievement for a magazine representing a community of people passionate about technologies for motorsport and who can drive racing's future. All the best to William, Soheila and their team for a bright future.

Rodi Basso
Motorsports Director
McLaren Applied Technologies

The extraordinary scope, depth and accuracy of your publication over the years are a credit to you! The exposure you bring to the technical side of the motorsports industry is of great value. As a catalogue of technology evolution your publications are a wonderful historical record….

Ben Bowlby
Ben Bowlby Racing

200 amazing editions, ATL could not be prouder to have been a part of nearly every one. Congratulations to all those involved in the publication of every single edition. Over the years Race Tech has contributed so much to the success of ATL, William's in-depth editorial inspired me through university and continues to fuel our business direction. Here is to the next 200!

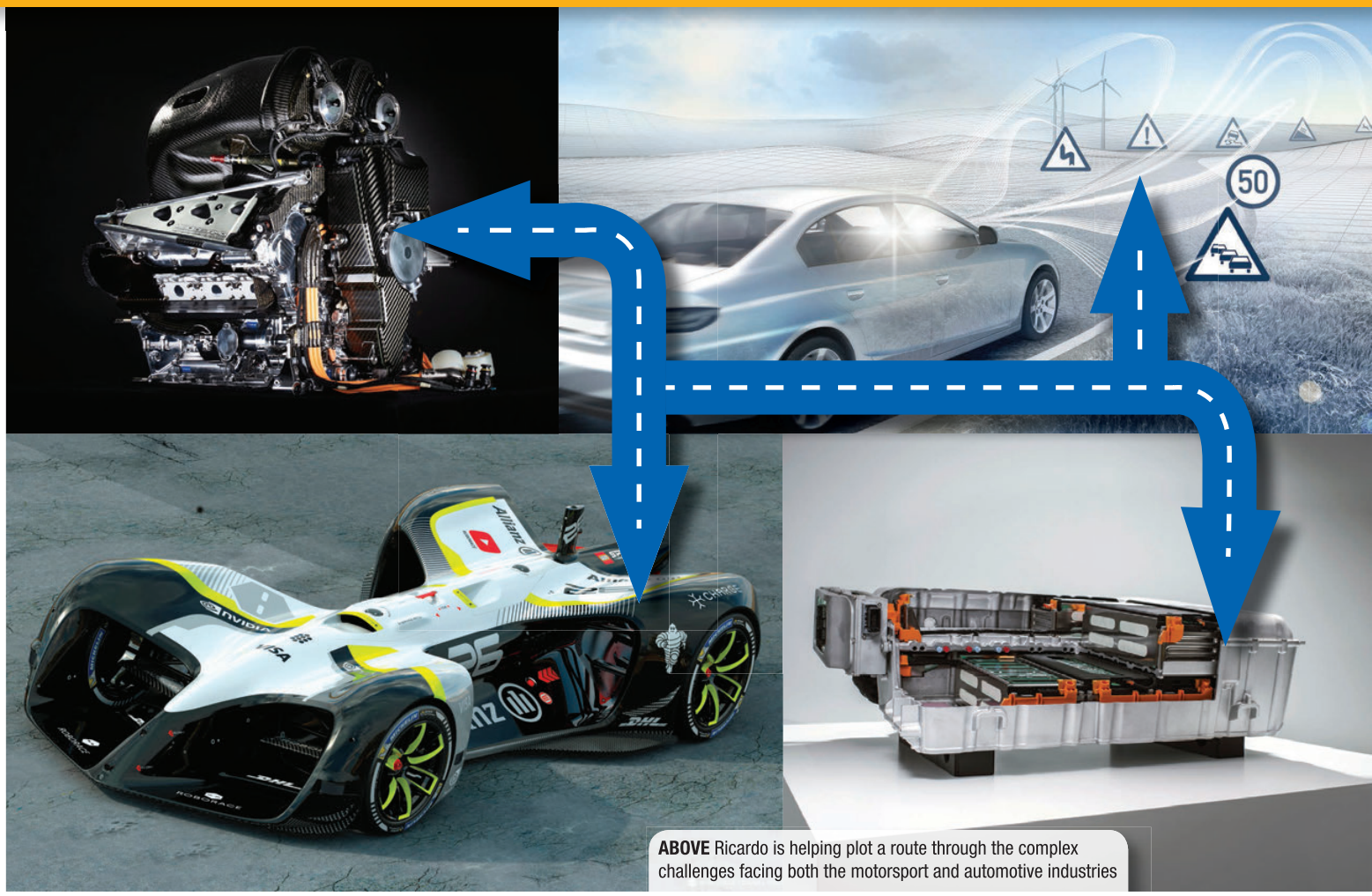
Giles Dawson
Managing Director
ATL — Aero Tec Laboratories

It has been a pleasure to work with the Race Tech Team over many years on BTCC Features, their continued support is appreciated. As a reader I find the content suits both the technical and non-techical reader and wish them well on their anniversary with many more issues to come.

Peter Riches
Riches Technical Services

Race Tech today is by far the best magazine for racing. The mix between articles and advertisements makes it lively, interesting and helpful for the daily work in racing.

Dr Peter Schoeggl
Vice President, AVL List



ABOVE Ricardo is helping plot a route through the complex challenges facing both the motorsport and automotive industries

ROADMAP TO THE FUTURE

With his finger very much on the pulse as the originator and author of the motorsport road map, Ricardo's Steve Sapsford is asked by **William Kimberley** to peer into his crystal ball. Where, from a technology point of view, is motorsport heading in the future?

ABOVE Sapsford suggests it is a mistake to write off the combustion engine

WHAT *is* the role of modern motorsport?

If it is just chasing after the entertainment pound, euro or dollar, then it's a straightforward answer and that is to make it as fan-friendly as possible and ignore everything else. However, if there is more to it than that, and it's not golf, for example, substituting cars for clubs, then it's a whole new ballgame altogether.

As the man responsible for the motorsport road map that was commissioned by the Motorsport Industry Association a few years ago, there is probably no better person to ask than Steve Sapsford, Ricardo's strategy director, when it comes to this question. After all Ricardo, the engineering consultancy company, deals with just about every vehicle manufacturer in the world in some form or other. It is also in the middle of a three-year contract it won from the UK Government's Department for Environment, Food and Rural Affairs to deliver quality assurance and quality control services to the Automatic Urban and Rural Network, the UK's largest air quality monitoring network.

Ricardo is also a valued technology ▶

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provider for motorsport. In other words, it is finely attuned to the challenges facing the automotive industry and government attitudes and policy creation. If motorsport *is* more than an entertainment sport, then any advice that Sapsford can feed back to the industry has to be of huge value.

Although a difficult 'sell' to the public at large and also to politicians, if there is one word that defines motorsport, it's efficiency – and when it comes to engines, motorsport engineers have really proved themselves. What the NASCAR powertrain engineers are getting out of their pushrod V8s is nothing short of astonishing, but it is Formula 1 that attracts attention. The energy efficiency of an F1 1 engine is in the mid-40s and nearer 50% with the energy recovery system, whereas a good production engine is in the high 30s. It is this aspect where Sapsford believes that lessons are being learnt.

"What Andy Cowell and his team at Mercedes AMG High Performance Powertrains have delivered is extraordinary and shows just what can be done," he says. "If you think about it, what they and the other engine manufacturers have achieved is completing the same race distances but on 30 per cent less fuel while still remaining as quick if not quicker than they were. That's one heck of a statement."

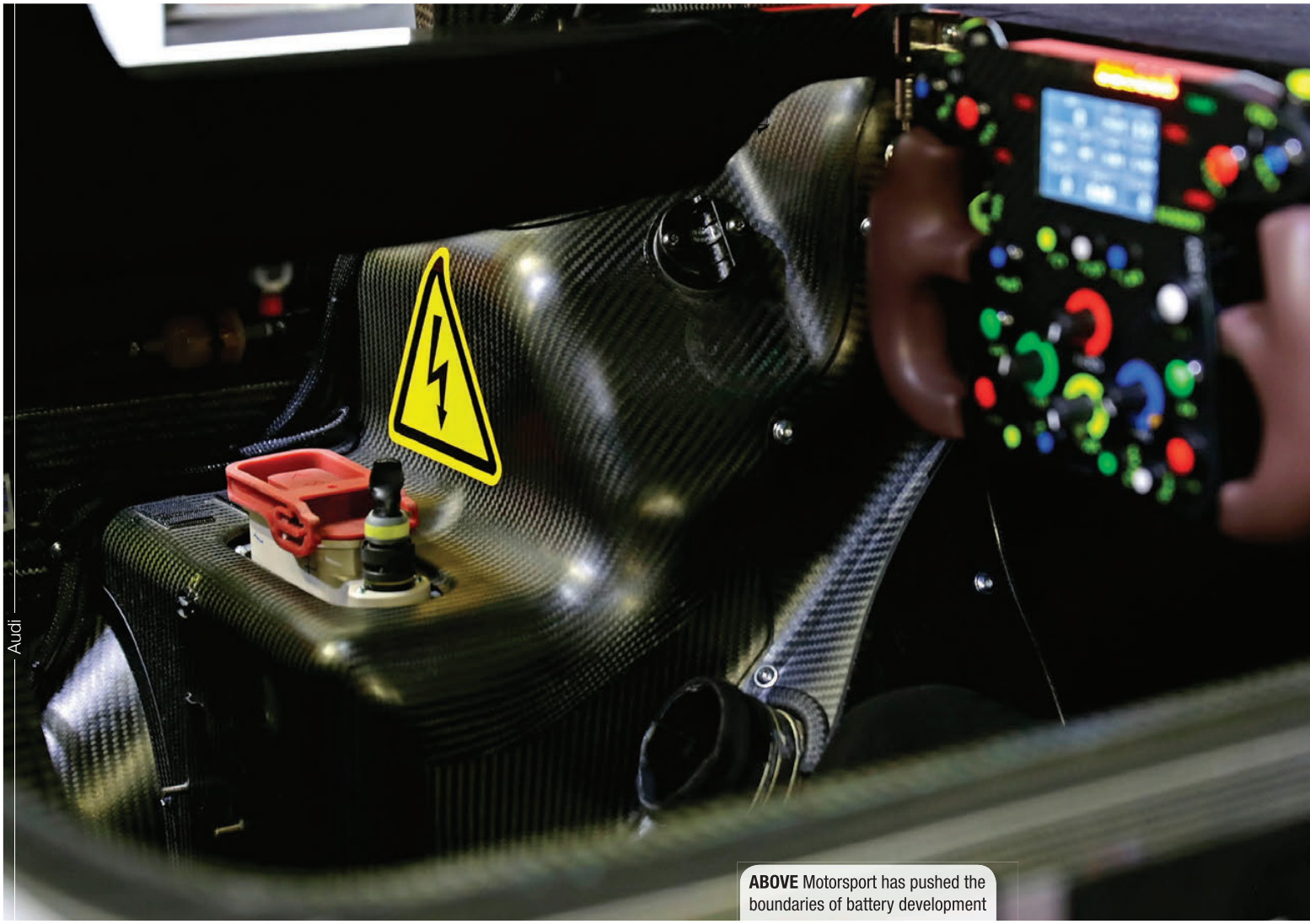
> *"'Cool' combustion is the subject of a great deal of excitement"*

Sapsford also talks about waste heat recovery, which is well suited to race engines as they operate at either high load or off, but not so much for production cars. "However, there's work going on in this area with different technologies being applied to that," he notes. "The work going on in Formula 1 is very relevant to understanding how it all works, although the lessons learnt will take some time to come through to the production engine due to the different operating conditions."

He is quite adamant that it is therefore a mistake to write the combustion engine off. "There are still gains to be had in developing it," he insists, "but some of the problems that have arisen around diesel have fogged the issue around how much resource needs to go into it."

One of the areas that excites him and various car manufacturers is something called 'cool' combustion. The 'cool' flame was first 'discovered' exactly 200 years ago by Sir Humphry Davy, who found that some types of flame neither burnt his fingers nor would ignite a match.

"Any time that a hydrocarbon fuel is being burnt in air at high temperatures, oxides of nitrogen are going to be generated unless it can be burnt cool," explains Sapsford. ▶



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ABOVE Motorsport has pushed the boundaries of battery development

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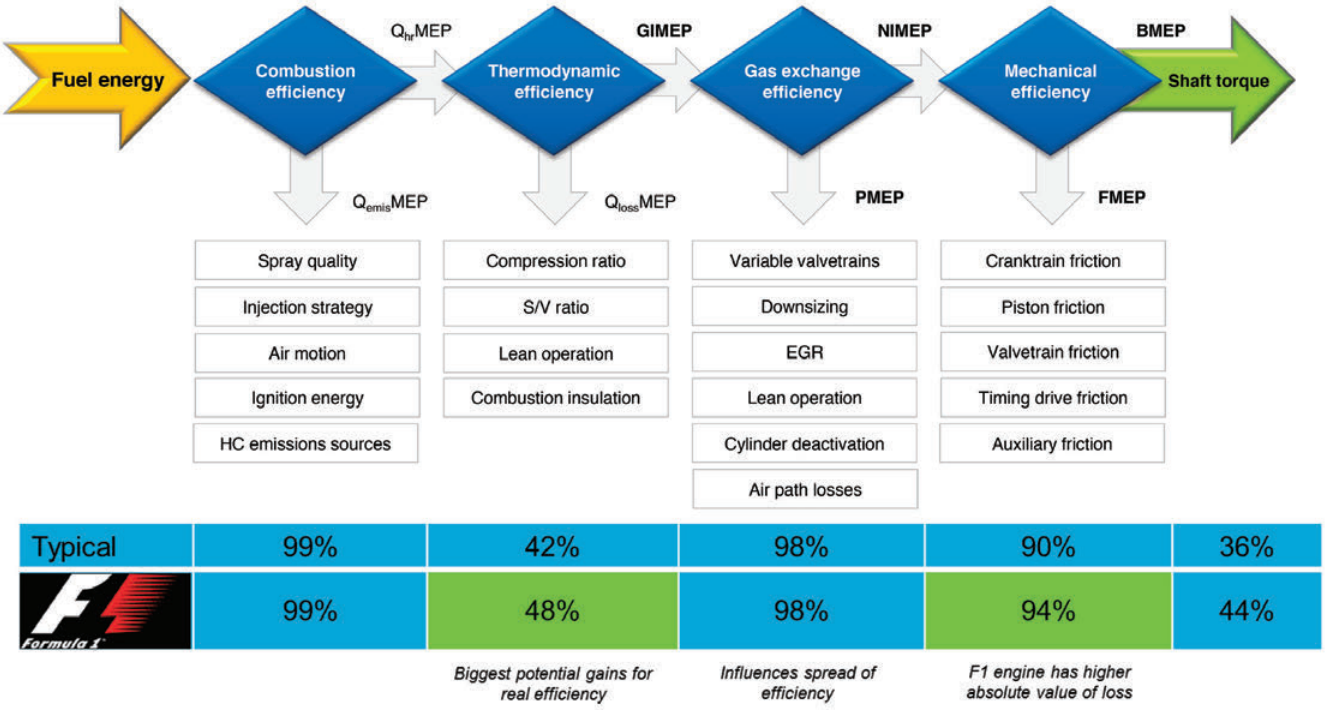
A current Formula 1 engine displays outstanding thermal efficiency

While the F1 engine does not have to meet legislative emissions and has a unique usage profile there are still significant lessons to be learned for production vehicles



"If you imagine that – the cool combustion deals with the main air quality issues, NOx – and you can also deal with CO2 via a bio/synthetic fuel, you have the energy density and power density of a liquid fuel, the infrastructure that makes millions of engines a year and the refuelling infrastructure, why is there the need to change everything? The worst case would be not getting it done in time and investing massive amounts in alternative solutions and infrastructure.

"Running a petrol engine lean is also a good thing to do from an efficiency point of view. There's a trade-off in fuel consumption versus the amount of NOx produced, so if you start running lean, the three-way catalyst stops working from a NOx perspective so some lean NOx aftertreatment is needed. However, there are a few sweetspots where you run particular air/fuel ratios where the NOx is minimised and it's quite lean. I don't think they're quite there yet on Formula 1 engines but they're getting there. It's interesting if we can get to that point because that would simplify the NOx aftertreatment running gasoline engines lean on road cars.

"If you look at NOx emissions, we've reduced them in diesel engines by 98% over the last 10 years, so how come the air quality hasn't got better? It doesn't make sense, so we need to understand where that link comes from as it's far more complicated than would first appear. Yes, it's related to drive cycles but there's a huge amount of complex chemistry that goes on after the tailpipe.

"Nitric oxide (NO) and nitrogen dioxide (NO2) are coming out of the exhaust pipe, the balance of which depends on the aftertreatment and how the engine is operating, but it's a reversible reaction. It can go either way and depends on atmospheric conditions. Every city will be different because the climatic conditions vary, but all we do is measure the car and what comes out of the tailpipe. There's lots going on over which there's no control. It's a hugely complex environment with the vehicle manufacturers and the air quality community and there aren't any models that go between the two. There's a great deal of modelling going on but it needs to be joined up for a holistic view."

From a greenhouse gas perspective, Sapsford believes that there will be a move from a narrow focus on tailpipe emissions to a more holistic position because while electric vehicles are considered as zero emissions, they are not. "Where does the electricity come from?" he asks. "If it came from all renewables, then you can say that but if it comes from burning natural gas or coal, it's not a zero emissions vehicle. There's also the embedded carbon in the manufacture of that vehicle. How much energy did it take to build, including the batteries? What did it cost to get the raw materials out of the ground? What does it cost to recycle or dispose of that car? It's about the entire lifecycle analysis and I think you will see legislation move from the tailpipe through well to wheels, which is the intermediate stage, and then full car lifecycle. It's only when you look at that that you make rational technology choices. The smaller the box is drawn, the greater the risk of making irrational technology choices."

What is interesting to watch, he says, is the development of synthetic fuels that have the potential of being a disrupter of the disrupters, as he terms it. "If we can get that to work really well, taking CO2 from the atmosphere and combining it with hydrogen to make a fuel that we then burn and release the CO2 back into the atmosphere so that the cycle just goes round and round, it would be very neat.

"At the end of the day, though, people are not that interested in efficiency if gasoline is cheap. Why are they going to pay for all that ▶

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expense of electricity, batteries and all that technology when gasoline is inexpensive? There are many external drivers that influence what technology's developed and how it's applied. It's hugely complex and subject to quite a lot of irrational drivers."

CONNECTIVITY AND AUTONOMOUS

Connectivity and autonomous are often talked about in the same breath, but they're not the same thing, explains Sapsford: "You can be connected but you don't have to be autonomous, but autonomous probably does mean you have to be connected. That is a huge subject area for vehicle manufacturers. It's a subject of massive debate and interest in the automotive industry at the moment, and we do worry about that."

He talks about the ownership of data. Will it belong to the OEMs or the software providers? "How that industry/value chain is going to settle down is a complete mystery," he suggests, "because people are going to own data that's going to be turned into information. Somebody's got to write algorithms that's deciding what to do with that."

Major questions that he says need to be addressed are how to ensure that the vehicles and their software are safe. "Because vehicles have a long life it will mean that they will have upgrades throughout their life, which may be done remotely, as happens with mobile phones and PCs. As we all know, though, this is not always a painless experience and can result in crashes or another 'patch' being sent remotely," he says. "This simply cannot happen with vehicles. At the moment we have annual tests to ensure the vehicle is still roadworthy, but how can that be applied in a semi- or fully-automated vehicle?"

However, this is where he believes that motorsport can play a role: "I think this can be introduced quite nicely and gently in motorsport as well. It's relatively easy to imagine such systems being trialled in the pit lane, on an autonomous safety car and maybe even in shuffling the order on reforming after a safety car period, because it all takes place in a controlled environment. I think there are opportunities there and it could be quite good fun developing it.

"I also think the opportunity of having autonomous vehicles racing is fantastic. Motorsport is an ideal development environment as it's safe, enclosed and if cars hit each other it doesn't matter. We could do some really quite bold things such as racing in a figure of eight with no control, the cars looking after themselves. Admittedly the heroes will be more difficult to identify, and could well be the engineers rather than the drivers, but there's an opportunity for accelerating development of the control algorithms and that sort of thing.

"Initially we will begin to see autonomous vehicles on public roads in very controlled areas. It's relatively easy looking 30 years in the future and seeing all the cars autonomous, the problem is how do we get there, what happens on the way and at what point do we allow a mixed autonomous and driven vehicle? That's a hard situation with which to deal.

"In terms of connectivity I think the whole industry has got to move massively. There's no reason why we can't all be streaming and experiencing the race through your phone or whether you can race live on your Playstation. You can do the first person view drone racing, and that's a bit of a back street-type sport, so just imagine what can be done once motorsport engineers get to grips with it. It doesn't even have to be Formula 1, but any type of racing. However, what I suspect will happen is that there will be wrangles about who owns the data, the rights and goodness knows what else, which would be disappointing." ▶

The Circular versus Linear economy provides a framework for more sustainable use of materials and energy

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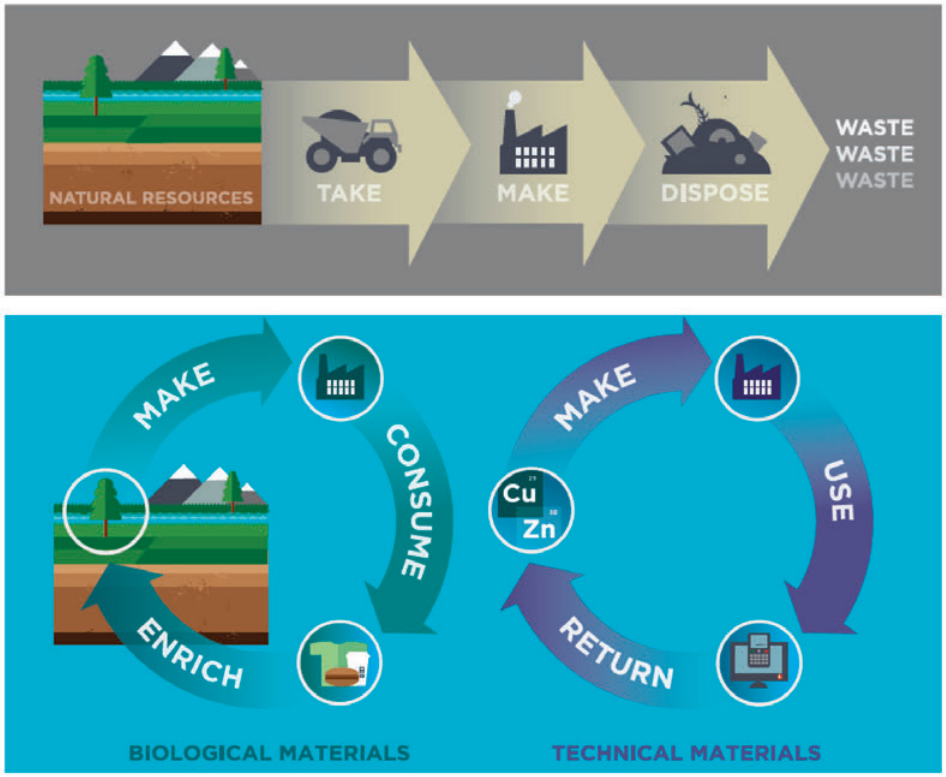

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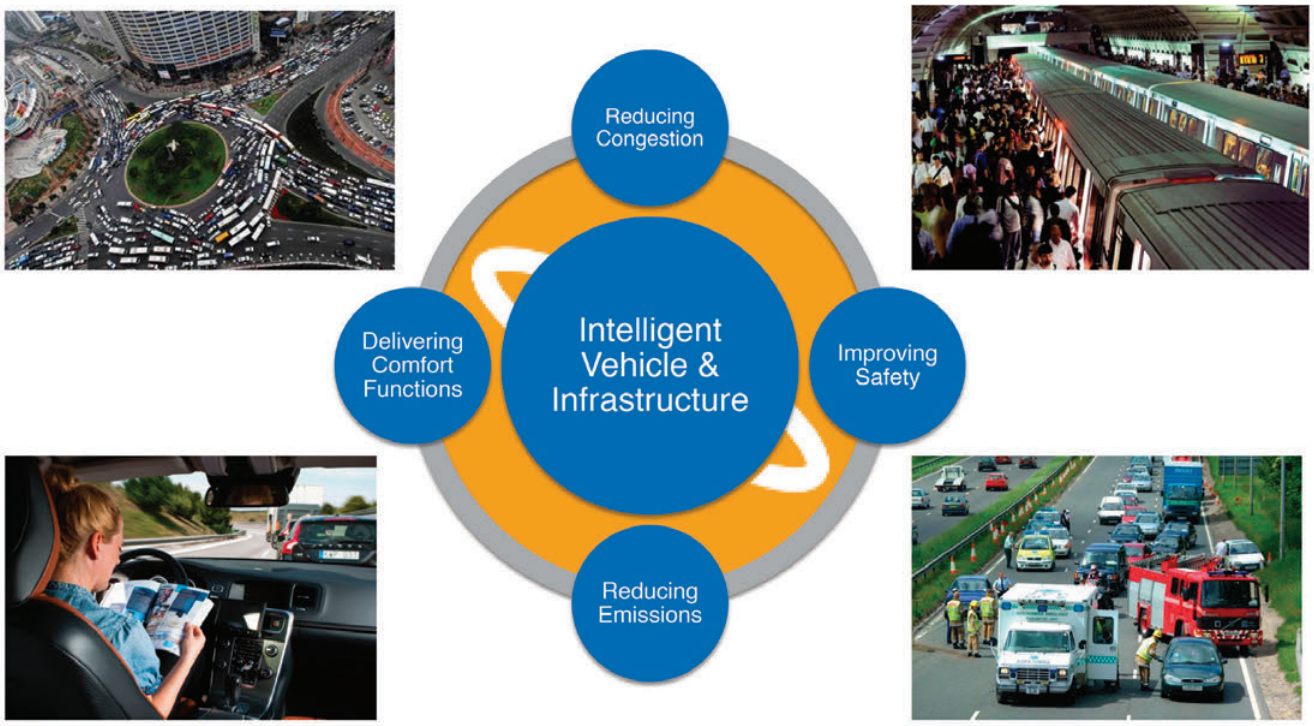

BATTERY DEVELOPMENT

When it comes to battery technology development, Sapsford believes that lithium-ion (Li-Ion) batteries will be around for quite a long time. "I think what Formula 1 and the WEC teams have done with battery technology in terms of how hard it's pushed cells and cell technology is very interesting," he says. "I think that when they first started, cell manufacturers were very cautious but things are all moving ahead massively.

"The big enemies are energy density and the cost. Relative to a tank of fossil fuel, there are still huge challenges to be met. There is talk of batteries getting down to $150 per kiloWatt hour (kWh) in 2025, and some people are even talking about $100 kWh. Getting down to those sorts of numbers means that you are now competing quite well with a fossil-fuelled engine. The trajectory is moving in that direction, but against that we don't get away from the weight.

"I therefore think we will see battery packs becoming part of the structure. Motorsport can play a part here and go down that route as it did with engines. There are many issues around crash and crushability, but it's a way of saving weight."

Commenting on Formula E, Sapsford points out that alignment with road car technology is important, as it is with Formula 1 and the World Endurance Championship, so that the return on investment in developing the electric motors and energy storage systems is sustainable.

"The teams can develop their own electric motors this year and so are investing in this area and for the ultimate in performance will be pushing their permanent magnet machines," he says. "This is in contrast to the automotive industry, which is doing pretty well everything it can to avoid rare earth permanent magnet machines. The clue's in the name and they're expensive! It's the ultimate in performance but does it hit the sweetspot in terms of performance versus cost?

"Everyone else is looking at different forms of electric machines. At the moment Formula E is busy trying to establish itself, but it needs to be relevant going forward. Where is road car technology going and what are the requirements because then I think regulations can be set up to do the same for road cars from a pure battery electric vehicle perspective that F1 has done for hybrids. We don't want to end up in a dead end and have technology for technology's sake."

THE ALTERNATIVES

More than 20 years ago the fuel cell-powered vehicle was seen as the coming saviour, but it all came to nothing or very little. There was even a fuel cell-powered car entered for Box 56 at Le Mans, which came to nought.

"We think fuel cells will be coming, but this could be limited for a number of reasons," says Sapsford. "One is customer acceptance, another is the refuelling infrastructure for vehicles and perhaps the most difficult is where does the hydrogen come from? If you are generating it as a result of renewables, that's good, but if you are getting it from hydrocarbons, then I'm not quite sure about the logic.

"Perhaps there is some logic to use hydrogen as an energy storage medium for intermittent renewable energy but who is going to pay for this? A personal view, and not Ricardo's, is that the right place for fuel cells is in the home in combined heat and power units, as dragging around a mobile chemical processing plant doesn't seem like a great idea because of the complexity involved in doing that. We also have the same infrastructure problems in storing hydrogen." RT

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ABOVE If the diamond ear studs and tattoos are rare in F1, so is Hamilton's level of talent

"Just five months into his F1 career, he had enough confidence to ignore an instruction to let Alonso past, and to tell Ron Dennis where to put himself, over the radio!"

We've all winced at his sparky exchanges over the car-to-pits radio, but what's it *really* like to work with Lewis Hamilton? **Tony Dodgins** finds out

LEWIS Carl Davidson Hamilton, according to the *Sunday Times* Rich List, is Britain's richest sportsman, with a net worth estimated at £131m. That, some would suggest, is conservative.

Taken after the first five races of the 2017 campaign, a decade on from stunning the motorsport world with his dramatic '07 F1 rookie season, the three-times world champion's numbers look ever more impressive: 55 GP wins (second only to Michael Schumacher's 91), 108 podiums and 64 poles (Schumacher has 68 and Ayrton Senna, 65).

Hamilton polarises opinion. Read comments on motorsport forums and fans love him or hate him. Few are ambivalent. But what nobody can deny, is a natural talent possessed by just a tiny few throughout the sport's history.

Talk to those who have worked with Hamilton and three things stand out: his extraordinary car control, his *racing* as opposed to pure *driving* ability, and his unshakeable self-confidence.

These traits were instrumental in McLaren's decision to pluck Lewis straight out of GP2 and put him into a front-running F1 team as reigning twice world champion Fernando Alonso's team-mate – a scenario that quickly 'went nuclear'.

To re-cap, Alonso had secretly signed to join McLaren in '07 at the end of '05. Hamilton had just dominated his second season in the F3 Euroseries and was poised to graduate to GP2 with ART.

Lewis took an early lead in the '06 GP series and there were wins at Nürburgring, Monaco and a feature/sprint race double at Silverstone, where he stunned onlookers by passing two cars in one move, including championship rival Nelson Piquet Jr.

Such moments can be defining. Some 10 years and more earlier, Sir Frank Williams had watched, transfixed, as Frenchman Jean-Christophe Boullion drove around the outside of Franck Lagorce at Spa's Blanchimont! Sir Frank decided at that moment that he wanted Boullion in his car and signed him up to test, before loaning him to Sauber. What perhaps Frank didn't appreciate from the side-on camera shots, was that there was only one dry line, and Boullion was on it...

But Hamilton kept on astonishing. Not long after Silverstone came Turkey. Lewis was under pressure after a Hungarian double from Piquet Jr, who also won the Istanbul feature race, ahead of Lewis. For the following day's sprint race, Hamilton told his ART team that he needed more straightline speed and to back right off on the rear wing. His engineer was dubious, pointing out features such as Istanbul Park's high-speed Turn 8, where decent downforce was a prerequisite.

"Don't worry about it, just do it, I'll sort it out," Hamilton said.

When he spun early in the race, there were grimaces and knowing looks at ART. But it wasn't lack of downforce; he'd just taken a bit too much kerb at Turn 4. There then began one of the most stunning recovery drives ever seen, with Hamilton coming through from the back to finish second, ▶

ABOVE Britain's richest sportsman in familiar territory — Daimler AG


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BELOW Hamilton in attack mode

passing men such as Timo Glock and Piquet en route. Unable to afford an error in this, the penultimate race, it put Lewis's championship back on track.

"It was the most amazing race I've ever seen," said series chief Bruno Michel. "To be honest most people thought he must have been cheating because he was going so well, but the guy was just completely outstanding."

Hamilton's developing affinity for the likes of rap music, fashion, film and celebrity, can mask his focus and work ethic much more than with a driver like Senna, who was much more one-dimensional in his devotion to duty. But a young Lewis had religiously listened to French language tapes in order to better communicate with the ART crew.

His engineer that day in Turkey, Frederic Guyot, said of that recovery drive in which Hamilton earned bonus points for fastest lap – 0.85s quicker than anyone else! – "It was just incredible pace. And he showed without doubt that he is the best racer."

McLaren was in something of a dilemma. Should it risk putting a rookie, straight out of GP2, into its team? Historically it didn't do things like that. It didn't need to. And Alonso himself was not keen, telling Ron Dennis that he would never win the Constructors' Championship with a rookie. Whether that was a genuine belief or whether Fernando, with an eye on what Lewis had been doing, was a tad disingenuous, is open to question!

But, a month after that Turkish display, Hamilton was confirmed as a 2007 McLaren driver. At the time, McLaren was running Michelins and Alonso had never driven on anything else. The story goes that the first time they tested together, Lewis was almost half a second off and Alonso, laying down an early psychological marker, said words to the effect of 'What are you doing?'

But, for '07, after Michelin's withdrawal, Bridgestone was F1's sole tyre supplier and Hamilton had just won his GP2 title on the Japanese rubber. The feel was very different to the Michelins and when the McLaren pair first ran Bridgestones, Hamilton was quicker, and allegedly didn't waste the opportunity to quote Fernando's words back at him!

"I hadn't actually heard that one!" smiles Paddy Lowe, the man who would spend all but three months gardening leave working with Hamilton at McLaren and Mercedes over the next decade, "but what I can tell you is that when Lewis first tested for McLaren at Silverstone at the end of '06, we were super-impressed.

EXCEPTIONAL CAR CONTROL

"It was immediately obvious that he had exceptional car control. The car was quite oversteery under braking and he was just managing it all with a load of steering input. The guys expected him to be complaining when he came in but he didn't say anything – didn't even mention it! He was clearly very, very talented.

"The big thing about Lewis's first year that was absolutely incredible, and I doubt we'll ever see again, was nine podiums in his first nine races, including winning in Canada and the US, races six and seven. When we went to Nürburgring which was the tenth race, at one point he was craned back onto the track with the engine still running, which prompted the FIA to look at what I'd call the first of several 'Lewis Hamilton rules' – rules written to stop people doing what Lewis did and got away with. You can no longer be recovered by a crane with the engine running and carry on racing, but he did it that day!

"We'd made a number of mistakes and he ended up tenth. I remember him coming on the radio on his 'in' lap and asking us what to do, because he didn't actually know what to do or where you go when you're not on the podium! It was his first experience of that, at race 10, which summed it all up really…"

By then, McLaren had imploded. Amid the 'Spygate' controversy in which the team had ▶


Bellanca/LAT

ABOVE Defining moment: Istanbul, 2006, scene of one of the most remarkable GP2 drives. Here Hamilton battles Timo Glock

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Tee/LAT

ABOVE Alonso and Hamilton face the media as their relationship unravels in 2007

come into possession of Ferrari documentation and was trying to limit the fall-out, it had an increasingly angsty Alonso on its hands. Fernando was rattled by Hamilton's pace and the fact that this rookie could come straight in and perform at his level. Over time, he came to understand that the phenomenon that is Hamilton was a special case but, in '07, Alonso's sole focus was trying to assert the number one status he felt he'd been promised on signing. Just five months into his F1 career though, Hamilton had enough confidence to ignore an instruction to let Alonso past for an extra 'fuel-burn' lap in Hungarian GP qualifying, and to tell Ron Dennis where to put himself, over the radio!

Alonso responded by blocking Hamilton in the pits so that Lewis didn't get his second qualifying run in, for which Fernando received a grid penalty. It precipitated an internal collapse at McLaren that ultimately brought about the team's $100m fine and the realisation that it couldn't put two bulls in one field…

GLOBAL MEGASTAR

Hamilton has gone from wide-eyed rookie 22-year-old to three-time world champion global megastar with Bombardier private jet and one of the most recognisable faces on the planet, with the attendant personal pressure. Interestingly, though, Lowe believes that the biggest discernible change in him came between 2007-8.

"From the very start he had complete confidence in his ability and I don't remember anything that needed to be managed (Budapest '07 notwithstanding-Ed!). He just got on with the job, enjoyed it and was very light-hearted. Because he didn't have the pressure, expectation or responsibility. He just enjoyed that ability to get on with the racing and not have to take it too seriously. But when he jumped to the next year and was de facto number one, he felt the pressure of being the driver that this great team had to follow. He took on that responsibility, managed it really well and, of course, won a championship under that pressure."

Guyot's comment about Hamilton's pure racing prowess is echoed by Lowe.

"It was clear from the beginning and you've seen it particularly across the past four years. I think it marks him out as one of the greatest, if not the greatest driver we've seen in the sport.

"You can't tell him anything about race-craft. It's completely instinctive and hard-wired. And he's very, very fair. Very tough but fair. Always correct. And sportsmanlike. But during that first year there were a number of drivers who started a bit of backchat about Lewis's overtaking tactics. They talked as if it was too aggressive because he did overtake a number of established, top drivers. It prompted me to look at it and I remember thinking no, he's just really, really good at it! I don't remember any of the moves being incorrect or out of control, unlike some drivers we've seen in recent years."

But were there not times, during Hamilton's intense battles with Nico Rosberg over the past three seasons, when Nico might have taken issue with that? One thinks of Bahrain 2014 or Austin/Suzuka 2015, where Rosberg felt that, if not quite ushered off the circuit on the opening laps, he at least hadn't been left racing room. ▶


Tee/LAT

ABOVE Total commitment: Hamilton locks his brakes as he battles with Raikkonen en route to his first title, with McLaren in 2008

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BACK TO THE DRAWING BOARD

How Mature Technologies are Making a Comeback

Everything is changing but in a sense it's the same as it ever was, to quote Talking Heads.

Over the last few years we have peered into the far horizon and considered the increased electrification of the powertrain, autonomous racing, racing and many other future technologies almost overlooking the fact that the combustion engine is still here and is still being developed, as are other parts of the car.

So it's time we took that into consideration.

There is a vast amount of work going into making the combustion engine even cleaner and more fuel efficient than ever. It is still likely to be a vehicle's primary motive power for years to come, and this will be reflected in motorsport, not just in terms of competition but in terms of continued development. Cool burning, variable valve timing and lift, pre combustion chambers, and synthetic fuels — the possible disrupter of the disrupters — are just some of the areas of current intensive research.

While going back to the drawing board we will be going into aerodynamics, vehicle dynamics and lightweighting but not forgetting modern issues like connectivity, autonomy and increased hybridisation in the quest to engage a wider audience.

So put **Wednesday, 29th/Thursday 30th November** in your diary to come and join us as we debate the immediate future.

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Ferraro/LAT

ABOVE Ron Dennis gave Hamilton his big break

Lowe smiles. "If you go and analyse those things – and believe me, I analysed those things in great depth because I had to manage the fall-out! – all of those moves were tough but fair enough. Because when you have the inside line, it's your track. But going back to '07 I remember feeling that all the moves were correct but people just didn't like it. If someone overtakes me on the road I might feel peeved and I'm not a professional racing driver, so just imagine how it must have felt when this rookie came charging past…"

There's probably something in that because past drivers with other-worldly ability, men like Gilles Villeneuve and Senna, also upset their peers prior to a grudging acceptance that they were simply on another level.

TURN-IN OVERSTEER

Lowe says that looking at Hamilton's telemetry it's not as if things leap out and hit you all over the place but what is noticeable is that total comfort with turn-in oversteer. F1 cars tend to understeer in low-speed corners and oversteer in high-speed. Comfort with the latter means that you can dial out more of the former with set-up, allowing a bigger operating envelope. If ever Hamilton appears to be frustrated, it tends to happen on the rare occasions when the nuances of tyre performances sometimes transcend even his wider comfort zone and deny him a car balance. A case in point was Sochi 2017, when Hamilton could not 'bring the tyre in' and get it to offer him single lap performance over the entire lap to the same extent that team-mate and race winner Valtteri Bottas did.

"He's not a perfect driver because he has odd bad races," Lowe adds. "Sometimes in adversity he can let his head drop and it's all a really bad day. You hear those frustrated radio communications. You have to try to encourage him from the pits. The days when he's back in 16th, everything's going wrong and the car's damaged. And you've got to say, 'Look, just keep plugging away because you never know what might happen. And don't give up.'

"It's sometimes said that's one of his weak points but those days are reasonably rare and, as we saw against Nico, he has an ability to pull out those amazing qualifying laps where you go, 'Where did those eight tenths come from!?' Because it wasn't in the car.

"That's what you see with the really, really great drivers. Not every week but three or four times a year. But Nico could do that as well. He was actually a great qualifying driver too, which is why the competition was so fantastic to be part of. But the other bit is, apart from those rare bad days, Lewis on a good day, which is most of the time, when you get into a race, is just a phenomenon, like we've not seen in many drivers in history."

If there's an aspect of Hamilton that sometimes rubs people up the wrong way, it's the off-track persona. The rap music, the diamond ear studs, tattoos and bling are unconventional in a motor racing world that is by nature, conservative. But Lewis now, is big enough not to care.

In a 'racing box' from the age of eight, and closely controlled by his father at first, and then by McLaren's Ron Dennis, he went from a child with strict boundaries to a multi-millionaire with the world at his feet and the celebrity girlfriend, almost overnight. With his opinion sought every two weeks on all and sundry, was it any surprise that such a transition was not always straightforward?

"He went through some tough years," Lowe admits, "eventually switched teams and I think ▶


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ABOVE Fans love him or hate him

ABOVE The flirtation with fashion can mask his underlying work ethic

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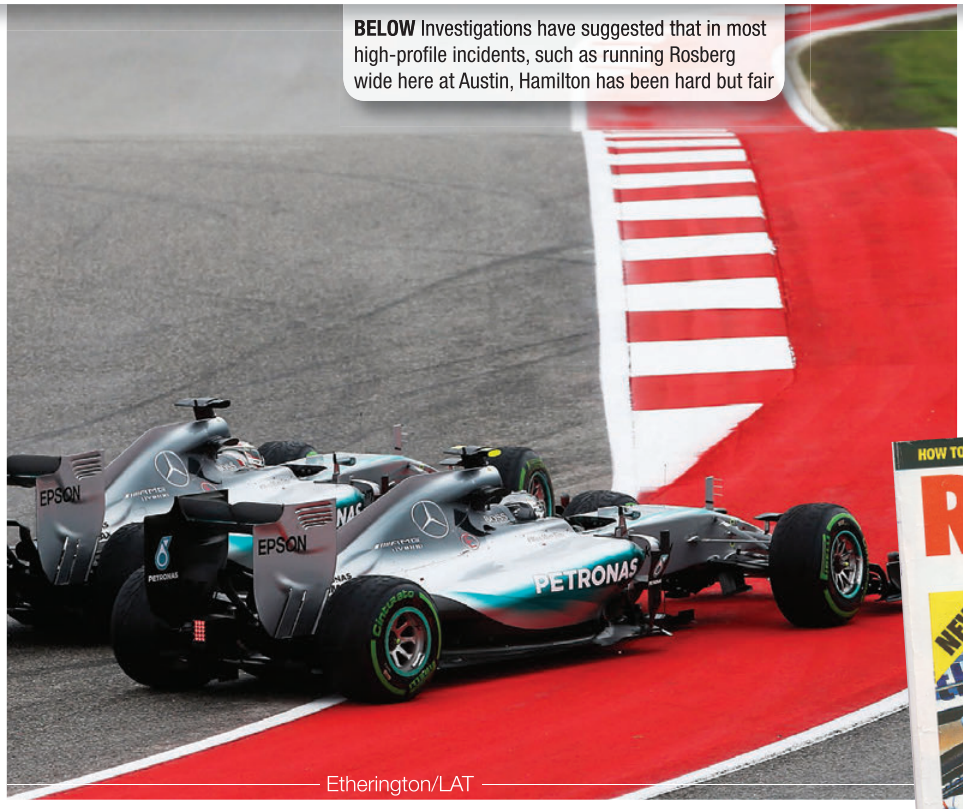

BELOW Investigations have suggested that in most high-profile incidents, such as running Rosberg wide here at Austin, Hamilton has been hard but fair

Etherington/LAT

in a way that was a coming of age – getting out of the McLaren system and into a team with a fresh start with a bit more freedom to be himself. You saw him relax into his own character much more and I think he's generally been very happy at Mercedes."

Through it all, Hamilton said what he thought and, sometimes, that didn't work out. Particularly if, sometimes, he didn't actually know what he thought and the intended image projection was a bit ham-fisted. Then there were the times when his pure competitive instincts got the better of him.

At Spa in 2012, for example, he posted McLaren telemetry on Twitter to prove that it had been differing rear wing levels that had allowed team-mate Jenson Button to beat him to pole, and not superior skill. In the process, Hamilton gave away lots of team data, such as ride height levels, etc, causing some apoplexy within…

"We told him to take it down and he apologised, and did," said then team boss Martin Whitmarsh. "That was an example of his competitive instincts overcoming the need to think things through…"

Hamilton also found it hard to be magnanimous when he lost out to Rosberg in 2016, wanting the world to know that it was unreliability, not Nico, that had cost him his world title. And, if you were paying him £30m a year and had just delivered him back-to-back world championships and countless race wins, you may have taken a dim view when, post-Malaysian blown engine, he stood there wearing a three-pointed star cap and put across the message that he couldn't trust Mercedes reliability. At 31, perhaps a modicum of maturity and discretion would have been better appreciated in Stuttgart…

Nigel Mansell was another who could sometimes convey the impression that the world was against him. Lowe, of course, worked with Mansell in his Williams glory days too.

"Lewis has some similarities to Nigel," he says. "They're not the same, they're both unique, but the fearlessness around what's got to be done, the exceptional oversteer car control, the commitment, not needing to really understand the car well but just naturally feeling how to get the best from it without a great deal of study or coaching, are common. They just naturally go and do it, find the laptime and wring the car's neck." And that's what Lewis's legion of worldwide fans identify with. RT

ABOVE There are parallels between Hamilton and Nigel Mansell, who we featured on our very first cover

Dunbar/LAT

ABOVE Hamilton needed the world to know that it was Merc's unreliability, rather than his team-mate's skill, that had been his undoing last season

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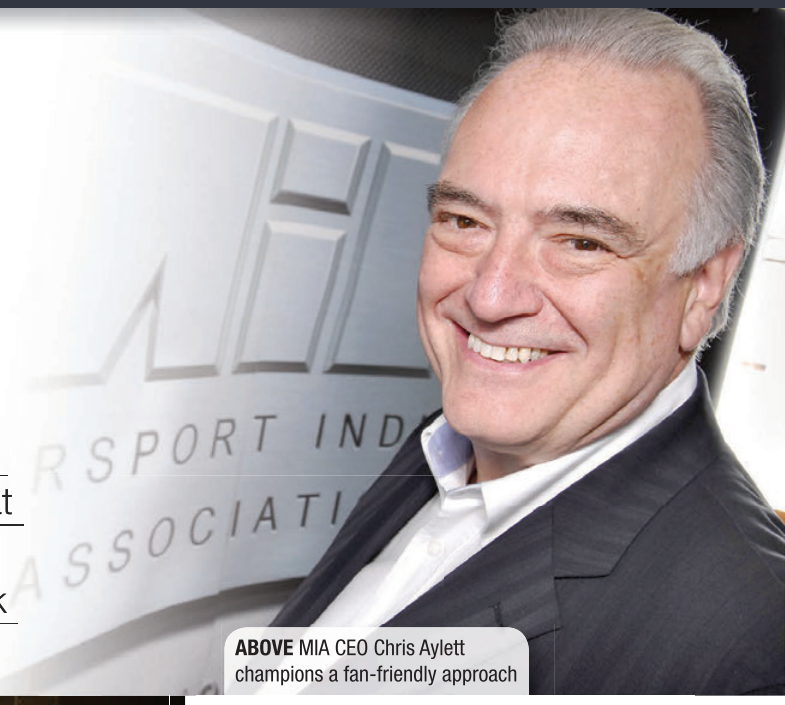
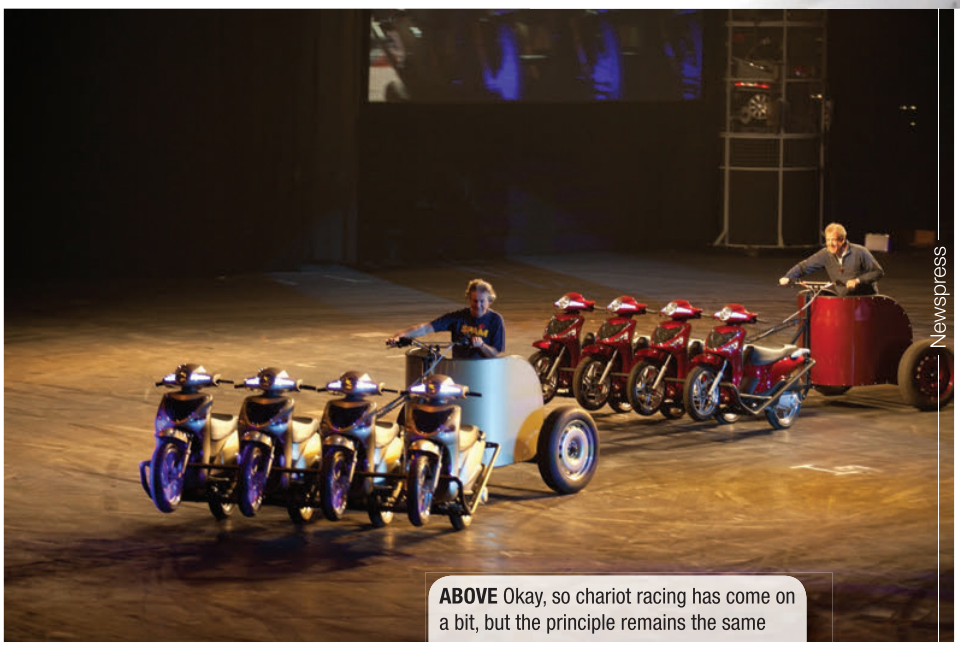
CHARIOTS OF IRE!

It's the year 2025. **William Kimberley** and MIA CEO Chris Aylett reflect on the fact that if a chariot race in the 6th century could attract a quarter of a million fans, what took motorsport so long to get its act together?



ABOVE MIA CEO Chris Aylett champions a fan-friendly approach



Newspress

ABOVE Okay, so chariot racing has come on a bit, but the principle remains the same

"**D**o you remember when motor racing was solely the province of the petrol engine?"

"Just about," comes the reply. "I can't believe just one type of engine was used. It was the only thing we knew, of course. Yes, there were different configurations, but compared to the age we now enjoy, how boring!

"Look at what we have! Full and semi-hybrids of all sorts; different types of electric cars using various motors and battery packs; a variety of diesels which became fashionable again after being left out in the cold until, inevitably, CO2 emissions began to increase significantly. I really enjoy the Alternative Powertrain Series and that new Hydrogen Fuel Cell Championship looks great, reminds me of those early days of Formula E."

"… and we've got the fabulous Robocar Figure of 8 Series. Now that's *real* racing, way better than the old-style rallycross that had drivers, can you imagine! I must confess I never really got drone racing but this is something else, virtually sitting in the autonomous car as it races around the track, chasing, catching and overtaking the others."

It was a cold and blustery day when Chris Aylett, still going strong as the CEO of the Motorsport Industry Association, and myself were reminiscing about the not so good old days as we sipped our Babychams at a pub in November 2025. We were celebrating *Race Tech*'s issue 300 and looking back over the eight years since the July 2017 issue 200 of the magazine.

How things had changed since then. As Chris had forecast, most carmakers had launched substantial electric fleets by 2020. Sales were comparatively low, accounting for no more than 12 per cent of new cars being bought. OK, sales had increased from zero a few years before and there was clearly a direction of travel moving away from fossil fuels. But there was still a long way to reach the 35 per cent forecast for 2040 by reports published back in 2017. It meant the car we knew back then was still, by far, the favoured mode of personal transport even eight years later, and motorsport entertainment, as always, reflected that.

"Enjoying entertainment from racing the transport of the day, whether boats, planes, cars, trains or chariots, has been with us forever," Chris pondered. "The method of propulsion used in motorsport has always reflected the various and most popular solutions of the time, just as they did in the steam/electric/gasoline pioneering days of the early 20th century when they raced what they had. And so it has continued into 2025 with the transport of today.

FORMULA E TRAILBLAZER

"Look at the Alternative Powertrain Series, a snappy title I know, that has come on over the last few years. You could say the trailblazer was Formula E, which is now firmly established all over the world. I can remember the time when we thought we would never see a diesel-powered car on the race track for many reasons, one of which was the expectation of a lot of unhealthy black smoke trailing the car. Who would have thought it was a forerunner showing just how innovative and creative powertrains would become and still are. Looking into the future, beyond 2025, I'm excited by the thought of enjoying the sight of a fascinating ▶

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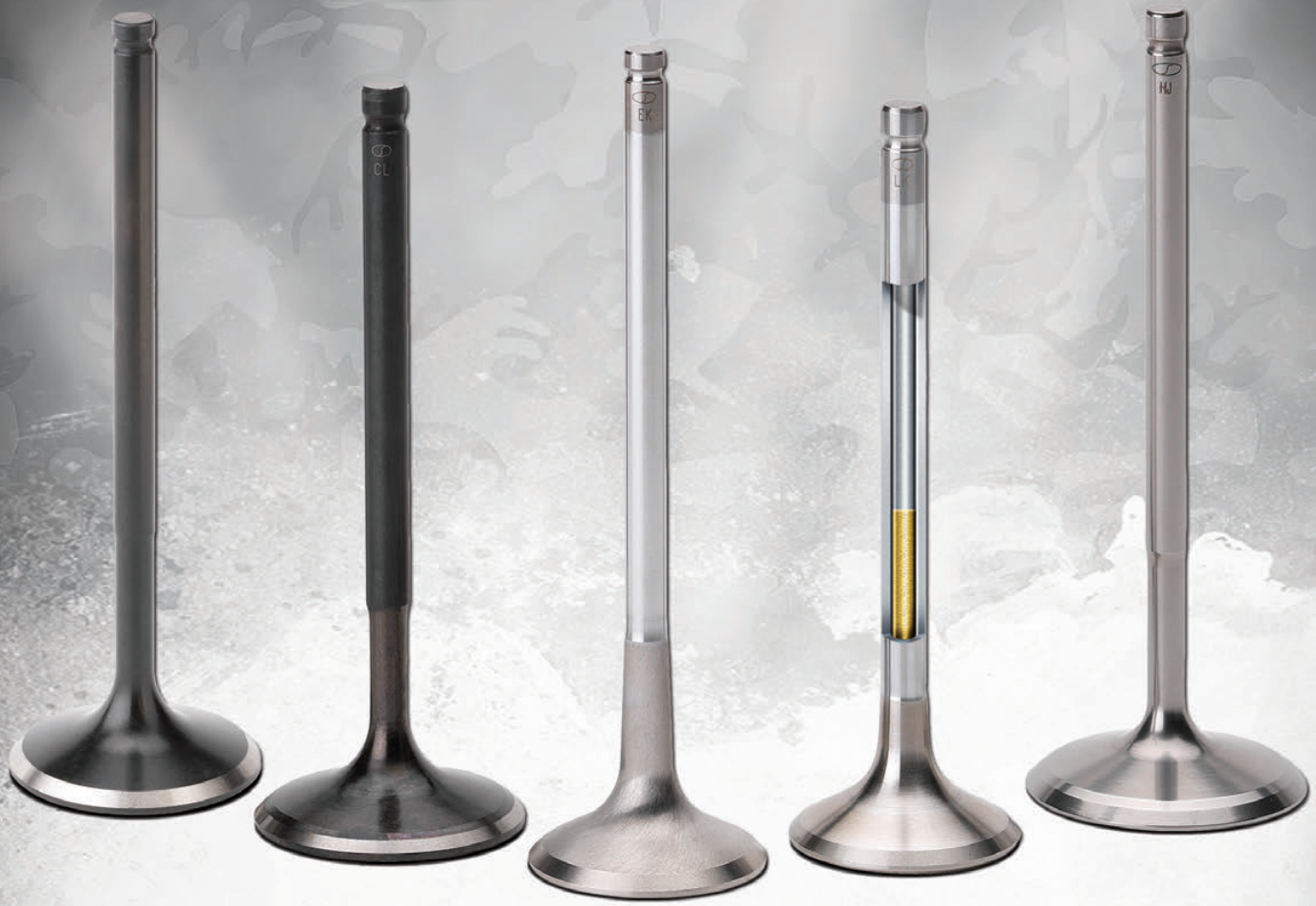

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> *"The experience most fans want is to be close to the cars and drivers"*

cocktail of powertrains competing against each other, and the engineering challenges that will bring.

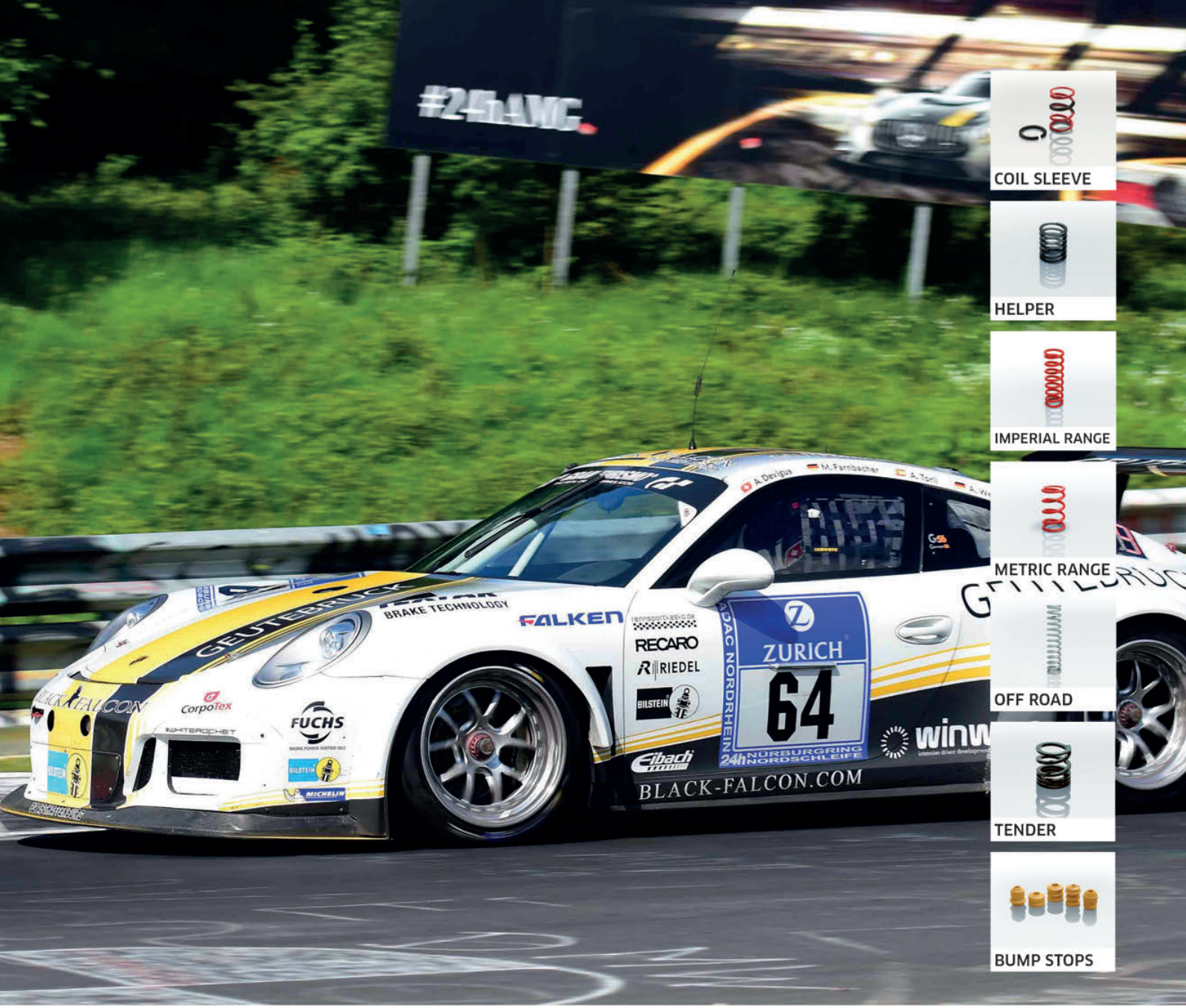
"What motorsport has always done so well, which the success of Formula E has shown in recent years, is to popularise engineering solutions, including powertrains too," Chris continued. "Even back in 2017, I felt autonomy would come into motorsport, in some form, so the automotive industry and government could demonstrate to the public what they saw of the future. It just seemed inevitable, and relatively simple, for the whole pit area to become the autonomous zone we see today. The safety car looked a pretty simple target too. But whether it was controlled by a human and connected to them or could really think and act by itself, so being truly autonomous, had to be resolved over time and that took some doing."

On the political front, there was real upheaval after the UK left the European Union in 2019 and it took two or three of years for the dust to settle. There had been some disruption felt by Motorsport Valley companies but, being the global players they still are, and motivated motorsport businessmen being pragmatic and optimistic by nature, the industry as a whole thrived. The European marketplace still played an important part but the market had become truly global, with many companies opening up offices in the USA, India and China to catch the fast-growing business there.

A couple of Formula 1 teams threatened to locate in their home countries, but soon realised the cost of disruption and distance from the experienced UK supply chain far outweighed the extra cost of remaining in-situ. German teams were content to live and work in the UK and keep winning, as did the French keep trying. They also enjoyed UK government support which encouraged inward investment, grants and special concessions on corporation taxes and R&D so there was no better place to be – in fact, business had never been so good.

LIFE AFTER BREXIT

As Chris forecast, poor commercial decisions by weak politicians had forced high-performance engineering companies in the UK to increase their trading prices with the EU, which led to motorsport there becoming more expensive. However, it was interesting ▶



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Renault Sport

ABOVE F1's come a long way in a short time, hasn't it?

to see profits of high value added, low volume engineering companies increase, being less affected by the rise in cost of imported raw materials compared to those involved in mass production.

As he ruefully noted, "There's no doubt that, in 2025, we now live in a more expensive world thanks to the politicians who failed to agree on a way to allow businesses to be more competitive."

On the positive side, though, as he had said back in 2017, Liberty Media taking over Formula 1 was a major plus for the sport as a whole: "I remember Chase Carey, the-then boss of Formula 1, saying on the grid at the Spanish Grand Prix in 2017 that his first thoughts were about entertainment and how to engage more fans. They were putting them first, something that hadn't happened for decades.

"The trickledown effect from that enlightened strategy on the rest of motorsport was fantastic. Back in the day, pre-Liberty, I tried hard to get someone to listen. I just knew increasing the number of fans in the live audience was the heart of future financial success for motorsport and we would have to fight other sports very hard to capture and keep them. I was just banging my head against a brick wall but how things change!"

Liberty Media's ownership of Formula 1 had brought with it the ability to look at the big picture and what the synergies might be with other providers. It had taken into account the demands of the Generations X, Y, and Z, those born after 1999, that were totally different to the Baby Boomers who ruled the roost with their values until 2017.

The business of Formula 1 could no longer live off the earnings from outdated TV and radio broadcasting rights, screwing every last penny out of the circuits, and selling rights to the circuit advertising hoardings during a grand prix weekend. Although much of that was still in place, attention was increasingly directed towards attracting more fans, and once having got them, keeping them.

Things that previously would have been abhorred were now commonplace. Fans were allowed entry into the paddock, and there were driver signing sessions, video streaming, opening up and allowing Formula 1 content on You Tube, Facebook and all the many new social media outlets that were springing up every week it seemed. Every Grand Prix event became just that, an event over several days, not solely focused on Formula 1 but all kinds of family entertainment and with much more racing as well, over the weekend.

The fans loved it and as a result, all motorsport moved into a new golden era. As Chris himself had long maintained, entertainment and competition for the fastest transport had always gone hand in hand. "Look at Circus Maximus," he would say, "… a chariot race attracting 250,000 people in the 6th century – that's a quarter of a million people watching horses pulling transport around!

F1 WAKES UP

"It's the volume fans who bring in the money by attracting sponsors. In turn, they spend money on teams who, in their need to please the sponsors with a win, spend it on the suppliers to get their cars to beat the others. It's a valuable, virtuous and highly competitive circle. The solution wasn't complicated: most other sports had got it a long time before but not motorsport, especially Formula 1. It was well out of step ▶

Roborace

ABOVE Autonomous cars racing each other? Even back in 2017 we knew it was only a matter of time

with the true value of sports entertainment until Liberty Media arrived on the scene."

The same was true of GT racing in Europe, where success was measured by the number of cars on the grid rather than the number of spectators in the grandstands. It was like measuring the success of a football match by the number of players on the field rather than the people watching it. Some promoters woke up and changed their business focus, learning from the new Formula 1.

Tee/LAT

ABOVE Do you remember then-F1 owner Chase Carey that day on the grid in Spain? He suggested putting fans first but nobody really thought for a moment that would catch on!

REVOLUTIONARY VISION

Even the good old FIA saw the chance for more action and, when considering a new race series, made promoters demonstrate their plans to increase the live fan audience. They also put in place new rules for circuits, who had to improve fan experience from toilets and Wi-Fi, to food and seating. Nowadays, from the moment a fan arrives to the moment they leave, they are king (or queen) for a day, even in club racing. At the time this was a revolutionary vision for Europe, but not so in the USA, Liberty Media's home territory, where all sports had long prospered by putting the fans first.

"What's still yet to happen at club and national racing level, is something I pushed hard well before 2017," mused Chris. "These are an important customer group and the bedrock of our fanbase. I still want host circuits of these less commercial events to send fans directly into the paddock and make them welcome there, not to some windswept grandstand far away from their cars and drivers. In fact, I would close down all but one grandstand for club racing, leaving just the nearest one to the paddock and drivers.

> *"F1 was well out of step with the true value of sports entertainment until Liberty Media arrived"*

"At the end of the day, at this level, the experience most fans want is to be close to the cars and drivers. I argued long and hard for clubs to adopt this policy, but none have. Hopefully one day they will see the light."

The conversation then drifted to politics and the Corbyn-Trump era and its unexpectedly positive effect on UK-US relations. Nobody ever believed that would happen either! But that's a story for another day. RT

BELOW Formula E led the way with the wireless EV charging technology employed in its safety car. Before long, the car was autonomous

FIA/Formula E

THE ROAD TO AUTONOMOUS

Dominic Harlow guides us around a few of the obstacles that lie ahead for autonomous motorsport

WHEN Race Tech first went to press in 1995, one of the greatest racing drivers of all-time had just tragically lost his life. His rival, a new name destined to be to this day the best-ever, had just taken his first Formula 1 World Championship and was on his way to a second. It is also safe to say that, apart from the character Douglas Quaid, played by well-known motorsport fan Arnold Schwarzenegger in the early nineties movie *Total Recall* – in which he jumps into a "Johnny Cab" to escape his assailants – no one had really considered self-driving or autonomous vehicles, let alone how they might be raced.

At that time, the focus remained very much on the human drivers, enhancing safety and limiting what were felt to be pervasive systems or aids that overrode their input. Indeed, active suspension – something which could make cars appear to be 'alive' when going through a system bleeding process in the garage, looking like a morning exercise class or ballet lesson, as so well described by Steve Matchett in his book *The Mechanic's Tale* – had just been banned. Steps such as an extra hole in the airbox were also being taken to prevent the clever engine control strategies that Benetton-Renault had employed to good effect during its championship-winning seasons.

100 ISSUES

After 100 issues of Race Tech, things had of course moved on in Formula 1. The


Bosch

LEFT & RIGHT Automotive AI (left) could be taken to the next level by Roborace, whose 'DevBot' (right) is being used as a mobile testbed for the technology

late 2000s saw the end of the first big car manufacturer era and a raft of regulation changes aimed at, amongst other things, improving overtaking and permitting the drivers to further demonstrate their skills through a return to slick tyres.

Technologically, the investment brought about by the involvement of the OEMs and continued growth of the series, combined with Moore's law, had resulted in a rapid advancement of the capability and use of all types of simulation. One of these, Quasi-Steady State (QSS) lap simulation, had of course been around for a long time at this stage, 30 years or more, with Bill Milliken's work at Cornell on the re-development of Watkins Glen in '71 probably the earliest record of such a study.

Although impressive in its output, the principle employed to generate a driven lap of car data, a path curvature, speed at any point, including the driver inputs of throttle, brake, steering and (if required) gear selection, readily comparable to real track data could not be claimed to be intelligent.

> *"Autonomous motorsport is no longer the future but a serious and credible reality"*


Roborace

Nor is it autonomous in having the freedom to act independently.

One might recall also the work of Alan Turing just 20 years before Milliken, but it's also not true that the computers involved were really 'thinking'. The latter ability is surely a pre-requisite for independent action, in solving these problems, even if we don't really know if, with the right programming, they could have passed his now famous test[1] – The Imitation Game.

It seems fair to say, however well the results could be tweaked to match reality, that simply solving equations of motion for equilibrium at discrete time intervals is a long way from really driving a car. A great deal of discussion and effort then went into considering how these tools and models could be improved, though. A lot of this work centred around the concept of a driver model that went beyond just seeking the limit condition at any given consecutive point in time. This arose out of a desire for still better correlation between simulation and reality, knowing a QSS lap sim is hopeless for determining perceived balance, for example, and a wish to exploit dynamic simulation for the deeper analysis and understanding of transient behaviors.

In these intervening years between issues 1 and 100 (1995 and 2009), and after the lifting of the prohibition on certain driver aids, there was also a definite optimism about what might be possible with a vehicle's control systems in combination with learning algorithms. After advances in longitudinal controls (ABS and TCS), the big remaining prize in motorsport was a kind of stability control that was adaptable to different conditions, basically measuring and predicting changing grip levels and putting the car closer to the limit than a driver could at any given point.

The irony was that the driver didn't seem to have any less to do. Instead – perhaps due to the bandwidth of the control actuators, the availability and reliability of certain sensors and the difficulty in modelling tyres – it often seemed that the driver was used even more to set up these various scalable systems through an array of rotary switches and menus. Even today, when these systems make an appearance in road cars, they often appear to be more about accident prevention than outright performance.

That's not the case in aviation, ▶

[1] Computing Machinery and Intelligence. Turing, A.M. *Mind*, 59, 433-460; 1950.

ABOVE & BELOW Audi's RS7 autonomous concept car completed a lap of Hockenheim's GP circuit at racing speeds at the 2015 DTM finale

incidentally, where fighter aircraft like the F-22 and F-35 would be completely unflyable, whether straight and level or at 50 degrees and more angle of attack, were it not for the tens of millions of lines of code behind their avionics. Also, just as with land vehicles, in military and some branches of civil aviation, drones and particularly intelligent swarms of drones such as the US' Perdix variant, are bringing autonomous operation to the forefront of options for many different missions.

Another simulation technology that had become commonplace by 2009 was the driver in the loop simulator. Not really AI, but more VR in today's terminology, and an interesting crossover of these areas. Certainly, some DIL simulators could be driven automatically, or autonomously, using driver models that interacted with the vehicle model and generated data. But this was perhaps more of an esoteric development area, contributing to general R&D and system testing, than a tool with any direct outcome for the track.

It's an interesting avenue, though, when one considers how with the advent of iRacing-type events the different levels of virtualization might mix. One day, autonomous and human-driven cars might compete together on the racetrack while, at the same time, other humans and simulations race alongside them in the virtual world!

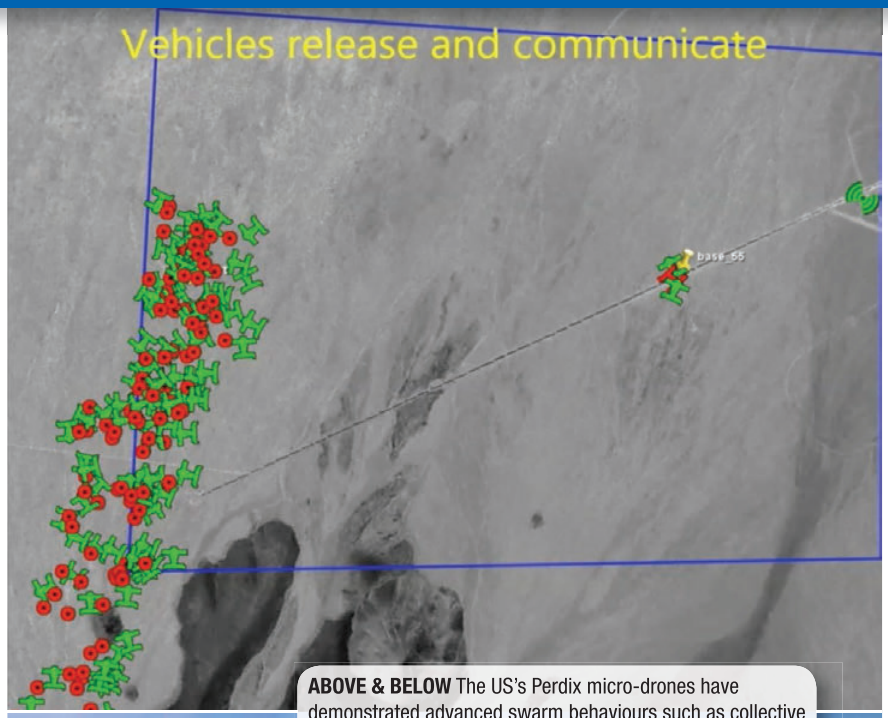
Within Formula 1 and motorsport in general, it took some of the best brains and most long range antennae to gain a sense of what the future might hold. In discussions and articles both Pat Symonds, with a finger on the pulse of F1, and Ulrich Baretzky, close to the heart of a world-leading OEM, suggested that motorsport would be well advised to begin considering the impact and future of autonomous vehicle technologies on its landscape.

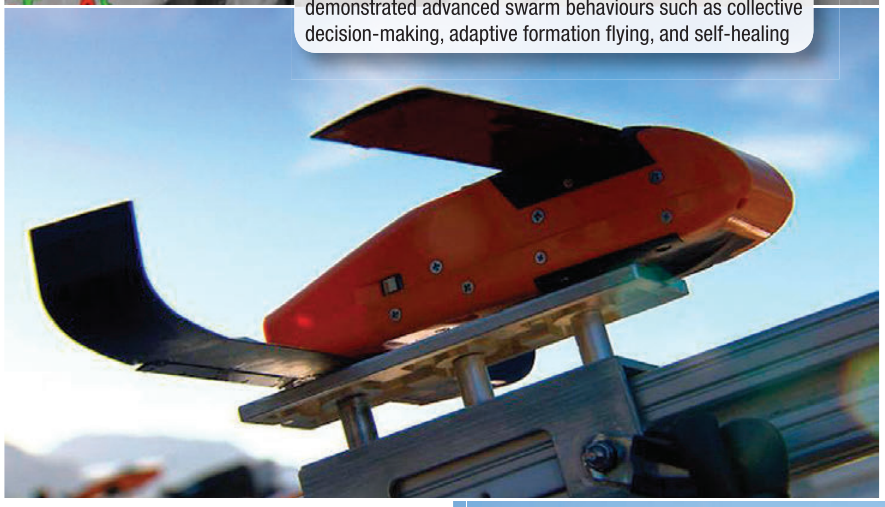
Frequently prompted by the editor of this publication, many more interesting questions were raised among peers during Race Tech's recent World Motorsport Symposiums. They ranged from the technological, "How would changing track conditions be dealt with?" to the commercial "Would there be an audience for this kind of entertainment?" and from the philosophical "Would it still be sport?" to the personal "Would they still need a race engineer?" Engineering curiosity and an enthusiasm for new ideas certainly overcame any cynicism in most of the responses I heard at that time.

200 ISSUES

As Race Tech moved closer to its 200th issue, the pace of change has become ever more frenetic. At the end of 2015, Roborace, the world's first autonomous electric vehicle motorsport championship, was announced. Autonomous motorsport is no longer the future but a serious and credible reality.

Just a few months earlier, Audi had ▶





ABOVE & BELOW The US's Perdix micro-drones have demonstrated advanced swarm behaviours such as collective decision-making, adaptive formation flying, and self-healing

displayed an autonomous vehicle at Hockenheim. A relatively standard RS7, nicknamed Bobby and driving some sporty laps of the track, got to 240 km/h and within 30 seconds of a DTM car's laptime. No records were broken, but it was one of those moments that grabbed the attention of all those present, both those in the grandstands and those with access to a monitor or screen showing the action.

There has been an explosion in global interest in autonomous vehicles on and off the track, and there is a race amongst many big players to dominate the consumer market. It's a sizeable market too: estimates put the yearly value for autonomous cars at $25 billion by 2025. By any standards this is huge. Add to that the potential for commercial vehicles and by 2030 predictions for the combined value end up at nearly $100 billion. Close to 90 million cars and light commercials of all kinds were sold in 2016, which was a record year, so these figures represent a not insignificant proportion.

> *"Estimates put the yearly value for autonomous cars at $25 billion by 2025"*

At the CES (Consumer Electronics Show) this year in Las Vegas, the atmosphere was more like a motorshow with multiple OEMs attending to show off self-driving technologies. One of the wilder products on display was even a Honda self-riding motorbike…

The SAE recently created a standard for road-going autonomous vehicles, which is being formally adopted worldwide. It has defined six levels for the systems, with self-driving with no human intervention being level 4 and fully human equivalent (they don't say who!) as the top level 5. Companies like BMW and Mercedes are promising to release level 4 vehicles in 2021 or before. Tesla already offers many features on its electric vehicles (its autopilot system is level 2 and all new cars are equipped with level 5 hardware) and players such as Nvidia – Roborace is using its electronics – Intel and Bosch are rapidly forming alliances to push their technology to the forefront of the market.

There are some caveats, however. Talking recently with an engineer from F1's communications technology side, a note ▶

Lockheed Martin

ABOVE Fighter aircraft like Lockheed Martin's F-35 would be completely unflyable without the code behind their avionics

Pirelli

ABOVE Some of the software employed in F1 to optimize power unit energy management strategies already relies on a form of AI or machine learning

of caution that others are also sounding arose. "What about the infrastructure to enable these technologies to take hold?" he asked. "They seem straightforward but is it just around the corner as we might think, or could there be more that really needs to change?"

The implication was that clearly the future wouldn't be quite as close this time as we might imagine. Such issues are apparent if we think about the 5G or other networks that are needed for vehicle connectivity, or the suitability of current urban infrastructure.

The communications issue is worth picking up on. One thing that makes AI and autonomy more feasible in vehicles for mass mobility is the ability for the fleet to learn collectively. In theory, only one vehicle need experience a given scenario for that data to be fed back to its producer's central hub, to then permit a software or database update which immediately rolls out to the entire fleet. Perhaps this point is one reason that motorsport could become the perfect environment in which to develop, because the race circuit immediately removes these issues of wide area connectivity and offers an ideal group on which to experiment.

ROBORACE'S OPPORTUNITY

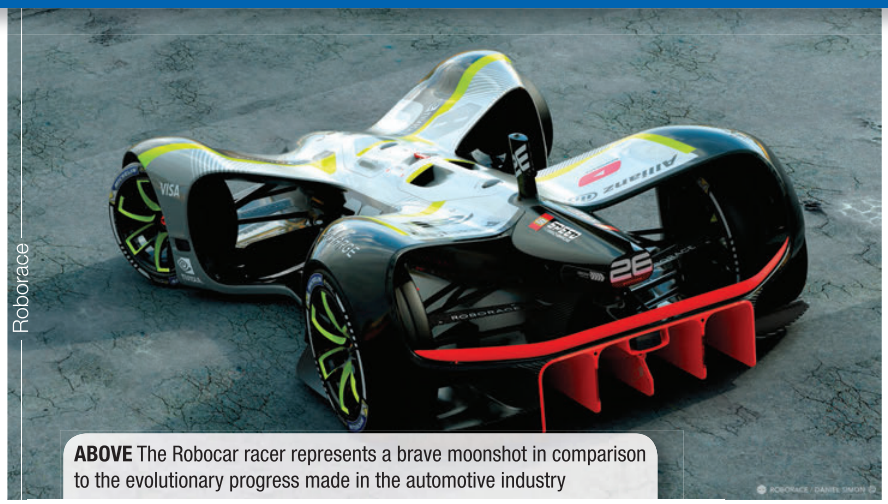
This is where Roborace steps in, offering a platform for technology companies to develop self-driving AI. The series already has two 'Devbots' serving as testbeds and destined to continue as the championship's laboratory. The test vehicles have run individual and parallel laps at demonstration and test venues and their development continues. A race version of the chassis is designed and has certainly generated interest and publicity.

The basis of the car is a conventional EV, operated by electrical and pneumatic control actuators for steering and braking. There are multiple Lidar, Radar, Sonar and Doppler sensors, together with cameras, GPS and conventional transducers fitted to the car and a real-time telemetry capability.

The sensors are an area where development is rapid and where a series like Roborace could offer an ideal proving ground. The demands of adequate range are obviously increased as the speed of a vehicle rises and manoeuvres must be initiated more quickly and the motorsport environment is usually more harsh than automotive when it comes to the issues of heat and vibration. Companies like XenomatiX are springing up to offer full solutions to the problems of environment mapping, surface detection and large and small object recognition, 360 degrees around the vehicle and in any conditions of light and weather. All these capabilities could be tested and proven on the track.

The possibilities for how the series could develop as a competitive endeavour are huge and fascinating. Clearly driving for optimum laptime is just one part of the challenge and assumes that a form of laptime-based qualification is used at all in configuring the races. It then must be determined what the race objective should be and within what constraints. Is it enough, for example, to target only minimum time or should there be other factors involved such as avoidance of incidents and correct observance of safety protocols? If, for example, yellow flags are needed at all, what should be the penalty if they are disobeyed, and can that be done willfully? In the absence of a driver briefing, will Race Control have the ability to override all other systems?

These are sporting questions but there are also technical ones to address. The cars will ▶


Roborace

ABOVE The Robocar racer represents a brave moonshot in comparison to the evolutionary progress made in the automotive industry

be standard across all the competitors with software layers opened to modification. That would appear to eliminate most of the car setup parameters and aerodynamics as performance differentiators. There are still some interesting areas where racing knowledge might be applied, however: tyre management, brake management and, if necessary, energy management, to name three.

With telemetry and naturally a vast amount of data potentially available, another consideration will be whether two-way telemetry in any form is permissible and what kinds of adjustments can be made this way. Could software patches be applied mid-race, for example, or could the vehicle be taught about competitors' performance or the true grip available? This might happen in the real world, after all.

It's also interesting to consider how much of the data should be shared and how widely. Clearly open data is hugely advantageous for development but could be contradictory to some competitive elements of the series or bring issues of IP. In general, given the 'virtual' nature of the technology employed by the competitors, the regulation of such a competition does indeed become a challenge.

In Formula 1 in most quarters there is a tempered enthusiasm for these new technologies. It was noted recently that some of the software employed to optimize the power unit energy management strategies actually relied on a form of AI or machine learning, refining recovery and deployment lap by lap to determine the best solution without the driver needing to sweep multiple different switch settings.

The sport is also toying with the reintroduction of active suspension, the reincarnation of those living Williams FW14B and FW15C beasts of years ago! There is enormous potential here to deploy and develop new technologies, which are complementary to a human driver, and which presuming the TAG320 is replaced ▶


Williams F1/LAT

ABOVE F1 possessed cars that could have driven themselves, long before autonomy became an industry buzzword. The Williams FW15C that carried Alain Prost to the 1993 title had anti-lock brakes, traction control and active suspension. A ban on 'driver aids' followed swiftly

Renault

ABOVE Renault's vision of F1 in 2027 incorporates autonomous driving function. Driving duties would automatically be delegated to the computer during safety situations such as the deployment of safety cars, yellow flags etc

to facilitate the additional control, are eminently possible. On the other side, however, the recent successful push to increase the physical strain on the drivers during racing and to allow more aggressive race driving through more robust tyres and increased fuel allowance is rather anathema to some of these new ideas.

> *"If we say F1 has to align itself with road cars, then logically we end up with an electric car that drives itself"*

CONCLUSIONS

This is a challenge for Formula 1's new leadership and one which they have acknowledged. "If we say F1 has to align itself with road cars, then logically we end up with an electric car that drives itself," the pragmatic Ross Brawn summed up recently. This is clearly not the differentiated technological, sporting and entertainment product with superstar drivers at its centre that F1 wants to be. Almost by implication though, this statement clearly defines a space for autonomous racing within the motorsport sphere and can begin to form our conclusion.

The fact that the driver will never feature as an element in a Roborace championship allows the focus to move on from old-world skills and thinking – like changing gear or the desire to maintain an element of danger or physical fitness – to other areas of the package. There seems no reason why that can't become an enthralling proposition.

It should also not escape notice that Brawn anoints EVs as the current successor to IC or Hybrid as the means of mass mobility. This seems to be becoming increasingly evident if not yet conclusive, as governments back electric and banish diesel and companies such as Daimler abandon or scale back hydrogen fuel cell vehicle research.

For some of the established players the road to level 5 autonomous is an evolutionary one, to be taken one step at a time. For others, like Roborace, it is much more of a moonshot, a leap to be made in one go from zero to one and all the braver and more exciting for it. It's clear that the future is upon us in motorsport and we should be looking to enjoy the journey and perhaps have a little more patience and apply a little more logic than a certain Mr Douglas Quaid. To finish with the same words as Turing seems appropriate, "We can only see a short distance ahead, but we can see plenty there that needs to be done." RT

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MISSION TO WIN LE MANS

In 1997 Toyota designed one of the most iconic sports cars in history with the aim of winning the Le Mans 24 Hours. Twenty years on, the mission remains the same. But the manner of the car's design and development have, as **Gary Watkins** discovers, changed beyond all recognition

TOYOTA'S mighty GT-One challenger for Le Mans 24 Hours glory in 1998-99 broke new ground. It was the most extreme of a line of GT1 machinery to race in the French enduro through the second half of the 1990s and can with some degree of certainty be said to be the first racing car to be designed entirely on a computer.

But things have come a long way in the intervening years. The design and manufacturing processes involved look positively old-fashioned when compared with those that have resulted in the latest Le Mans contender to emerge from Toyota Motorsport GmbH in Cologne.

The GT-One project, which was also given the TS020 type number by Toyota in Japan, can be viewed as a link between two ages of racecar production. Yes, it relied heavily on digital technology, but nearly 20 years on, many of the old-school practices employed by Toyota have long since disappeared. You certainly won't find a wooden mock-up of this year's TS050 HYBRID anywhere in TMG's Cologne facility.

DESIGN

Renowned sports car designer Andre de Cortanze, whose Peugeot 905 claimed back-to-back Le Mans victories in 1992-93, took TMG into the digital age. When he joined to lead the GT-One project in January 1997 there wasn't one drawing board in the design office and it remained that way throughout.

There weren't any CAD stations either, and only a handful within TMG at the time, and they were in use on the organisation's World Rally Championship programme. Time was of the essence, however, because de Cortanze wanted the first GT-One up and running by the end of December of that year, and he hit his target to the day with the help of computer-aided design.

"The main driving force for the use of CAD and the absence of drawing boards was the timescale," says John Litjens, then a young integration engineer and now chief project leader on the LMP1 programme. "The processes should be quicker because you are working in three dimensions, so you can work out possible problems and areas of interference."

Yet the CAD systems employed at TMG back in the late 1990s appear rudimentary by the standards of today. "Everything is much more integrated these days," says Litjens. "Before each designer had his own CAD PC, so if you were a suspension designer and needed some information from say a composite designer, you would have to go to their PC and look up the part. Now we have a data management system for the complete car, which you can go through to find the correct part. It is much more organised now.

"The visualisation tools are so much more powerful today. You can quickly call up the external surfaces of the model when you are discussing ideas and principles. And if you are at the track, you can quickly check something without it taking ages to load up."

Packaging a modern twin-system hybrid has inevitably resulted in the design of the TS050 being a much more complex affair than that of the GT-One.

"We were more worrying about the external surfaces of the car in those days," reckons Litjens, who went on to engineer the GT-One that finished second at Le Mans to BMW in 1999. "The car is much more complex internally these days and not only because you have two hybrid systems and a battery to think about. You also have to think about the hydraulics for the gearshift, for example. You don't have to worry about routing a cable, but you still have to find room for the pumps and actuators. It moves the job from inside the cockpit to the engine bay."

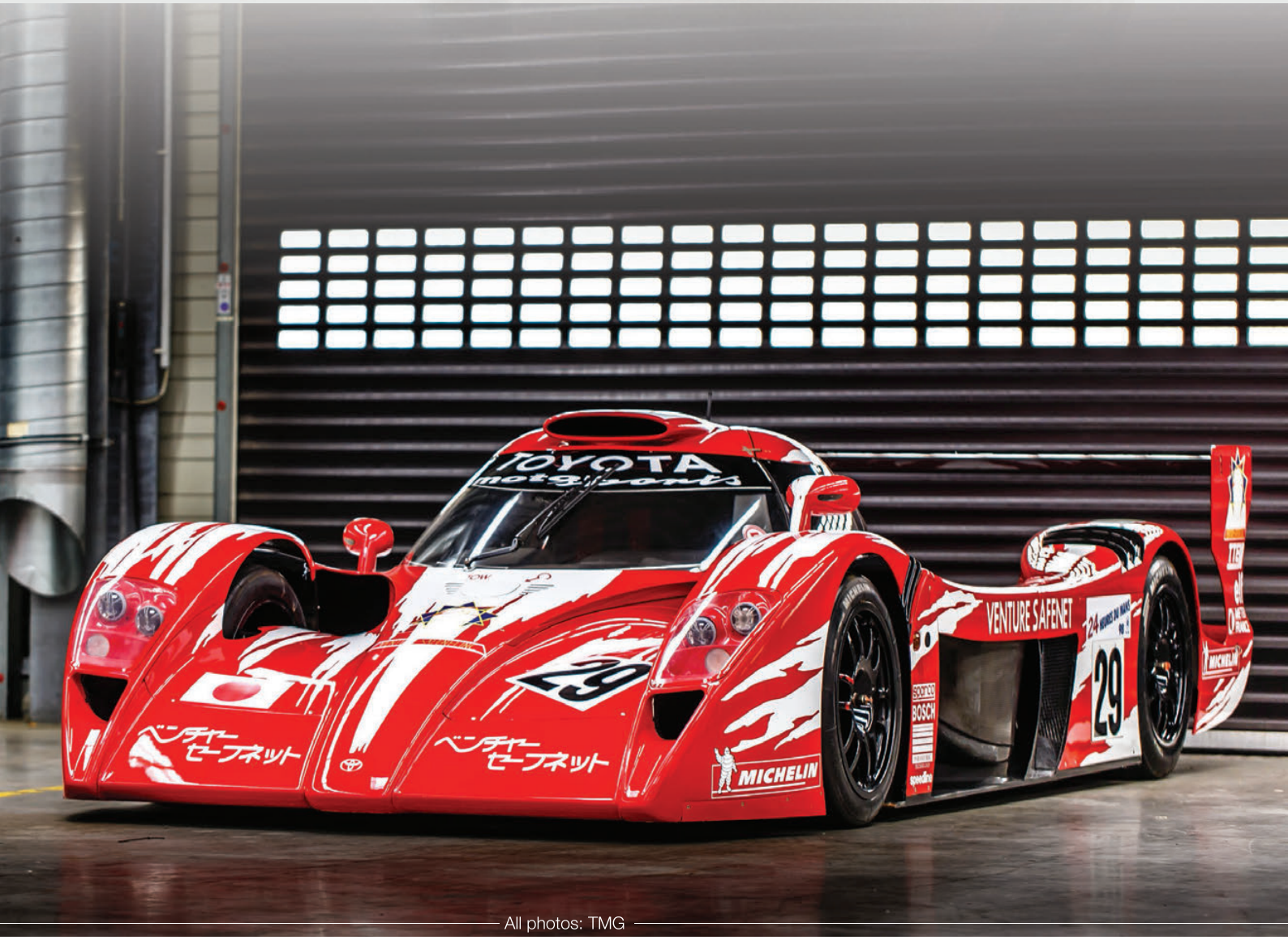
The windtunnel programme was much more labour-intensive in the late-1990s for the simple reason that TMG was working with an outside supplier in Dallara Automobili in Italy. There was no windtunnel in Cologne. No one on the design staff, de Cortanze included, knew it at that time, but the GT-One programme was a lead-in to Formula 1. Today, Litjens and his team have the resources available to them that were built up after the decision to go to F1 was communicated to the Frenchman just after the GT-One's first Le Mans in 1998.

A windtunnel programme at distance caused its own problems. "The models had to be prepared at base and then taken to Italy," recalls Litjens. "Someone was almost fully employed checking things in Cologne and then doing the testing at Dallara. Now we have two wind tunnels here at TMG; we test with a 60% model but we also run the full car in the tunnel usually once a year to make sure the numbers correlate with the model."

The way a modern racing team works in the tunnel has also changed. The smoke lances that were once used to enable the engineers to observe flow patterns across and through the car have been replaced by PIV (particle image velocimetry) and up to 512 pressure sensors built into the model itself, accurate to 7 Pa. This information can then be correlated with the CFD (computational fluid dynamics) aero programme, a technology that TMG barely used in the late 1990s.

Some things haven't changed, however. Toyota still uses Flow-Vis fluid at the racetrack to provide the final validation of its aero programme. "We used that in the old days and we still use it today," says Litjens. "Unless ▶

ABOVE & BELOW Meet the family: 20 years on from its ground-breaking GT-One (below), Toyota's TS050 has been built and developed with technical resources that the original project's engineers couldn't have dreamed of



All photos: TMG

Adrenal Media/WEC

ABOVE The Porsche 919 Hybrid and Toyota TS050 HYBRID in low-downforce configuration at the WEC Prologue

you're lucky and it's raining and you can see the airflow patterns where the rain takes all the mud and dirt."

The homologation process for an LMP1 car is much more involved than in the time of the GT-One. Back then there was only one, frontal crash test and no impact tests. But there was an added complication during the early days of that project. The GT-One had to be road homologated, though the Automobile Club de l'Ouest rules, as opposed to those of the FIA GT Championship of the time, stipulated that only one road car need be built. That changed for year two of the programme when GT1 morphed into the LMGTP class.

"Some of the design solutions that you might want to use for racing weren't possible because the GT-One also had to be a road car," remembers Litjens. "There were a lot of compromises involved and you couldn't explore your mind fully. There were strict rules on openings in the bodywork, for example.

"I remember a lot of meetings with the TuV [the Technischer Überwachungsverein, which certifies road vehicles in Germany]. We really went through the rule book, asking what we could do and what we couldn't do. It took up a lot of time because we were producing a road car based on a racing design."

MANUFACTURING

A wooden mock-up, for so long an essential tool for any team building up a racecar, was constructed for the GT-One. This was used not only to work out a suitable seating position for the driver, but also to partially build up the car with prototype components to make sure everything fitted.

"The primary reason for making the mock-up was to check the driving position and the cockpit ergonomics," explains Litjens. "But afterwards we used it on the engine installation. I remember spending quite a lot of time with the base bodywork working out the exhaust positioning on the GT-One. It was a question of laying the body over the 'chassis' and seeing what space was left.

"If the tooling was ready, we would take a glass fibre splash before we started making the real part. This allowed us to make a small modification if we needed to react."

The advances in design and manufacturing techniques have consigned the wooden mock-up to the history book, at least for a large organisation such as TMG. "With modern CAD modelling techniques you know the exact size of each driver – you even know the angle of his foot on the throttle," he reveals. "You don't have to wait for driver feedback any more." ▶

Le Mans or bust!

MANY questioned Porsche's decision to take its pair of 919 Hybrids to the opening two rounds of the 2017 World Endurance Championship at Silverstone and Spa in Le Mans 24 Hours configuration. In fact, all it was doing was following the strategy that had served it so well in previous seasons.

Think back to 2014, and its re-entry into top-flight sportscar racing. The German manufacturer pitched up at Silverstone with the original version of the 919 in the low-downforce configuration that it would run at Le Mans. A year later, it fielded what might be described as an interim body package, and not the definitive high-downforce aero that would come on stream – and dominate – from the first post-Le Mans WEC round at the Nürburgring. And it started last year with an update of that kit before, again, turning up with its all-singing and all-dancing 'sprint' aerodynamics in Germany.

New regulations for 2017 limiting each LMP1 manufacturer to just two specifications of bodywork – down from the initial limitation of three last year – removed that option. So Porsche came to rounds one and two of the WEC in April and May respectively with its Le Mans car, albeit with more downforce screwed on.

It argues that it doesn't have the resources to develop two aero packages in parallel, or rather doesn't want to compromise one or the other by doing so. Resources are concentrated on the Le Mans aerodynamics first and, once they are signed off, it's full speed ahead on the high-downforce car.

So much so that when Porsche LMP1 team principal Andreas Seidl was asked at Spa when the world would see the car in sprint form, his response was that it would have to wait until round four at the Nürburgring on July 16. And there's no secrecy around the high-downforce 919, he insisted.

"You can't see it," he said, "because it doesn't exist yet." RT

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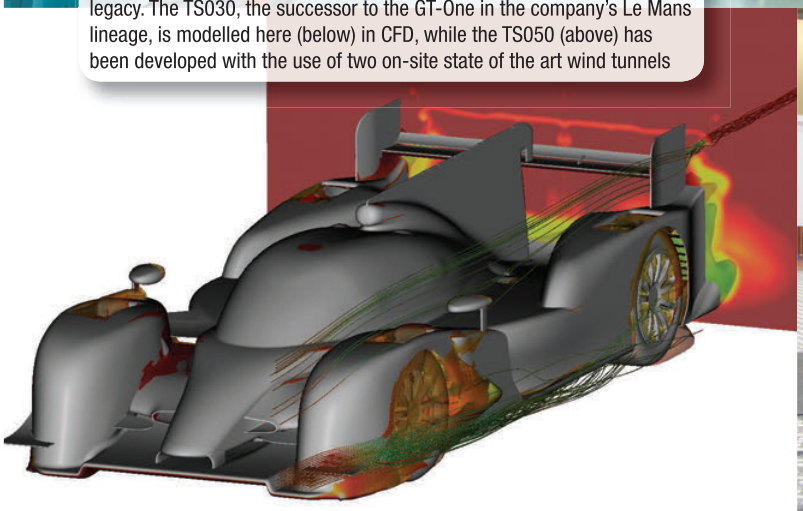
ABOVE & BELOW TMG's WEC aero programmes benefit from Toyota's F1 legacy. The TS030, the successor to the GT-One in the company's Le Mans lineage, is modelled here (below) in CFD, while the TS050 (above) has been developed with the use of two on-site state of the art wind tunnels



ABOVE Major components now undergo a 30-hour test cycle on a dedicated rig to confirm reliability

That said, driver ergonomics are much more strictly controlled in the modern era. There are now set rules on the angle at which the driver sits and their field of vision out of the car. It is, reckons Litjens, something that "no one really cared about 20 years ago".

A modern racing car designed on CAD should bolt straight together, though it doesn't always work out like that. "The mechanics joke about that," admits Litjens. "Sometimes they say, 'Hey, it fits in CAD, but it doesn't fit on the real car'. Sometimes there is a bit of grinding to do, maybe one or two millimetres here and there. But we are only talking fine tuning. The big problems or big errors that we used to see happen in the past, where you might have components interfering with each other, are a thing of the past.

"Most of the parts come together for the first time as the car is built up, though there are occasions that we use three-dimensional printing or rapid prototyping. That can help save time because you don't need access to your machine shop to make the parts."

It is also worth pointing out that much more of today's TS050 is made in-house at TMG than on the GT-One in the organisation's pre-F1 days. Its production capabilities were much smaller 20 years ago prior to its stint in F1 from 2002 to 2009. The tooling for the GT-One monocoque was made in-house, but the build of the tubs was subbed out to a carbon specialist.

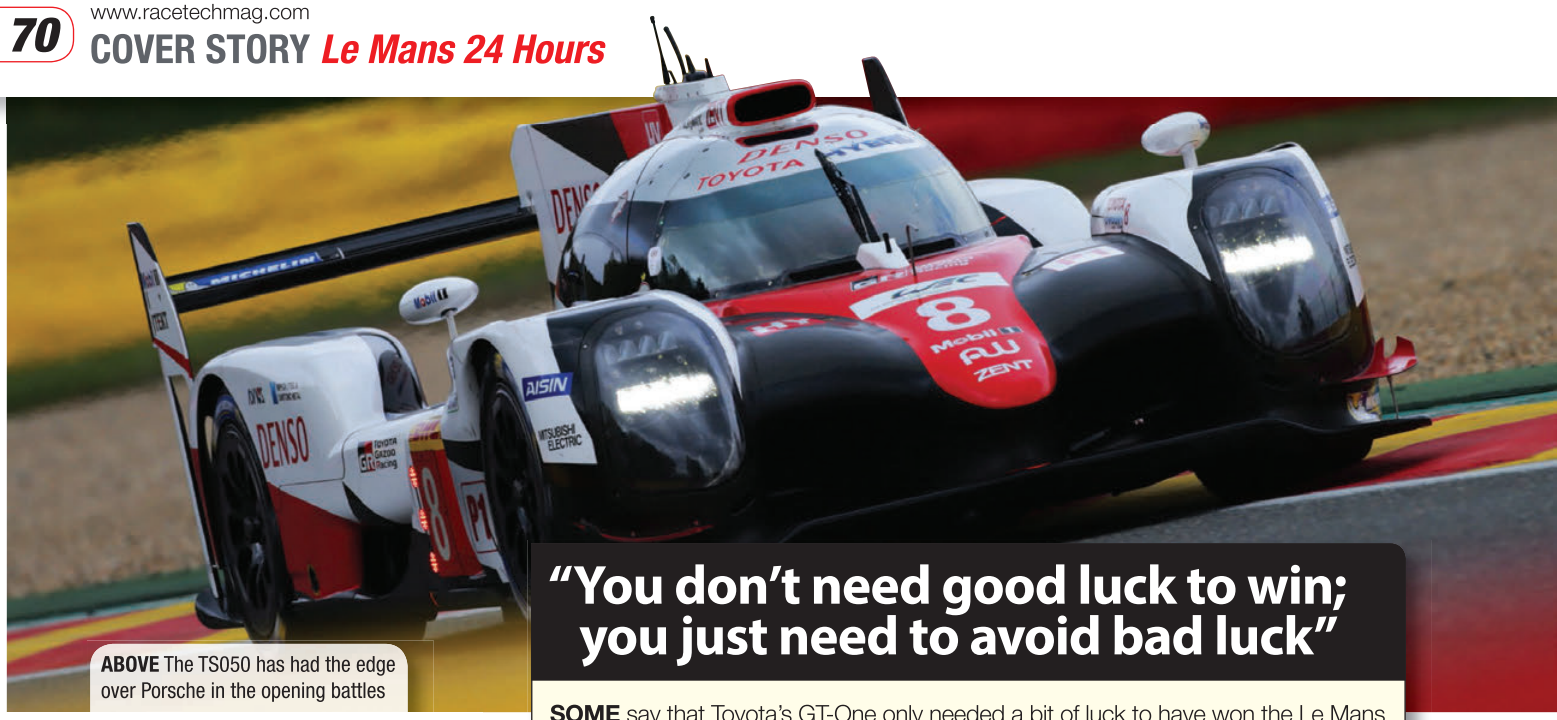
ABOVE A driver-in-the-loop simulator allows the team to experiment with the TS050's setups in a virtual world before the car even reaches the racetrack

Modern manufacturing techniques have resulted in much lighter carbon parts. Think back to days of old, and mechanics heaving off an engine cover. Today, it's much less of a struggle. Litjens estimates that the rear bodywork section of the TS050 is as much as 40 percent lighter than that of the GT-One.

"Now with the optimisation of the materials, using pre-impregnated fibres for example, and the lay-up techniques we can make the composite components much lighter," he says. "The carbon lay-up was much more labour-intensive in the old days."

TESTING

Advances in rig testing have been massive since the days of the GT-One. Litjens remembers only "doing some basic load checks" and doesn't even remember if the car went on a seven-poster rig. And if it did, it wouldn't have been at TMG, because it ▶



ABOVE The TS050 has had the edge over Porsche in the opening battles

didn't have one.

"These days major components are tested on the rig through the length of a Le Mans distance," he says.

Virtually all of the components on the TS050 are vigorously tested before they ever reach the car, with TMG putting major items through a 30-hour testing cycle on a dedicated rig to confirm reliability.

Simulation was something that, again, was in its infancy 20 years ago. These days it enables TMG to work out an accurate setup before the car ever turns a wheel. A driver-in-the-loop simulator allows a race driver to tune the setup of the TS050 in a virtual world in the run-up to every WEC race, something that is particularly useful in the modern world of hybrid powertrains and fuel restrictions.

"In the old days, people like Andre and Jean-Claude Martin [his number two on the project] would use their experience to come up with a base setup," says Litjens. "Then it was a case of crossing your fingers, hoping it wasn't too bad and evolving it from there on the track. Now we are much more prepared before we even get to the track. We work out a setup beforehand on the sim. This means comparing downforce levels and suspension settings, as well as adjusting the hybrid recovery and boost options."

The question is whether the advances in technology, in terms of design, manufacturing and simulation, make developing a car capable of competing for outright victory at Le Mans easier or harder. Litjens isn't sure.

"Maybe the tools we have now mean it is easier to get a base level," he says. "But it is the fine-tuning that makes the difference. Nothing has changed there, except that it feels harder because I'm getting older." RT

"You don't need good luck to win; you just need to avoid bad luck"

SOME say that Toyota's GT-One only needed a bit of luck to have won the Le Mans 24 Hours on either of its two assaults. Designer Andre de Cortanze puts it another way: "You don't need good luck to win; you just need to avoid bad luck."

The Toyota might have won in year one but for gearbox trouble on the car shared by Thierry Boutsen, Geoff Lees and Ralf Kelleners late in the race. They were leading with 80 minutes to go when gearbox failure put them out.

The gearbox was the weak link on the first iteration of the GT-One, which still had a sequential shift, and the Toyota that led in the penultimate hour had already undergone two changes of gear cluster. But the reason for the final retirement might well have been the result of the failure to correctly tighten the sump plug on the transmission during the second change. The casing of the 'box was too badly damaged for a third change of internals to take place.

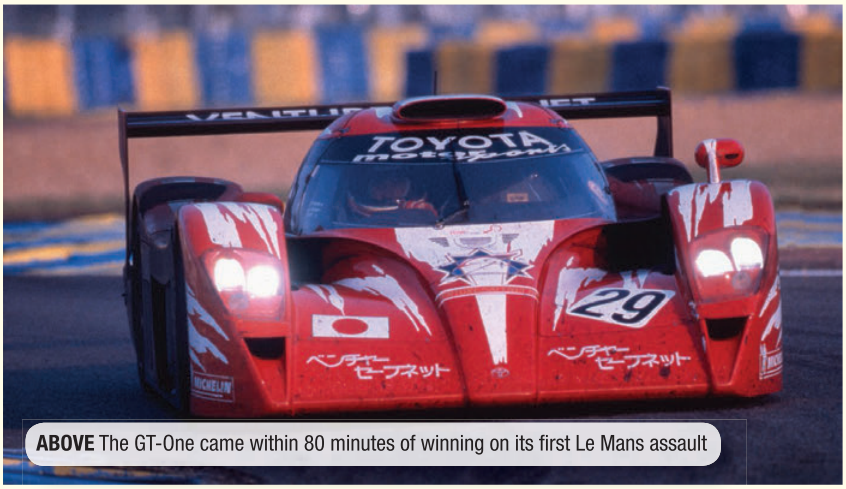
"All I know was that there was hardly any oil left and there was a plug missing," says Litjens. "Whether this happened at the cluster change, I don't know."

The late retirement of the last of the three GT-Ones entered for the race allowed Porsche to come through to take victory with the 911 GT1-98 shared by Allan McNish, Laurent Aiello and Stephane Ortelli. It was the 16th Le Mans victory for the Stuttgart marque.

What no-one knew at the time was that it would be its last for 16 years. The plug was pulled on Porsche's top-flight sportscar programme at short notice at the end of the year. It announced that it would be taking a sabbatical and would be back bidding for outright honours at the Circuit de la Sarthe in 2000.

A new car and engine were built, the V10-powered LMP2000, but there was to be no Le Mans return. Porsche opted to focus its financial and engineering resources on development of the Cayenne SUV and it would stay away for another 14 years.

But when it did return, Toyota would be one of its competitors with a car built at TMG in Cologne. RT



ABOVE The GT-One came within 80 minutes of winning on its first Le Mans assault

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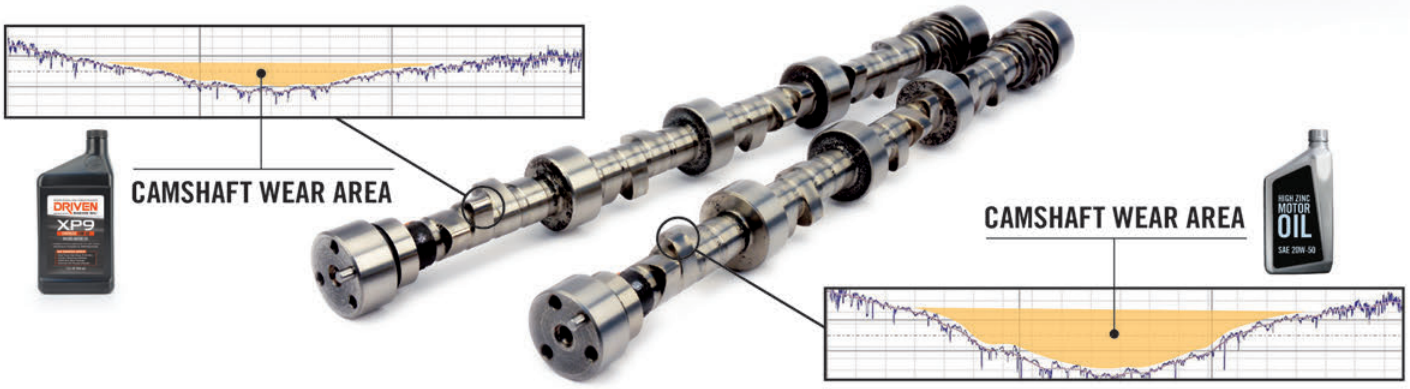
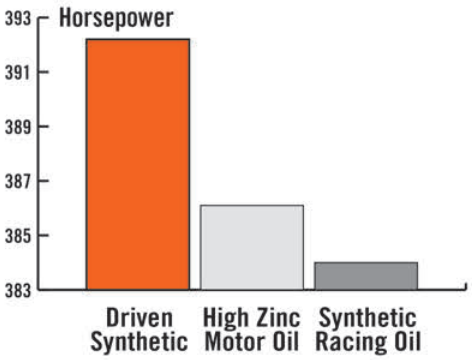
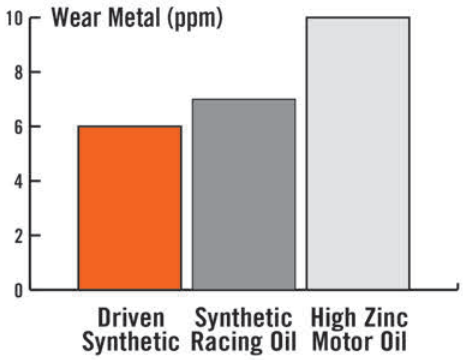


HORSEPOWER INCREASE



USED OIL ANALYSIS



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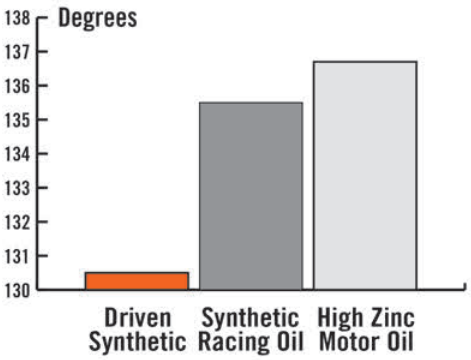

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LIFE ON THE LIMIT

The advent of fuel-restricted hybrid engines in F1 and sportscar racing has prompted Ilmor to explore the crossover between the two, as **Chris Pickering** discovers

IT all used to be so simple. Once upon a time, racing engines could be neatly divided into those that used some form of forced induction and those that did not. Mechanically, of course, there were myriad complexities, but as far as the combustion was concerned that really was about the size of it. Except now there's a third way.

The last few years have seen the pinnacles of open-wheel racing and sports prototypes both switch to a fuel flow limit as the key constraint in their engine regulations. While the motives behind this may be different for Formula 1 and LMP1, the result is that engine designers in both categories have had to adopt similar strategies to get the best out of their powerplants.

"There is a huge step from a conventional turbocharged or naturally aspirated engine to a fuel-restricted engine," comments Ian Whiteside, chief engineer for advanced projects at Ilmor. "You have to unlearn a lot of what you've done before. Fuel flow restricted engines tend to be a lot more complicated to develop, with many more compromises required. That means you need to carry out a lot more simulation and testing upfront."

For companies like Ilmor, which has worked behind the scenes on one of the recent turbocharged V6 Formula 1 engines, it means adopting a whole new philosophy. But it also raises a question: With the fuel flow limit having such a decisive impact on the combustion design, and the engine configurations used in F1 and sports cars looking increasingly similar, would it be possible to share elements of a common design between the two?

It's not a new idea, of course. Cosworth, Matra and Ferrari have all adapted Formula 1 engines for use in sports cars in the past. But these days the regulations actively mandate a lot of common ground. The 100 kg/h fuel limit imposed in F1 until the start of this season is

tantalisingly close to the non-hybrid LMP1 Lite (LMP1-L) limit, which currently stands at 101.4 kg/h. Turbocharging (which is mandatory in F1) is virtually a prerequisite in LMP1 too, while there's also a very sound argument for using the same six-cylinder configuration.

In the hybrid (LMP1-H) category, things get more complicated. The cars are given a different fuel allocation per lap based on their energy storage capacity and the type of fuel. This opens up a multitude of different options right from the start, unlike the F1 rules that dictate the basic specifications of the IC engine and the hybrid system. Nonetheless, the use of a fuel flow limit and

ABOVE 1D simulation is a powerful tool for optimising fuel-restricted engines

ABOVE Common design challenges between sports car engines and their F1 counterparts prompted Ilmor's feasibility study for an LMP1 Lite offering

> *"There is a huge step from a conventional turbocharged or naturally aspirated engine to a fuel-restricted engine"*

an electric hybrid system still opens up the potential for quite a lot of crossover – conceptually if not physically.

This isn't just an academic exercise, either. "We have looked into the possibility of developing an LMP1 Lite engine," Whiteside confirms. "A number of teams have approached us about it, which has led us to carry out quite a lot of simulation to assess the feasibility."

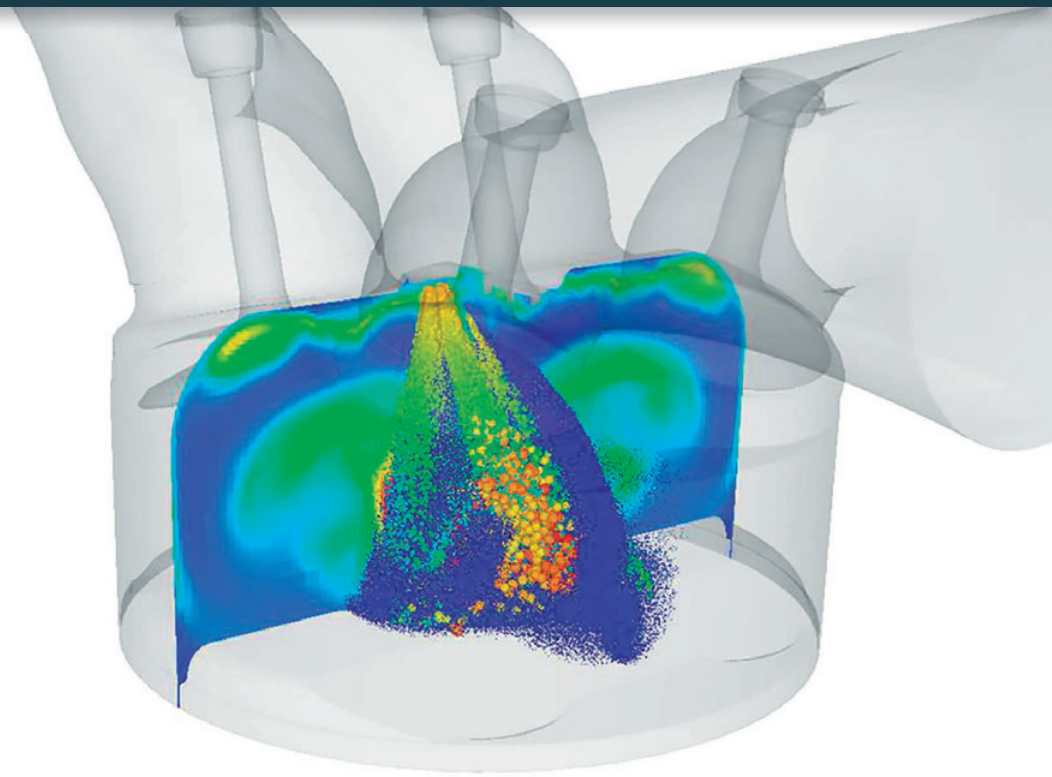
COMPARISON

So how much commonality could there be between the two applications in principle? The fundamental design of a Formula 1 engine is laid down in the rules: it has to be a 90-degree V6, displacing 1.6 litres, with four valves per cylinder and one single-stage turbocharger. The bore is also mandated at 80 mm, which implies a stroke of around 53 mm.

In comparison, the LMP1 regulations are wide open. The first dilemma you'd encounter if you were to apply F1 design principles to a sports car engine would be the displacement. Although comparatively small turbocharged engines are favoured, you can in theory go right up to 5.5 litres in LMP1-L, or as far as you like in LMP1-H.

This is exactly the sort of thing that Whiteside and his colleagues pondered during their investigation. "Generally you don't want the cylinder pressures to be too high, so that might push you towards a slightly larger capacity," he says. "On the other hand, you need to think about mass and frictional losses when you start increasing the size of the engine."

Another factor is engine speed. In theory, this is unlimited, although the fuel flow rate effectively imposes ▶



ABOVE Understanding fuel spray and charge motion is essential in lean-running fuel-restricted engines

an upper boundary. "You wouldn't want to rev it as high as a Formula 1 engine – the 15,000 rpm limit in those regulations is partly written in to increase the spectacle. Speed equals friction, so I think you'd be looking at 8,000 to 9,000 rpm at the most. Maybe 7,500 rpm. Under the Lite regulations, that would probably steer you towards a (turbocharged) engine with a capacity of 2.5 to 3 litres."

Current F1 engines have a bore to stroke ratio of just over 1.5:1. This heavily oversquare configuration works well at high rpm, where it allows for larger valves and lower peak piston acceleration than a long-stroke engine. For a somewhat slower-revving sports car engine, however, it's likely you'd want to run a 'squarer' ratio (somewhere in the order of 1.2, Whiteside suggests). This tends to increase thermal efficiency, because less heat is lost to the swept portion of the bore than to the cylinder head.

From there, the next question is cylinder configuration. This takes in a range of factors, such as heat loss, friction and the individual masses of the reciprocating components. For a capacity of around 2.5 litres this all points towards a six-cylinder configuration. Packaging considerations and the potential issues with crankshaft flex on inline sixes, mean that a vee layout is essentially a given.

FORCED INDUCTION

"This tallies with what we see in LMP1-H," Whiteside points out. "The Toyota is a 2.4-litre V6, while the Porsche is a 2-litre V4. I'd imagine four cylinders was starting to become a marginal decision at two litres, but it has the benefit of reducing the engine's dimensions."

In theory, you could build a naturally aspirated LMP1 engine – until recently several manufacturers did – but the general consensus now is that the fuel flow restriction favours forced induction. The reason is that the engines now run comparatively lean – around 1.2 to 1.3λ – to make the most of the limited fuel allocation. As a result, they need more air than a traditional engine, so without some form of turbocharging they would either have to rev significantly higher or use a much larger displacement, both of which have their drawbacks.

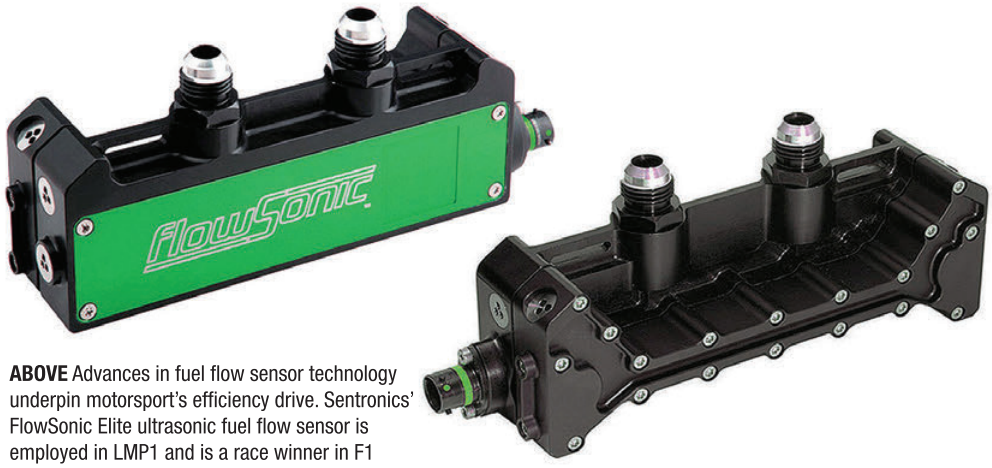
So, do you run one turbocharger or two? For hybrid applications with heat energy recovery – particularly if you were looking to share some of the hardware with an F1 unit – it's likely you'd go for a single turbo. Running two motor generator units would add weight, cost and complexity, plus it would deviate further from the F1 recipe.

On an LMP1-L engine, however, it's likely you'd go for two. "Twin turbos often allow for better packaging," comments Whiteside. "You can have one either side of the engine rather than a single larger unit in the centre of the vee, so you can lower the centre of gravity. Depending on the design of turbine housing used, there is also a secondary consideration of potentially inferior exhaust tuning on the single turbo due to pulse interference between the two banks."

Traditionally, race engines have run slightly rich to maximise power and reduce the risk of detonation. That's no longer practical in a fuel-limited formula, so it's become even more important to ensure the in-cylinder conditions prevent knock. From a design perspective, one of the most critical aspects is charge motion.

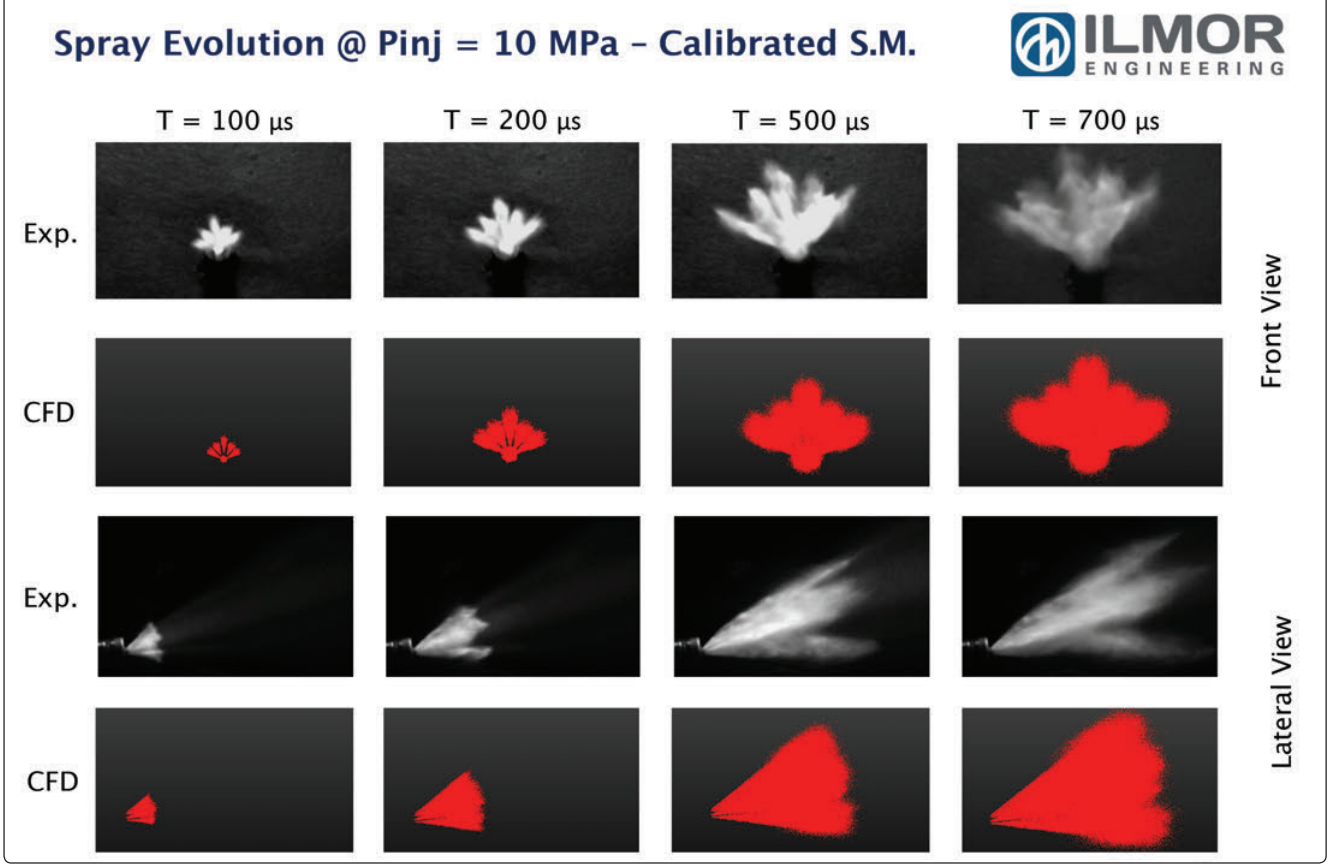
"We're trying to create a tumbling motion inside the cylinder," comments Whiteside. "That's another reason it pays to use a comparatively long stroke: it gives you more space to set up that motion, whereas a heavily oversquare engine tends to result in a wide, flat swept volume."

This is where much of the testing – and, in particular, in-cylinder CFD work – comes in on a fuel-limited engine, he explains: "One of the fundamental departures from traditional engines is that you're less concerned about the total amount of air ▶



ABOVE Advances in fuel flow sensor technology underpin motorsport's efficiency drive. Sentronics' FlowSonic Elite ultrasonic fuel flow sensor is employed in LMP1 and is a race winner in F1

BELOW In-cylinder CFD is used increasingly in engine development, but correlation is vital. This shows a comparison of simulated spray patterns to physical testing



you can squeeze into the cylinder. Instead, it's about getting the right charge motion and the right lambda value to suit the available fuel supply. It's a trade-off, but generally it's worth compromising the peak airflow value to improve the mixing, because it increases combustion efficiency and reduces the risk of detonation."

The downside to prioritising charge motion is that more boost is required to force sufficient air into the cylinders. This increases the engine's pumping losses, but it's generally worth doing, Whiteside notes.

There's a similar shift in the philosophy behind the design of the inlet and exhaust systems. Traditionally, these were designed purely to maximise volumetric efficiency, but now they're tuned to reduce the risk of detonation, he explains: "On the air-restricted engines previously used in LMP1, you had to be very careful to avoid blowing any of the inlet air straight through the engine. With the restrictor it wasn't possible to make up for the lost air. That's no longer an issue on the current engines, which have no air restrictor. Instead, you can focus on scavenging the exhaust gases from the chamber during valve overlap. That way you're removing heat, which minimises the chances of knock."

This new breed of engines is pushing far more reliance on in-cylinder CFD. Ilmor has recently invested in a new computing cluster, plus software licences for Converge CFD. Gamma Technolgies' 1D package GT Power also continues to be used extensively for design and optimisation.

"In-cylinder CFD is relatively new for us," comments Whiteside. "We've used 1D simulation for many years, but that's now far more intensive. It's so important to understand the intricacies of what's going on inside the combustion chamber."

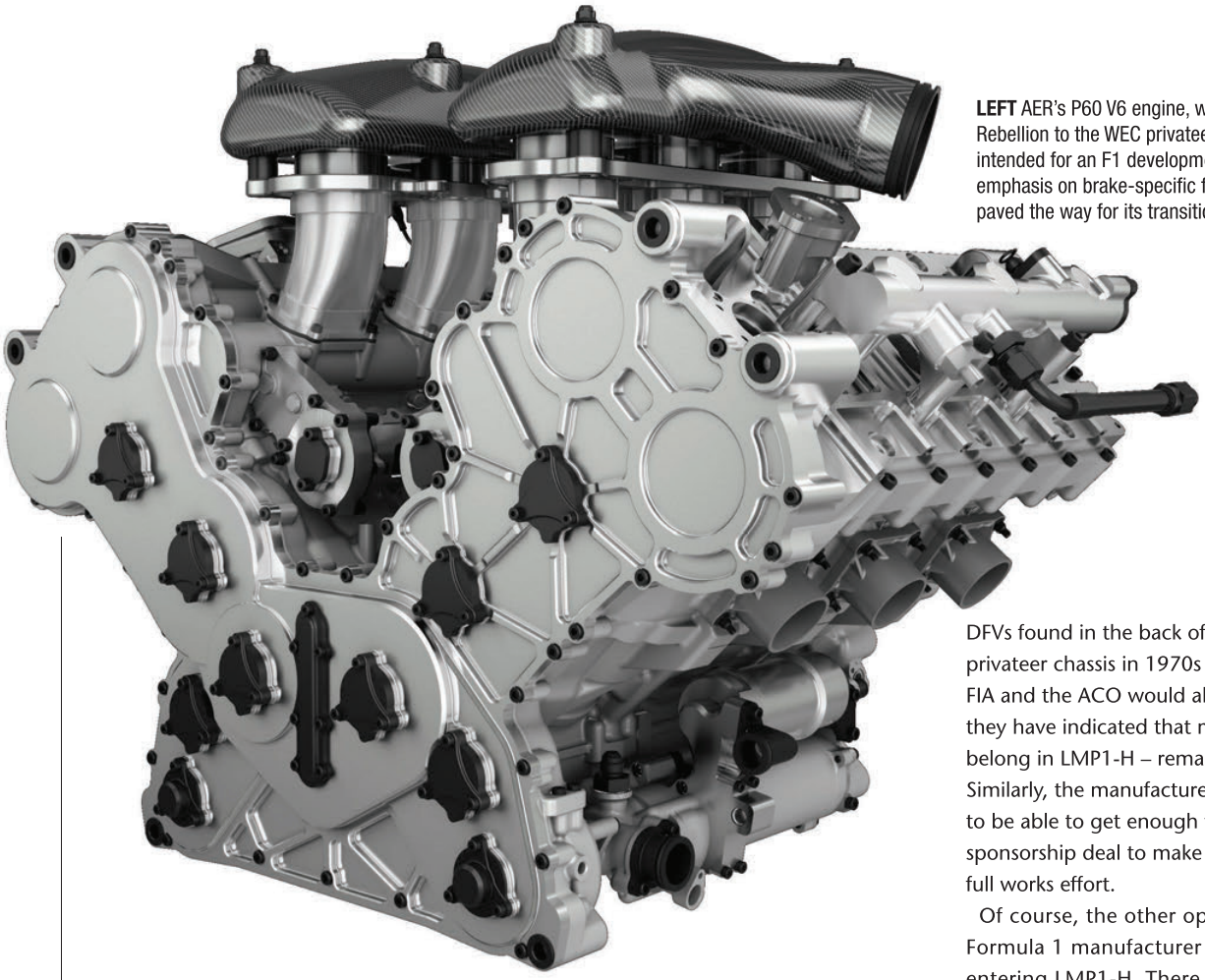
SHARED TECHNOLOGY

It's clear that there's a degree of synergy between Formula 1 and LMP1 engines, but could we actually see shared hardware?

"Physically, I wouldn't expect to see that much crossover on the base engine," says Whiteside. "You can't just scale up the architecture of an F1 engine into an LMP1 unit – it's likely to be running at two thirds the speed, for a start, which means the mechanical loads are quite different. But the benefit that comes from sharing a philosophy between the two categories is that you can carry over the knowledge of how to optimise and develop a fuel-limited engine. There is quite a lot of learning required the first time you do it, and potentially quite a lot of investment in the simulation tools, so any company that has worked on a current Formula 1 engine would certainly have a headstart if it decided to tackle an LMP1 project."

The major castings are likely to require a full redesign. Tempting as it might be to machine off an unused boss here and there, Whiteside reckons it would take more effort to adapt a common design than it would to develop each application from scratch. Nonetheless, the basic concepts, such as the casting process, the cylinder layout and the design of the water jacket, could be shared.

Not surprisingly, a hybrid LMP1 engine could have more potential for crossover. With comparatively similar fuel allocations and a common layout, it's likely the fundamentals – and perhaps even some of the physical components – of a Formula 1 heat energy recovery system (MGU-H) could ▶



LEFT AER's P60 V6 engine, which powered Rebellion to the WEC privateer crown, was originally intended for an F1 development project. The WEC's emphasis on brake-specific fuel consumption paved the way for its transition to sportscar racing

be shared with an LMP1-H sports car engine. Part of the challenge, Whiteside explains, would be pairing the inertia of an electric motor to a high-speed turbocharger ("that knowledge is very definitely something that would transfer," he notes).

COMMERCIAL CASE

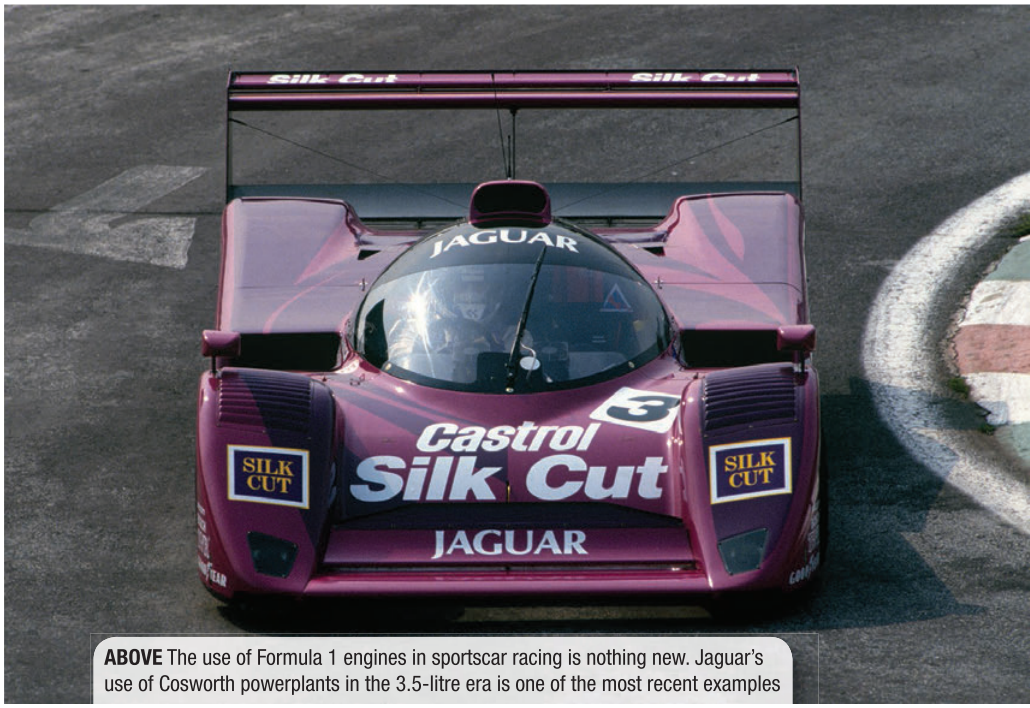
One of the biggest differences between modern Formula 1 and sportscar racing – certainly where privateer teams are concerned – is the budget. So would the technology be prohibitively expensive to share?

"You could share the same core principles without carrying over the more expensive aspects of an F1 engine, so it could be quite a cost-effective way of producing an LMP1 unit," comments Whiteside. "It's hard to say, though. A lot of the cost comes from developing the engine, which either has to be paid upfront or amortised over a number of units. That's a difficult business decision for an engine supplier until you have an idea of how many you would sell."

He estimates the lead time would range from around one to two years, depending on whether there was a suitable race engine design which could be used as a base. This could also be tricky for privateer teams, where there isn't always a guarantee of on-going funding.

One option would be manufacturer sponsorship of the engines within the privateer class – similar to the Ford-badged DFVs found in the back of numerous privateer chassis in 1970s F1. Whether the FIA and the ACO would allow that – when they have indicated that manufacturers belong in LMP1-H – remains to be seen. Similarly, the manufacturer would have to be able to get enough value out of the sponsorship deal to make it preferable to a full works effort.

Of course, the other option is that a Formula 1 manufacturer might look at entering LMP1-H. There are no obvious candidates at the moment (even the persistent rumours of Ferrari re-entering sports prototypes seem to have gone quiet) but that's not to say it couldn't work the other way. An LMP1-derived Formula 1 engine from Porsche or Toyota? It's not impossible. RT



ABOVE The use of Formula 1 engines in sportscar racing is nothing new. Jaguar's use of Cosworth powerplants in the 3.5-litre era is one of the most recent examples

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Pit lane services for racers

GREAVES Motorsport is a well known name in endurance racing but has always defined itself as more than just a team in engineering terms.

Over the years it has developed products initially for itself but which were so good that they attracted the notice of other teams in the pits, who would enquire about their availability. As a result it has developed this part of the business, naming it Greaves 3D Engineering, so that it is now a full product and service provider specialising in endurance racing.

For the last few years it has been helping teams at Le Mans in particular, where it sets up shop at the end of May for the duration until the 24-hour race has finished. As such, it has provided many a team with back up services that would otherwise have seen that outfit unable to compete in the race.

This year it has partnered with Grand Design Systems, which since the late '90s has manufactured seamless garage walling systems and pit equipment for some of the most highly recognised and prestigious teams across a varierty of disciplines. The relationship between the two companies is close, having co-developed what they claim is probably the best fuel rig on the market. All of the casing, doors and substructure are built by GDS while the boom, the chassis and hoses are built by Greaves.

At Le Mans the two companies are working together to provide teams with all pit equipment needs, offering fuel cage surrounds, Le Mans boom mounts, gantries with lighting, flooring, walling and set-up pads for hire. They are also offering graphics, vehicle wrapping, full installed 4-layer tear-off windscreens, paint protection film, Paoli servicing, the Greaves refuelling equipment servicing and onsite fabrication.

"Teams like having us there if there are any issues or problems because they know they can get something sorted very quickly," said Laura Frary, business development at Greaves 3D Engineering. "We can respond really quickly because even if we don't have anything at the track, we can get it brought in from the UK almost immediately. It gives them a reassuring feeling, especially in the occasional OMG moments where we might need to produce some different products or parts immediately for the teams.

ABOVE Greaves 3D Engineering refuelling and pit stop rigs

"Having provided these services at Le Mans since 2012, we also have a pretty good idea of what the teams are going to want so we'll have a stock of different things we can provide off the shelf, so as to speak. We like to think that we are the answer to all the questions."

"What really helps is that we have established a reputation in endurance racing, so we know the challenges and problems," said company director Jacob Greaves. "We know what the teams are likely to require and what the product needs to do, as we have the same experience as our customers and that really helps."

Greaves 3D Engineering pit equipment products are becoming increasingly popular across race series globally, with a demand for the products to be shipped. The company is therefore building a network of distributors, such as with United Race Parts in North America, not only to keep costs down, but also help meet customer requirements. RT

Silicone hoses

ONE of the essentials in all racecars is the silicone hose, often just an afterthought but actually a vital component.

SamcoSport is a world leader in performance silicone hoses and accessories, with over 20 years' experience in their design and manufacture. The brand is trusted in various motorsport disciplines: from Formula 1, NASCAR, world rallying and drag racing, to leading teams in World Superbike, MX GP, the BTCC and drifting.

All its hoses are designed, tested, hand-crafted and "Made in Britain" from the finest quality European-sourced silicone and reinforcing fabrics, specifically designed for automotive use. Its high-grade silicone offers much better stability at the high operating temperatures and pressures encountered during racing. Additionally, flow rate and heat transfer to the radiator can be improved while expansion and deformity under load is reduced. Its hoses meet or exceed the requirements of SAE J20 and are manufactured under an ISO 9001 quality system.

Its hoses are available in a wide range of original and premium solid colours as well as SamcoSport's unique camo designs. These allow a team or driver to choose a hose that either complements or contrasts with car colours or team livery.

SamcoSport constantly develops new and innovative products such as its Samco ProFuel, the world's first performance silicone hose for permanent fuel use. With over 650 replacement kits for the car tuning scene, over 500 replacement kits for motorcycles and the world's largest range of universal parts for motorsport and race cars, SamcoSport offers the best quality hoses, for exceptional performance, and guaranteed reliability. It is so confident of the quality and durability of its hoses that it offers a full lifetime warranty for ultimate peace of mind. RT

ABOVE SamcoSport's silicone hose

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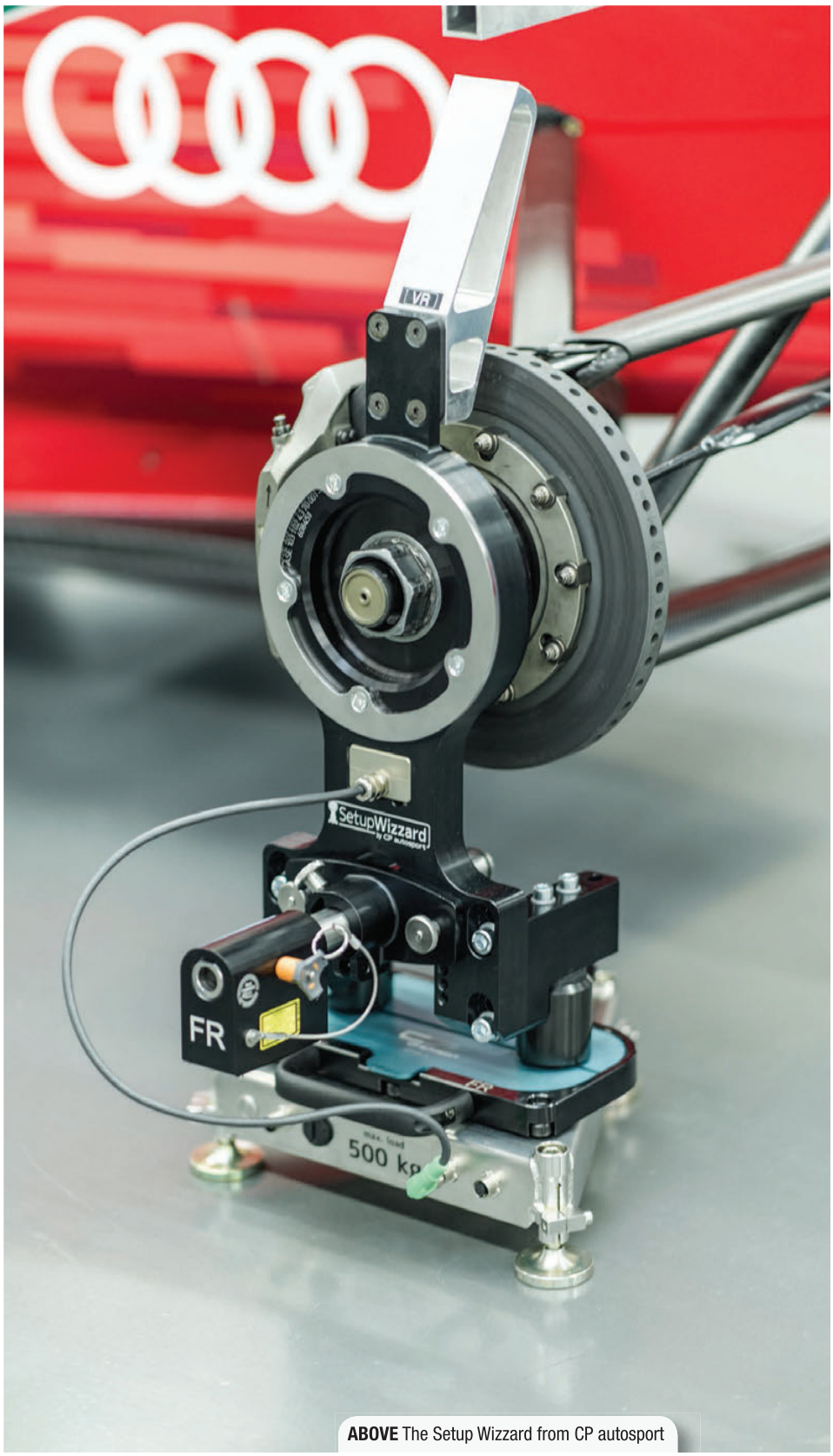
Setup Wizzard from CP autosport

THE innovative wheel alignment system Setup Wizzard from CP autosport ensures perfect suspension measurement of toe, camber and corner weights at the racetrack. An optional ride-height measurement system is also available.



ABOVE The Setup Wizzard from CP autosport

Usable for almost every possible racing series from GT3 to TCR and from rallying up to Formula E, the system's big advantages include saving valuable time between practice sessions on a race weekend, quick and easy assembly of the measurement system and making the suspension components easily accessible. Other benefits include increased measurement accuracy compared to conventional systems and a modular design subject to customer demands.

During the measurement, the vehicle is not mounted on its tyres but on the Setup Wheels, making the accessibility to the chassis components far easier. It therefore negates any variation in the dimensions and stiffness of the tyre due to manufacturing tolerances, air pressure and wear. The ball rolls of the Setup Wheels also almost completely eliminate the friction in the contact patch. The chassis can therefore move free of forces in the wheel contact patch.

Another advantage of the system is that the measurement wheels can be changed universally. The Setup Wheels contain a vehicle-specific adapter which can be replaced easily and inexpensively in case the connection to the vehicle is changed.

The measured values are transferred via Bluetooth, making the mounting and dismounting of the system much quicker. The complete measuring system is housed in a compact flight case for safe and easy transportation. The consistent system with quality components increases the measurement accuracy and repeatability significantly.

In summary, the CP Setup Wizzard significantly simplifies and accelerates chassis measurement and adjustment and can be carried out by just one person without any problem within the shortest possible time. In addition, the likelihood of human error is drastically reduced by the automated processes.

The Setup Wizzard has already celebrated two wins at the Nürburgring 24 Hours. Audi Sport Team WRT used it on its Audi R8 LMS in 2015 and AMG-Team Black Falcon won the prestigious endurance race in 2016. In the same year, Konrad Motorsport and driver Sven Müller clinched the title in the Porsche Carrera Cup, also with the help of the Setup Wizzard. RT

THE CLEVER PROBLEM SOLVER

William Kimberley reports on an innovative solution that cuts through some common misconceptions

TURBOSMART'S new patent pending OPR40 is a true oil pressure regulator for turbochargers. It solves a problem that is usually misunderstood. However, to see the true magic in this solution, you must first understand the problem.

Turbochargers require a good source of oil and more specifically, they're built around a preference for a specific 'window' of oil pressure and flow. The turbocharger assembly itself has oil, hot exhaust gas and compressed air all within the tight confines of its core and this is where some compromises need to be addressed. The relationship between the three needs to be relative and that is because seals are in place to stop one mixing with the other.

A common misconception is that there is a 'seal' that stops oil getting into the inlet air or the exhaust gas and that is simply not the case. The seal is, in fact, a gas ring and more resembles that of a common piston ring than any kind of rubber seal. Its function is to hold the exhaust gas or compressed air out of the oil system, not the other way around, as is often assumed – and it is here that modern turbochargers have created a little issue of their own.

With the reduction in the oil needs of turbochargers, there was a corresponding change in gas ring profile so that the balance of pressures fighting each other – exhaust gas, compressed air and oil – was maintained. This overall creates a beneficial system where less energy is consumed by seals and the bearing assembly, resulting in a more responsive turbocharger.

However, engine oil pressure requirements within a modern engine are often higher than that of the turbocharger assembly and this is where a problem arises. Most of the engine requires a good steady feed of oil flow at high pressure for good efficiency and reliability, while the turbocharger's needs have reduced. The common solution, even at an OEM level, has been to fit a restrictor in the oil feed line to the turbocharger assembly.

The problem with this method, though, is that there is a major difference between controlling flow and controlling pressure. The restrictor method that is most often used is actually an oil flow reduction method. What occurs is a compromise: reducing flow with a view to achieving a more suitable pressure, rather than directly reducing pressure itself.

This method's impact on oil pressure is also subject to oil grade, viscosity and supply pressure. A change in any of these variables has a huge impact on the resulting pressure and this is why this method can be tricky and cumbersome.

This is where Turbosmart's OPR40 shines. It is designed to regulate oil pressure without any impact on flow – simple as that. It's able to achieve the desired oil pressure in the face of high supply pressure, at any temperature and resulting viscosity and does so without impacting flow. It is a true regulator and takes the guesswork out of orifice sizing for oil supply and removes the need of the black art in the tuning of, and carefully balancing oil supply line size versus oil drain sizing for custom turbocharger fitment.

"It's one of those solutions we're truly proud to stand behind," says Chris Milne, Turbosmart UK's general manager. "Our guys came up with an innovative solution to a problem people have been frustrated by and barely coping with for years!" RT

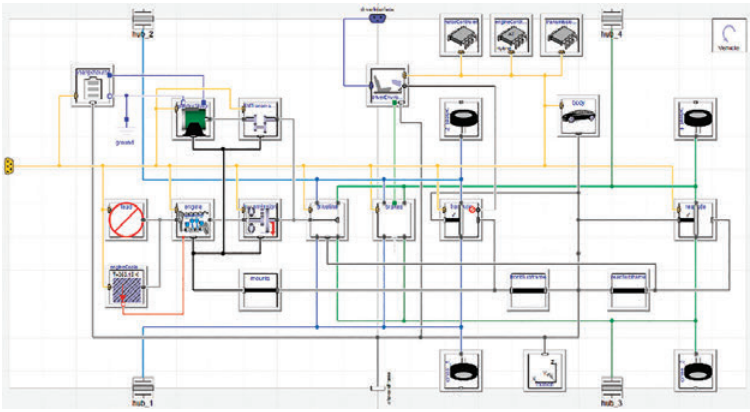
BELOW The OPR40 is a true oil pressure regulator for turbochargers

New platform for Vehicle Systems Modelling and Analysis

BUILDING on the Modelica solutions that it has developed over the past 10 years, Claytex, the systems engineering specialist, has created VeSyMA. This is a new platform for Vehicle Systems Modelling and Analysis that has been created using Modelica and is available for Dymola.

The core VeSyMA library enables the modelling of conventional, hybrid, electric and novel vehicles to predict their performance, fuel economy and energy usage. It includes experiments for straight line acceleration, drive cycles and gradeability tests. A set of common vehicle templates are provided, but there is flexibility to allow the subsystems to be reconfigured to look at any vehicle architecture idea.

The VeSyMA – Motorsports extension is dedicated to motorsport vehicle dynamics applications. It builds on the VDL Motorsports Library that has been developed by Claytex over the past eight years and is used in Formula 1, IndyCar and NASCAR. This new solution focuses on improvements to the suspension models and setup experiments. The library includes double wishbone suspensions and NASCAR rear suspension and models them as MultiBody systems, including a full set of physical adjustments, for example, shim thickness, that can run in real-time.



ABOVE The core VeSyMA library enables the modelling of conventional, hybrid, electric and novel vehicles to predict their performance, fuel economy and energy usage

The VeSyMA – Driver-in-the-Loop extension enhances the integration of Claytex's solutions with rFpro, the software for Driver-in-the-Loop simulation. This extension provides the complete tool chain to plug a vehicle model into rFpro and provides for the full range of features available in the program, including the high fidelity track models based on LiDAR scans.

Claytex says that the motorsport-orientated solutions will provide new and improved ways to develop and use simulation throughout race teams. One of the key objectives is to make the solutions more accessible by making it easier to run kinematics studies, evaluate suspension setups and lap time prediction. The VeSyMA solutions cover more than just vehicle dynamics as they also cover a race car's power unit, electric motors, energy storage and thermal management. RT

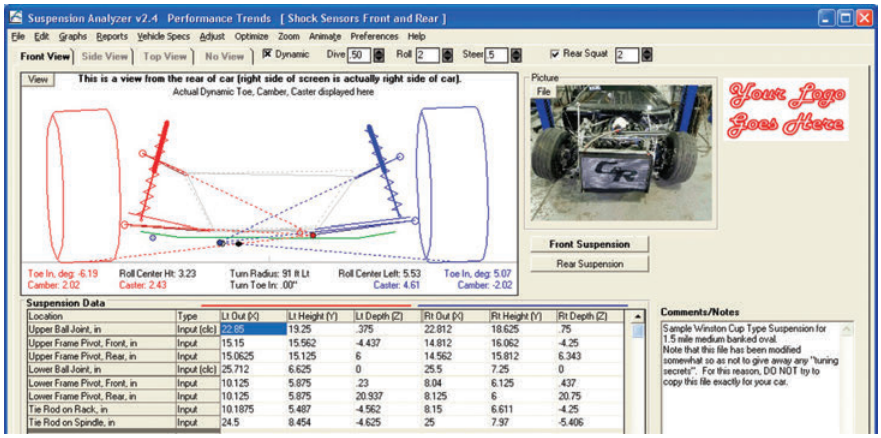
Updated Suspension Analyzer program

PERFORMANCE Trends has updated its very popular Suspension Analyzer program to 2.4 B that has two new steering options, one typical of Jeep and other truck suspensions, and one typical of some Alfa Romeo suspensions. It's also possible to use a Panhard bar or a Watts link with leaf springs. There are new inputs for front, rear or all-wheel drive (what percent of the power is being delivered through the front drive tyres), inboard or outboard brakes and unsprung weight.

There are new calculation utility screens that calculate kingpin dimensions for solid axle front suspensions and bump springs, including "stacked springs". The opposite end of the car can also be specified, applying "pitch" to the vehicle and bump springs can be added for the front and/or the rear suspension, which is popular in circle track racing. There are also new calculated outputs such as bump spring force and dynamic (after dive and roll are applied), roll stiffness, roll couple, front and rear lateral load transfer, and natural frequencies. It is very handy to watch what happens once the bump springs are encountered with suspension movement.

There are new inputs for ride height that can be watched as it changes when bump and roll are applied along with the new pitch input to the suspension.

A picture file is included with the suspension that will be drawn on the main screen if there is room and will be included in report printouts or graphs as instructed. There are also new print options for graphs and reports, including the suspension picture file (if any), data table, and various customisations of comments and labels. The program also can read some types of Bill Mitchell's WinGeo (.gem) suspension files. RT



ABOVE Performance Trends has updated its very popular Suspension Analyzer program

Aerodynamic sensors


ABOVE The Texys 8xPDIF is popular in F1

FROM its base in England, Renvale supplies the benchmark Tony James electrical wiring harness systems to a worldwide customer portfolio of motorsport professionals, operating at the very highest levels in the sport. It also distributes the Texys International range of top quality electronic sensors. The 4xPDIF, 8xPDIFand 16xPDIF differential pressure sensors have become very popular with Formula 1 aero departments in recent years. This is due to their class-leading packaging, accuracy, thermal stability and 0.1mPSI/bit resolution.

A notable addition to the range of aerodynamic sensors is a wireless version of the 8-channel differential pressure sensor – the 8xPDIF-W, that is available with pressure ranges from ±50 to ±1000 mBar, bringing high accuracy in a compact housing and delivering the eight readings through the CAN Bus. Specifically aimed at front and rear wing installations, this unit can be paired with the Texense GenWM generic master receiver.

Other sensors in the wireless range include the IRN8WS4 8-channel tyre temperature sensor, driveshaft torque and thermocouple amplifiers. A typical installation could see 2 x wireless 8-channel tyre temp sensors and 2 x wireless 8-channel PDIF sensors paired to the same receiver.

Texense has custom designed a tri-band auto-tuning wireless system that works on either 868 MHz, 902 MHz or 920 MHz frequencies depending on the country. All Texense wireless CAN sensors are user-configurable via an android application which is available for download.

Complementing these two is the new Yaw Pitot sensor, enabling measurements of differential air speed, differential yaw, air temperature and static pressure, all packaged in one unit with a CAN output.

The new Texense 16-channel A-CAN unit is a configurable analogue to CAN converter designed to bring swift and easy additional logging capability for a number of inputs. The end user can choose between 8 x Wheatstone bridge inputs, 16 x analogue inputs, or 8 x combined analogue and temperature inputs. Other bespoke inputs are available on request.

Another key product this year has been the High Temperature brake and clutch infrared sensor. "As temperatures within a Formula 1 car increase year by year, we needed to find a solution to minimise failures due to heat soak," said Jason Mowle, Texys UK's business manager. "By using the very latest PCB technology coupled with high temperature components, we have designed a new infrared brake and clutch temperature sensor capable of withstanding temperatures of up to 200°C. This has also reduced the need to cool the sensors using complex air ducts which reduces design costs for our customers." RT

New ultra-miniature 8STA connector

LANE Motorsport is now distributing the new ultra-miniature 8STA connector from Souriau along with a comprehensive range of accessories – protective caps, gaskets, nut plates and heat shrink boots – as well as all the assembly tools.

The Souriau 8STA standard circular connectors are designed specifically for applications where high performance, small size and light weight are key factors. They are used in many motorsport areas, including engine control units, communications equipment, data acquisition systems and harnesses.

Its features include a rugged aluminium body to provide long service in the harshest environments, a positive locking mechanism with locked colour indicators, five shell styles and up to 128 contacts. It is also sealed to IP67 and can work in a temperature range of -55°C to +175°C. RT

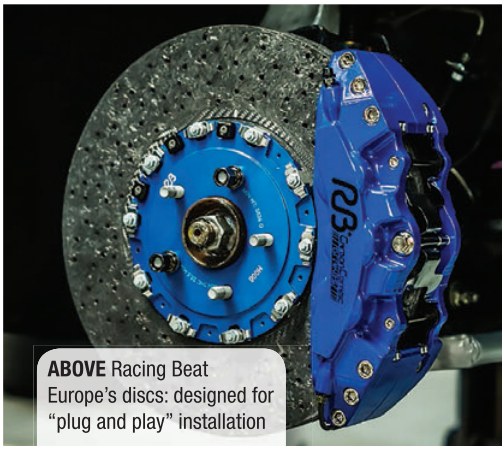

ABOVE New ultra-miniature 8STA connector

Latest generation carbon-ceramic discs

RACING Beat Europe in conjunction with Racingbrake USA is now offering the latest generation carbon-ceramic discs for a huge array of supercars from McLaren to Ferrari, Porsche and Aston Martin. They are also OE fitment on the Koenigsegg Agera One.

Racingbrake uses an advanced carbon fibre reinforced ceramic (CFRC), a Surface Transforms material that is produced by its own proprietary processes. It transforms carbon-carbon into carbon-silicon carbide (CSiC) ceramic. While the carbon-ceramic discs on production road cars conventionally use discontinuous – chopped – carbon fibre, the Surface Transforms process interweaves continuous carbon fibre to form a 3D multi-directional matrix, producing a stronger and more durable product with three times the heat conductivity of standard production components. This keeps the brake system temperature down and the brake performance consistent.

Surface Transforms has developed unique patented next-generation carbon-ceramic technology that provides what it claims is the ultimate braking performance for road and track. Along with conventional disc upgrades for many cars, Racing Beat Europe also offers carbon to iron conversion kits which are especially attractive to customers who want a more cost-effective replacement for OE carbon discs. RT


ABOVE Racing Beat Europe's discs: designed for "plug and play" installation

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BELOW Towering ambition: Formula E has changed the motorsport landscape

BIRTHDAY BASH?

As Race Tech looks ahead another 100 issues, what can the motorsport industry expect? Not much, suggests **Sergio Rinland**, unless the governing bodies take the bull by the horns

RACE TECH is 200 issues young this month and a lot of water has gone under the bridge since those early days.

When the first issue went to press, in 1995, the motorsport world was still recovering from the tragic days of Imola the previous year. A massive safety overhaul was reshaping Formula 1. Endurance racing was going through a transition of its own. The GT1 formula allowed McLaren to dominate with the Gordon Murray-designed F1, a car well ahead of its time compared with the more traditional GT machinery.

By contrast Indycars, or ChampCars as they were known then, were at their peak with major manufacturer participation. That scene was dominated by British car constructors Reynard and Lola, with good American challenges from the British-built Penskes and from the US-built Dan Gurney Eagles and Swift stable.

Motorsport worldwide was dominated by the British industry, not only F1. We could say that maturity arrived to it that decade.

By the time the magazine popped the corks for 100 issues, in 2009, there wasn't actually much to celebrate elsewhere: we were in the middle of the worst economic downturn since the 1930s depression. That year saw the introduction of electrification in F1, with the KERS, a timid attempt if we compared it with today. Not everybody bought into the technology; in fact, the advantage was small enough to allow the aerodynamically superior Brawn to dominate. Manufacturers were leaving F1 due to the economic situation.

Le Mans was at the start of the current boom, with the introduction of diesel by Audi and Peugeot. It was the time when diesel was promoted worldwide, by politicians concerned with the environment, as the fuel of the future thanks to its lower CO2 emissions. Unfortunately they missed the more lethal NOx.

By then, the Prodrive Lola Aston Martin was defending British honours. But the rules favoured the diesel cars, so it had no chance. In LMP2 and GT there was a good variety of machinery, with Aston Martin dominating the latter, and the UK motorsport industry had a strong presence from the tier 2 component suppliers as well.

By 2009 Indianapolis was a different world to 1995, now ChampCar had disappeared to make space for IRL. All the chassis were now manufactured by Dallara in Italy, with only some British components and the Ilmor-built Honda engine. To all intents and purposes, IndyCar was now a single-make championship, a far cry from the 1995 ChampCar era.

Fast-forward to these days, issue 200, and things are not much better for our beloved motorsport. F1 is entering the post-Ecclestone era, where the jury is still out, with new regulations which introduced faster and more spectacular cars with a high technology content in the drivetrain, for the benefit of the major car manufacturers.

In the intervening years Le Mans made a significant step forward from the technology point of view. So much so, that even car manufacturers are in doubt whether they can actually compete with the current Porsches and Toyotas. LMP2 is a controlled formula for the first time with no British-built chassis, but yes the engine, electronics, gearboxes and other components.

Indianapolis continues as in 2009, with only Dallara chassis built in Italy and engines from Chevrolet and Honda. Not in the best of health.

But most significantly, we have a thriving Formula E, with good UK technology presence in the powertrains and teams, but the chassis are – as with most other single-make formulas – made by Dallara in Italy. Is electric motorsport the future? Perhaps. Is the future of automotive electric? *Certainly*.

So, what can we expect from the years to come? Where are we going to be by the time Race Tech gets to issue 300 in 2025?

There will be interesting times ahead. While the automotive industry is going full steam (for want of a better word!) ahead into the electric and autonomous era, motorsport has to find its revised role, a theme that we touched on in the previous issue.

And what about our motorsport industry? Many visionary entrepreneurs are diversifying into automotive and aerospace, reducing the proportion of motorsport business they do. They can foresee the trend.

Personally, I was fortunate to have been involved in both the 1995 ChampCar era (Issue 1) and 2009 LMP1 scene (Issue 100). They were fantastic experiences. But the only way motorsport can be thriving in 2025 is if the governing bodies take the bull by the horns. They need to turn around motorsport to attract the younger generations and get the support of the automotive industry to develop the new and needed technologies. Going back to its roots? Perhaps… RT

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